中国纤维
流行趋势
CHINA FIBERS
FASHION TRENDS

NEW
FIBER

中国纤维

流行趋势报告

CHINA FIBERS FASHION TRENDS REPORT

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CCFA | 盛虹 SHENGHONG

NEW
WORLD

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中国新时代、纤维新视界

NEW FIBER NEW WORLD

2017 年中国化纤行业持续向好，高质量企业盈利能力再创新高，新凤鸣、台华、威海拓展等企业先后在沪深主板成功上市，成为资本市场关注的热点。中国纤维科技创新捷报频传，“干喷湿纺千吨级高强 / 百吨级中模碳纤维产业化关键技术及应用”项目荣获国家科技进步一等奖，溶剂法纤维素纤维实现国产化。中国纤维进入了战略发展的新时代，柔性制造、再生循环、生物基、功能性纤维等重点研发计划强势出击；智能制造、绿色制造、强基工程等集聚增力；国家工业大奖、单项冠军等品牌工程更显纤维力量。新时代必须把握新气象，新战略必然需要新理念，新视界必定催生新作为。

China chemical fiber industry continues its upward growth in 2017, and the profitability of high quality enterprises creates new heights. Xinfengming, Taihua, Weihai Expansion and other enterprises have completed their listing on the mainboard of Shanghai and Shenzhen stock markets and become the focused issue of capital markets. China Fiber make triumphant news frequently in innovation of science and technology, with its project of “the key technology and application for the industrialization of dry-jetted wet-spun kiloton high strength / 100 ton medium modulus carbon fiber” being awarded the first prize of national science and technology progress, cellulose fiber synthesized by solvent method have been localization.. China Fiber has entered the new era of strategic development. Flexible manufacturing, recycling, bio-base, functional fiber and other key R&D plans have made their debut, intelligent manufacturing, green manufacturing and strong base project have concentrated strength and the branding projects such as national industrial awards and individual champion prizes have displayed the strength of fiber. We should hold the new situations in the new era and implement new strategies on the basis of new concepts, as new visions must lead to the birth of new actions.

一、中国纤维：新气象
New Image of China Fiber

（一）中国制造，新一轮工业革命的主体

在欧、美、日等发达国家及地区的推动下，随着全球进入“工业革命 3.0”及“工业革命 4.0”时代，技术创新极度活跃，物联网、云计算、大数据、移动互联、3D 打印、智能机器人、页岩气、可再生能源以及生物质、新材料等领域的推陈出新层出不穷，持续推动技术进步，孕育新一轮工业革命。

世界最大的中国制造体系，围绕推动经济复苏、提升综合竞争力、确保能源安全、应对气候变化等需求，通过数字化、网络化、智能化与可再生能源、新材料的深度融合和广泛应用，不断培育出新产业、新业态、新模式，从而推进中国制造业的高质量发展，实现制造大国向制造强国的转变。

A. Made-in-China: Subject of new industrial revolution

As the world entered the era of Industrial Revolution 3.0 and the Industrial Revolution 4.0 era, promoted by the developed countries and areas like Europe, the United States and Japan, technical innovation becomes extremely active. With the endless disappearance of the old and the emergence of the new in the areas of the Internet of things, cloud computing, big data, mobile internet, 3D printing, intelligent robot, shale gas, renewable energy, biomass and new materials, technical progress was constantly made to give birth to a new round of industrial revolution.

As the largest manufacturing system in the world, China focuses on promoting economic recovery, enhancing comprehensive competitiveness, ensuring energy security, responding to climate changes and other needs. Through the extensive integration and wide application of digital, networked and smart technology with renewable energy and new materials, China manufacturing system cultivates new industries, new commercial activities and new modes continuously, with a view to promote high quality development of China manufacturing industry and realize the transformation of China from a big manufacturing country to a manufacturing power.

B. New Materials for Fiber: Strategic Commanding Height of Global Innovation Drive

Driven by the new round of industrial revolution and based on its own advantage, global fiber material industries expanded development channels, innovated development plans and strived to seize the strategic commanding heights in each subdivision area.

The United States has launched revolutionary fiber and textile programs, set up innovative institutions for fiber and fabric industry, and focused on developing the new generation of intelligent fiber and yarn technology and fabrics.

The EU has launched the plan of Horizon 2020, focusing on medical devices and intelligent fiber products, high-tech non-woven materials for new industrial development, lightweight high-performance complex fiber materials, advanced materials for nanofibers, and anti-corrosion safe fiber materials.

Germany has released Future TEX program in Industry 4.0, focusing on renewable fiber materials, client-oriented customized fiber products, and the future emerging fiber material with intelligent fiber as its main body .

（二）纤维新材料，国际创新驱动的战略制高点

全球纤维材料产业在新一轮工业革命的带动下，均从自身优势出发，拓宽发展渠道，创新发展规划，争相抢占各细分领域的战略制高点。

美国推出革命性纤维和纺织品计划，建立纤维和织物产业创新机构，重点发展新一代具有智能特征的纤维纱线技术和织物。

欧盟推出了 Horizon 2020 计划，重点是医疗器械和智能纤维制品，新工业发展用的高技术非织造材料，轻质化的高性能复合纤维材料，纳米纤维先进材料，安全防腐纤维材料等。

德国在“工业 4.0”中推出了 Future TEX 计划，重点是可再生纤维材料，以顾客为中心的定制化纤维产品制造，以智能纤维为主体的未来新兴纤维材料等。

日本依托具有强大研发能力的代表性企业，重点在高新技术纤维和高端纤维制品等领域推动研发和成果产业化，并以其科技综合优势和革命性创新，逐步占据纤维创新及产业战略制高点。

（三）纤维新材料，重塑行业战略的新时代

1、重塑开拓发展领域的新时代

随着全球纤维产业创新驱动战略的实施，我国纤维行业紧跟《国家创新驱动发展战略纲要》、《中国制造 2025》、供给侧结构性改革等政策步伐，明确高质量发展要求，推动新材料发展战略的实施，促进功能性纤维、生物基纤维等基础新材料，高性能纤维等关键新材料，石墨烯改性纤维等前沿新材料的创新发展。纤维领域与新兴科技交叉与融合，已形成前所未有的多维发展空间，呈现极限、多元、智能、绿色、融合、服务等新发展主题。

2、重塑引领消费战略的新时代

以纤维产业为代表的传统制造业的创新升级，直接带动了消费结构由以衣食住行的基本型消费为主转型为涵盖教育、医疗、健康、文化、环境等多重领域的服务型消费，而且这一升级趋势越来越明显，速度越来越快，不但蕴含着巨大的消费潜力，更重要的是，消费结构的变化极大的提高了已有各类终端产品的性能，并不断丰富着应用领域所涉及的范围。

Relying on the strong R&D capacity of representative enterprises, Japan focuses on promoting the R&D and industrialization of research results in high-tech fibers and high-end fiber products, and gradually occupied the commanding height of fiber innovation and industrial strategy by means of its comprehensive advantages and revolutionary innovation.

C. New Materials for Fiber: Remolding New Era of Industrial Strategy

1. Reshaping New Era of Exploitation & Development

With the implementation of the innovation drive strategy of global fiber industry, Chinese fiber industry keeps pace with the release of Outline of National Innovation Driven Development Strategy and Made-in-China 2025 and the policies of supply-side structural reform, clarify the development requirement for high quality, promote the implementation of new material development strategy, and advance the innovation and development of the basic new materials of functional fibers and bio-based fibers, the key new materials like high performance fibers and the cutting-edge new materials like graphene fibers. As fiber sector is intersected and integrated with emerging technologies, an unparalleled multi-dimensional space for development comes into being. Such a space turns out to be newly themed by extremity, diversification, intelligence, green, integration and service with its application beyond traditional fiber industry, providing key basic material and core material for the sectors of advanced manufacturing, intelligent and functional consumables, medical and health, environmental protection and prevention, modern architecture and agriculture and new energy.

2. Remolding New Era of Leading Consumption Strategy

The innovation and upgrade of traditional manufacturing industry represented by fiber industry have directly led to the transformation of consumption structure from the basic consumption form included by food, clothing shelter and transportation to the service form covering education, medical treatment, health, culture and environment. Such a momentum becomes more and more obvious with an increasing speed. It contains a huge consumption potential; more importantly, the changes in consumption structure greatly improve the performance of existing types of terminal products and constantly enrich the involved scope of applications.

二、中国纤维：新作为
China Fiber: Making New Progress

（一）实现高质量发展

新时代我国经济发展的基本特征就是我国经济已由高速增长阶段转向高质量发展阶段。高质量发展，意味着高质量的供给、高质量的需求、高质量的配置、高质量的投入产出、高质量的收入分配和高质量的经济循环。

中国纤维行业不断转变发展方式、优化经济结构、转换增长动力，始终坚持高质量的发展路径，以供给侧结构性改革为主线，推动发展质量变革、效率变革、动力变革，提高全要素生产率。消除无效供给，培育新动能，降低实体经济成本，扩大优质增量供给，实现供需动态平衡。

A. Realizing High Quality Development

The basic feature of Chinese economic development in the new era is that Chinese economy has shifted from high growth stage to high quality development stage. High quality development means high quality in supply, demand, disposition, input and output, income distribution and economic cycle.

Chinese fiber industry has constantly changed its development mode, optimized its economic structure and shifted its growth momentum. It always adheres to the high quality development path and takes the supply-side structural reform as the main line. It aims at promoting transformation in quality, efficiency and power, and improving total factor productivity. It makes effort to eliminate ineffective supply, cultivate new dynamic energy, reduce costs of real economy, expand high quality incremental supply, and thus realizing dynamic balance between supply and demand.

B. Constructing New Path for Development

The socialism with Chinese characteristics has entered a new era. The main contradiction of Chinese society has been transformed into the contradiction between the growing demand for better life of the people and the imbalanced and insufficient development. The demand of people for quality of life is increasing, and that for performance of products turns continuous diversification. With the innovation of technology and renewal of products, it is possible to satisfy all needs step by step.

Chinese fiber industry will continue to accelerate the development of high-tech materials, high-valued biomedical materials, energy-saving environmental-protective materials and resource-circular-using materials, and widely use them in fashion apparel, medium-and-high-end textile products and industrial textiles, so as to make public life surrounded by more environment-friendly and multi-performance quality products. In addition, new materials for the key strategic areas such as aerospace, marine equipment, wind power equipment, new energy vehicles and civil-military integration are always the focus of development. New growth point will be cultivated in medium-and-high-end consumption, low-carbon and health-related areas to form new dynamic energy, so as to promote the transformation from Made-in-China to Created-in China, from Chinese speed to Chinese quality and from Chinese products to Chinese brands. Through further comprehensive development, Chinese fiber industry will fully meet the requirements for people to have a better life.

（二）构建发展新路径

中国特色社会主义进入新时代，我国社会主要矛盾已经转化为人民日益增长的美好生活需要和不平衡不充分的发展之间的矛盾。人们对于生活质量的要求不断提高，对于产品性能的需求呈现持续多样化趋势。随着技术的创新与产品的更新换代，使一切需求的满足都逐步成为可能。

中国纤维产业将继续加快发展高新材料、高值生物医用材料、节能环保材料、资源循环利用材料，并广泛应用于时尚服装服饰、中高端家纺用品、产业用纺织品等重要领域，使大众的生活中围绕更多绿色环保、性能丰富的优质产品。此外，在航空航天、海洋装备、风电装备、新能源汽车、军民融合等战略性关键领域的新材料也始终是发展的重点，并在中高端消费、绿色低碳、大健康等领域培育出新增长点、形成新动能，推动中国制造向中国创造转变、中国速度向中国质量转变、中国产品向中国品牌转变，进一步通过更加充分的发展满足人民美好生活的需要。

（三）打造绿色发展共同体

21世纪的今天，环保是一种时尚，更是一种责任。在节约资源和保护环境的基本国策推动下，各行业均实行最严格的生态环境保护制度，形成绿色发展方式和生活方式，建设美丽中国，为人民创造良好生产生活环境，为全球生态安全作出贡献。

纤维行业坚持加强固体废弃物和垃圾处置，提高污染排放标准，强化排污者责任，健全环保信用评价、信息强制性披露、严惩重罚等制度。构建政府为主导、企业为主体、社会组织和公众共同参与的环境治理体系、绿色技术创新体系、安全高效能源体系、优化生态安全屏障体系等，并相继在行业中打造“绿色纤维”品牌、“再生纤维素纤维绿色发展联盟”等。积极参与全球环境治理，成为全球生态文明建设的重要参与者、贡献者、引领者。

生态文明建设功在当代、利在千秋。纤维行业牢固树立社会主义生态文明观，勇于自我净化、自我完善、自我革新、自我能力的提高。推动形成人与自然和谐发展现代化建设新格局，为保护生态环境作出我们这代人的努力!

使命呼唤担当，使命引领未来，共筑中国梦，共同开启“纤维新视界”！

C. Establishing Green Development Community

In the twenty-first Century today, environmental protection is a fashion and even a responsibility. Driven by the basic national policy of conserving resources and protecting environments, all industries implement the most stringent system of ecological and environmental protection and develop the development and life style in an environment-friendly manner, with a view to build a beautiful China, create a good production and living environment for people and even make contributions to global ecological security.

Chinese fiber industry insists on strengthening the disposal of solid waste and garbage, improving pollution discharge standards, reinforcing the responsibility of polluters, streamlining the systems of environmental credit evaluation, mandatory disclosure of information and severe punishment and penalty. We shall establish the environmental governance system, the green technical innovation system, the safe and efficient energy system and the optimized ecological safety barrier system, which are led by the government with enterprises as the subject and social organizations and the public as the joint participants, creat the GREEN FIBER brand and Collaboration for Sustainable Development of Viscosse. Chinese fiber industry shall actively participate in global environmental governance to become an important participant, contributor and leader in construction of global ecological civilization.

The construction of ecological civilization is the cause that takes pains for the moment but make gains for the future generations. Chinese fiber industry adheres to the concept of socialist ecological civilization, and behaves bravely in self-purification, self-improvement, self-innovation and increase of self-competence, so as to promote the formation of a new pattern of harmonious development between people and nature, and to make the efforts of our generation to protect ecological environments.

Our missions call for responsibilities and our missions lead the future. Let us work together for the realization of the Chinese Dream and the open-up of a "new fiber vision".

三、中国纤维：新视界

China Fiber: New Vision

（一）理念创新新视界

1、全方位理念

新时代纤维的创新体系贯穿产业全流程。瞄准世界纺织纤维科技前沿，强化基础研究，实现前瞻性研究，拓展实施国家重大科技项目，突出关键共性技术、前沿引领技术、现代工程技术、颠覆性技术创新，为建设纤维领域的科技强国、质量强国、航天强国、交通强国、数字强国、智能社会提供有力支撑。纤维行业因创造而分享，因分享而愉悦。伴随创新的深入，透过纤维内在的生命逻辑，深深体味创新的意义所在，进一步完善公共价值，构建人文和谐。

新时代纤维的创新体系支撑国家创新体系建设，强化战略科技力量。深化科技体制改革，建立以企业为主体、市场为导向、产学研深度融合的技术创新体系，加强对中小企业创新的支持，促进科技成果转化。倡导创新文化，强化知识产权创造、保护、运用。培养造就一大批具有国际水平的战略科技人才、科技领军人才、青年科技人才和高水平创新团队，充分发挥工匠精神。坚持创造性转化、创新性发展，不断铸就纺织化纤行业新辉煌。从而使行业得到大幅跃升。

2、多维度视野

新时代纤维更加关注社会责任、终端消费和未来发展。纤维材料领域的科技革新正推动纤维产业的颠覆性发展，催生新一代纤维产业，具有智能等多功能及超高性能、超高性价比、超高附加值、超高产业拉动效应、低碳绿色特征；其应用领域超越传统纤维产业，是先进制造业、智能与功能消费品、医疗与健康、环保与防护、现代建筑业与农业、新能源产业等的关键基础材料和核心材料，以及国家供给侧结构性改革的重要突破口。

A. New Vision of Idea Innovation

1. All-dimensional Concept

The fiber innovation system in the new era covers the whole process of fiber industry. It aims at world cutting-edge science and technology of textile industry, strengthens basic research to achieve prospective study. It expands the implementation of major national technical projects, highlights the innovation of key common technology, leading frontier technology, modern engineering technology and disruptive technology, to provide strong support to build China into a power in science and technology, quality, astronautics, transportation, digital application and intelligent community. The fiber industry shares its creation with delight. With the deepening of innovation, the logic of life and significance of innovation within fiber will be exhibited, which will further improve public values and construct cultural harmony.

新时代纤维创新多维化高度融合。原料从以石油为主发展为原料的多元化体系；新型纤维品种竞争优势强化，形成专业的产业链新格局；纳米纤维等前沿技术的推广与应用，催生新型产业发展体系；创新与资本融合的新型商业模式，推动行业资源优化与要素整合，形成包容性发展新体系；集成创新平台，支撑快速响应体系；基于消费者自我实现的个性化需求，形成定制化纤维材料体系，为多元化的创新需求带来广阔发展空间。

（二）策略创新新视界

1、资源可持续策略

> **出发点：**推动非石油资源的利用，解决生产过程中及产品使用废弃后的污染问题。

代表性产品：

- **生物基化学纤维：**包括 PLA、生物基聚酰胺 56 纤维、莱赛尔纤维等品种。原料来源广泛，部分或全部采用生物质材料，农、林、海洋等资源生物质储量超千亿吨，其产品可生物降解。
- **循环再利用化学纤维：**包括再生聚酯纤维、再生丙纶、再生高性能纤维及相关化学纤维。可以利用废弃聚合物和废旧纺织材料经回收后加工制成纤维，实现资源化、综合再利用。

原液着色化学纤维：包括原液着色聚酯纤维、原液着色聚酰胺纤维、原液着色聚氨酯纤维、原液着色再生纤维素纤维等。由含有着色剂的纺丝原液或熔体纺制成的有色纤维，降低了传统印染环保压力。

- **新型生态催化聚酯纤维：**采用钛系新型催化剂制备的聚酯纤维，在印染织造过程中无重金属排放，绿色环保、安全。

2、能源绿色化策略

> **出发点：**在应用过程中节约石油、煤炭、水等资源的消耗。

代表性产品：

- **碳纤维：**实现汽车轻量化，达到节约石油的目的；碳纤维风力发电叶片，高效率利用风能，节约电能及煤炭资源。
- **超细旦聚丙烯纤维 / 纳米级聚酰胺纤维：**耐高温、阻燃、电化学稳定性强，制造非织造布电池隔膜，可用于镍 - 镉电池和镍 - 氢电

The fiber innovation system in the new era supports national innovation system and strengthens strategic technical forces. We shall deepen the reform of science and technology mechanism, set up a technical innovation system that takes enterprises as the main body and market as the orientation with the deep integration of production, teaching and research, enhance our support for SMEs' innovation and promote the transformation of scientific and technical achievements. We shall advocate a culture of innovation and strengthen the creation, protection and application of intellectual property rights. We shall train a large number of internationally strategic science and technology talents, technical leading talents, young scientists and technicians and high-level innovative teams, and give full play to craftsmen spirit. We shall adhere to creative transformation and innovative development, continuously forge new splendor in textile and chemical fiber industry, and thus making the fiber industry leap.

2. Multiple Dimensions of Horizon

The fiber industry in the new era attaches more importance to social responsibility, terminal consumption and future development. Technical innovation in fiber materials is disruptively promoting the development of fiber industry, fueling new generation of fiber industry. It is featured with multifunctional and ultra-high performances such as intelligent functions, ultra-high price/performance ratio, ultra-high added value, ultra-high industry-drive effect and low carbon. Its applications go beyond traditional fiber industry as it acts as the key basic material and core material for advanced manufacturing, intelligent and functional consumables, medical treatment and health, environmental protection and prevention, modern architecture and agriculture, as well as new energy. It is the critical point for breakthrough in national supply-side structural reform.

In the new era, the fiber innovation is embodied in its multidimensional integration. The raw materials of fiber mainly come from oil products and form a diversified system. The competitive advantages of new types of fiber are enhanced to develop the new pattern of professional industrial chains. The popularization and application of nanofiber and other cutting-edge technology give birth of new industrial development system. New business modes with integration of innovation and capital promote the optimization of resources and factors of integration of fiber industry, and form the new system of inclusive development. The integrated innovation platform supports the rapid response system. Based on consumers' self-realization of personal demands, the system of customized fiber material is developed to bring broad development space for the demands of diversified innovation.

B. New Vision of Strategy Innovation

1. Resource Sustainable Strategy

> **Starting Point:** to promote the utilization of non-oil resources and solve the problem of pollution in the process of production and after the use or obsolescence of products.

Representative Products:

Bio-based chemical fibers include PLA, bio-based polyamide 56, lyocell and other fibers. The origin of the raw materials is wide for all or some of them come from biomass materials which reserves over 100 billion tons including agricultural, forest and marine resources. The relevant products are biodegradable.

Recycle and reuse chemical fibers include regenerated polyester fiber, regenerated polypropylene fiber, regenerated high-performance fiber and related chemical fibers. The abandoned polymer and waste textile materials can be recovered and processed into fibers to realize comprehensive recycling of resources.

The dope-dyed chemical fibers include polyester fiber, polyamide fiber, polyurethane fiber and regenerated cellulose fiber. The non-ferrous fiber made from spinning liquid or melt containing colorants reduces the pressure of environment-protection of traditional printing and dyeing methods.

New eco-catalytic polyester fiber is made of polyester fiber which is prepared by new titanium catalyst, with no emission of heavy metal during printing and weaving process, which makes it environmentally friendly and safe.

池等，这些电池主要用于笔记本电脑和手机中，直接影响电池的容量、循环利用以及安全性能等，另外电动汽车电源电池用非织造布电池隔膜需求量也正在逐年上升。

■ **土工合成纤维材料:** 可节约农业用水。

■ **分离功能纤维材料:** 可实现工业用水重复使用。

3、环境生态化策略

出发点: 保持水土生态，减少大气污染。

代表性产品:

■ **高温烟气过滤材料:** 包括聚酰亚胺纤维、芳纶、聚苯硫醚纤维、聚四氟乙烯纤维等，实现空气净化、大气治理。

■ **纤维膜过滤材料:** 包括聚丙烯纤维膜、聚丙烯腈纤维膜等，实现污水处理，工业废水及污水资源化利用。

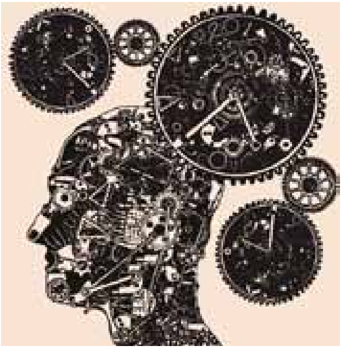
■ **土工用纤维材料:** 包括工程纤维、高强聚丙烯纺粘无纺布等，实现三废存储、填埋时防渗漏、防挥发，土壤污染治理，矿山生态修复，重金属污染治理，生态护坡加固绿化等。

4、健康可穿戴策略

出发点: 以人为本，围绕人类日常而展开的创新制造，为大众生活的各个方面带来更多便捷与更好的使用体验。

代表性产品:

■ **功能性纤维:** 包括抗菌抑菌、防污快干、导电、发热、防辐射等具有特殊功能的纤维，在智能服装、医疗、军事、体育和特殊职业等领域中形成广泛应用，促进了纺织市场的健康多元化发展。



2. Energy Greenization Strategy

Starting Point: to save the consumption of oil, coal, water and other resources during application.

Representative Products:

Carbon fiber aims at saving oil by means of the design of light weight of automobiles. The carbon fiber wind turbine blades can efficiently use wind energy and save electricity and coal resources.

Super fine denier polypropylene fiber and nano polyamide fiber are featured with high temperature resistance, flame retarding and electrochemical stability. They can be made into nonwoven battery diaphragms that are used for nickel cadmium and nickel hydrogen batteries, which are applied to laptops and mobile phones. These fibers can directly affect the capacity, recycling and safety performance of these batteries. Besides, the demand for nonwoven battery diaphragms used in power supply and batteries of electric vehicles is also increasing year by year.

Geosynthetic fiber materials can save water for agricultural use.

Separated functional fiber materials can be used for repetitive use of industrial water.

3. Environment Ecologicalization Strategy

Starting Point: to preserve ecology of soil and water and reduce air pollution.

Representative Products:

High temperature fume filter materials include polyimide fiber, aramid fiber, polyphenylene sulfide fiber and polytetrafluoroethylene fiber, to achieve air purification and air control.

Fiber membrane filter materials include polypropylene fiber membrane and polyacrylonitrile fiber membrane, to realize sewage treatment and recycling of industrial wastewater and sewage.

Geotextile fiber materials include engineering fiber and high-strength polypropylene spunbonded nonwovens, to realize three wastes storage, prevention of leakage and volatilization in landfilling, soil pollution control, mine ecological restoration, heavy metal pollution control, and ecologically protecting slopes via reinforcement of forestation.

4. Healthy & Wearable Strategy

Starting Point: to make innovation and production based on human-oriented daily life and bring more convenience and better experience for all walks of life.

Representative Products:

Functional fibers including the distinguished ones with antibacterial, antifouling, quick drying, conductive, heat-emitting and radiation-preventing properties are widely applied in smart clothing, medical treatment, military actions, sports and special occupations. They promote the healthy development of textile market diversification.

5、安全一体化策略

出发点：提供各类基建工程等项目的整体安全解决方案；推动军民融合深度发展；拓宽医疗方面的应用领域。

代表性产品：

- **安全防护用纤维：**包括阻燃、防辐射、耐高温、防割等特殊工装用纤维，达到人身防护的目的；应对自然灾害、公共及卫生事件，用于大直径高压输排水软管、救灾帐篷和冲锋舟、高等级病毒和疫情隔离服等领域。
- **国防用纤维：**包括高强高模、高阻隔、耐磨等纤维品种。广泛用于警用服装、防弹服及防护制服等。
- **医疗领域用纤维：**包括天然高分子材料，如胶原蛋白、甲壳质、壳聚糖等；以及合成高分子材料，如 PCL、PHBV、PGA 等。广泛应用于医用绷带、口罩、手术服等。

6、空间轻量化策略

出发点：在海陆空等空间领域高端装备中使用新型纤维，提高装备性能。

代表性产品：

芳纶（1313 和 1414）纤维、碳纤维、超高分子量聚乙烯、聚苯硫醚（PPS）纤维、聚醚醚酮纤维、芳砜纶 (PSA) 纤维、聚四氟乙烯（PTFE）纤维、聚酰亚胺（PI）纤维、高硅氧玻璃纤维、特种玻璃纤维、玄武岩纤维、陶瓷纤维如氧化铝和碳化硅等纤维。主要用于 C919 大飞机等航空航天领域；船舶、海洋钻井平台、海洋绳缆等航海领域；复兴号、和谐号高铁等陆路领域。

世界每时每刻都在发生变化，中国也每时每刻都在发生变化，实践没有止境，创新同样没有止境。纤维行业必须紧跟时代步伐，不断认识规律，不断推进理论创新、实践创新、制度创新、文化创新以及其他多方面创新，从而推动互联网、大数据、人工智能等前沿领域同纤维行业的深度融合，在中高端消费、创新引领、绿色低碳、共享经济、现代供应链、人力资本服务等方面培育新增长点、形成新动能。

沿着社会变革方向，不断推进纤维行业的质量变革、效率变革、动力变革，实现交融创新。全行业需勠力同心，不忘本来，吸收外来，面向未来，发挥中国智慧，更好的构筑中国精神、中国价值、中国力量，为人民提供物质及精神指引，体现纤维行业无限的生机活力，共同见证纤维行业的伟大飞越！

5. Security Integration Strategy

Starting Point: to provide the overall security solutions to various projects such as infrastructure projects, promote integrated development of the engineering jointly implemented by the military and the civilian, further broaden the application in medical treatment.

Representative Products:

Safe protection fibers including the ones used in the special working uniform with flame retarding, radiation prevention, high temperature resistance and anti-cutting, for personal protective purpose are applied to the solutions to natural disasters, public health and sanitation incidents, as well as major diameter high voltage water ducting and draining hoses, relief tents, assault boats and suits for quarantine of high level virus and epidemic situations.

Fibers in national defence including the ones with high strength, high modulus, high resistance or wear resistance are widely used in police uniforms, bulletproof clothes and protective suits.

Fibers in the medical field including natural polymer materials like collagen, chitin and chitosan, and synthetic polymer materials like PCL, PHBV and PGA are widely used in medical bandages, masks and surgical suits.

6. Lightweight Strategy in Aeronautic and Astronautic Equipment

Starting Point: to apply new fibers in high-end equipment in sea, land and air to improve performance of equipment.

Representative Products:

Fibers including aramid fiber (1313 and 1414), carbon fiber, UHMWPE fiber, PPS fiber, PEEK fiber, PSA fiber, PTFE fiber. PI fiber, high silica glass fiber, special glass fiber, basalt fiber, as well as ceramic fibers of alumina and silicon carbide are mainly used in aeronautics and astronautics of C919 aircraft, ship, navigation fields of offshore drilling platform and marine cable, and land transportation of Renaissance EMU and Harmony EMU.

The world is changing all the time, so is China. There is no end for practice and innovation. The textile industry must keep pace with the times, constantly understand the rules, and keep advancing theoretical, practical, institutional and cultural innovation, promote the further integration of fiber industry with the cutting-edge areas of Internet, big data and artificial intelligence, cultivate new growth points in medium-and-high-end consumption, innovation guidance, green low-carbon, shared economy, modern supply chains and human capital services, and form new dynamic energy.

We shall keep advancing the reforms of fiber industry in quality, efficiency and driving force to achieve integration of innovation. All the sectors of fiber industry are expected to make joint efforts, adhere to the original, draw on the foreign, face with the future, display China's wisdom, with a view to build up Chinese spirits, values and strength, provide material and spiritual guidance for Chinese people, highlight the infinite vitality of fiber industry and commonly witness the great leap of fiber industry.

中国纤维流行趋势 2018/2019 主题解读

THE INTERPRETATION ON CHINA FIBERS FASHION TRENDS 2018/2019

交融与飞越

INTERMINGLING AND TRANSCENDENCE

交 融

不同元素碰撞、交汇到融为一体。中国的古老文明以丝绸之路作为沟通东西方经济、政治、文化的大动脉，绵延搏动千百年。“一带一路”新时代，中国纤维承载新的历史使命，打开新视界，踏上新征程，促进科技、文化、理念、文明的深度融合，助力中国制造新发展。中国纤维不忘初心，作为全球生态文明建设的重要参与者、贡献者、引领者与环境、医疗、交通等领域水乳交融，共同实现建设绿色中国、健康中国、美丽中国的梦想。中国纤维牢记使命，凭借产业后发优势，以大国的责任担当和以天下为己任的情怀打造国际合作新平台，增添协同发展新动力，构建人类命运共同体。

INTERMINGLING

Intermingling means diverse elements come together, interact and fuse with each other. The ancient Chinese civilization bridged the economy, politics and culture between the East and the West with the Silk Road as the main artery communicating, which has been going on for thousands of years. In the new era of Belt and Road Initiative, Chinese fibers undertakes a new historic mission, opens a new horizon and embarks on a new journey to promote the in-depth fusion of science and technology, culture, ideas and civilization, and fuels the development of Chinese manufacture. Chinese fiber never forgot its original mission as an important participant, contributor and leader of the global ecological civilization construction. As a result, it fulfills its dream of building a green, healthy and beautiful China in perfect harmony with the environment, medical care and transportation. Chinese fiber keeps its mission firmly in mind. By virtue of its industrial advantages, it assumes its responsibility as the major power and the spirit of one for all to build a new platform for international cooperation through collaborative development, add new forces and establish a community of shared destiny.

飞 越

事物发展突破自身局限上升到一个新的阶段。中国纤维发展成绩瞩目，品种覆盖面最全、应用范围最广，产量占全球三分之二以上，拥有最完整的产业链配套体系。在迈入“化纤强国”的关键时期，中国纤维稳中求进，勇于变革、勇于创新，推行清洁技术与绿色低碳产品研究，构建竞争新优势，进一步推动产品质效的飞越。中国纤维全面增强“产、学、研、用”融合的深度和广度，拓展多维发展空间，不断提升科技创新、系统工程创新、服务创新、品牌创新，进一步打造创新体系的飞越。中国纤维拓宽原料渠道、发挥市场优势，建立创新体系平台，利用智能、绿色、柔性制造叠加效应优势，全方位鼓励产业与资本结合、制造装备与国际对接，打造从引领到全局掌握的中国模式，进一步实现行业发展模式的飞越。

TRANSCENDENCE

Transcendence implies that something goes beyond the usual limits and enters a new stage. Chinese fiber developed with remarkable achievements with the most comprehensive product coverage and the widest range of applications. Its output accounts for more than two thirds of the global yield, and it has the most complete industrial chain supporting system. In the crucial period of transforming into a " fiber powerhouse", China's fiber industry is making progress steadily, taking the courage to reform and innovate. Both the clean technologies and carbon-emission-reduction products construct a new competitive edge and further promote the quality and efficiency of the products. Chinese fiber comprehensively enhances the depth and breadth of industry-university-research cooperation, expands the space for its multi-dimensional development, and continuously improves the innovation on science and technology, system engineering , service and brand and further builds up its innovation system. Chinese fiber broadens the sources of the raw materials, gives full play to market advantages and establishes an innovation system platform. By utilizing the advantage of the addition effect of the intelligence, green and flexible manufacturing, Chinese fiber encourages the combination of industry and capital in all aspects and makes equipment and international docking to create a leading-to-dominating China model, further achieving a jump in the industry development model.

技术交融：

中国纤维与智能制造融合，引领产业变革，助力中国制造转变为中国“智”造；中国纤维与绿色制造融合，秉承金山银山就是绿水青山，坚守环境友好、可持续发展，打造世界上最大的再生资源产业链；中国纤维与高新技术融合，加快与能源、大数据、人工智能等科技前沿和纳米、生物、石墨烯等新材料交融，铸就行业中高端价值链的核心竞争力。

产品交融：

中国纤维从被动满足需求到引领需求、创造需求，主动与终端产品融合，传达纤维的内涵与理念。纤维设计更加关注展现绿色、功能及文化的品牌形象；纤维开发更加注重与光学、电子、智能等领域的跨界融合；纤维制造更加聚焦低碳经济、绿色发展、质效提升的新趋势。

应用交融：

中国纤维聚焦专业化细分、个性化定制、突破自身的发展空间，与新的应用方向不断交汇，彰显多元化发展。中国纤维贯彻军民深度融合，高性能纤维从航空航天、高温过滤领域逐渐渗透到民用领域，由高端领域进入寻常百姓家；中国纤维将功能与科技高度融合，民用纤维冲破传统服饰应用逐渐步入产业用领域，为工程领域贡献全新选择。

Technology intermingling:

Chinese fiber integrating with intelligent manufacturing leads the industry transformation and helps China shift from “Made in China” to “intelligent Manufacturing in China”. Chinese fiber integrates the green manufacturing upholding the concept of “Lucid waters and lush mountains are invaluable assets”. The world's largest renewable resource industry chain is being created adhering to the environmentally friendly manufacturing and sustainable development. Chinese fiber integrating with high-tech speeds up its melting the fusion of cutting-edge technology such as energy, big data and artificial intelligence with nano-materials, bio-materials and grapheme, which sets up the core competitiveness in the mid- and high-end industry chain.

Product intermingling:

Chinese fiber developed from passively meeting the demand to leading the demand, creating demand and takes the initiative to integrate with the terminal products to convey the connotation and concept of the fiber. Fiber design pays more attention to the brand image unveiling green, function and cultural values. Fiber development lays more stress on cross-border integration with optics, electronics and intelligence. Fiber manufacturing focuses more on the new trend of low-carbon economy, green development and quality improvement.

Application intermingling:

Chinese fiber focuses on the professional subdivision, customization and expanding its own development space and continuously meets the new application directions, demonstrating its diversified development. The development of Chinese fiber implements the in-depth integration with the military and civilian fields. The high-performance fibers gradually diffuse from the aerospace and high temperature filtration to the civilian areas and they are thus from the high-end fields into the household life. The development of Chinese fiber combined the functional application and high-technology together. The civilian fibers break through traditional apparel applications, gradually into the industrial applications, contributing a new choice for the engineering application.

技术飞越：

关键原料的制备技术实现飞越，突破资源约束，形成了中国特有的竹纤维，生物基戊二胺、己二酸、壳聚糖制备体系；功能性纤维制备技术实现飞越，开发石墨烯制备及改性、复合多功能高效制备、多组份共聚改性技术等；高性能纤维制备技术实现飞越，攻克干喷湿纺高性能碳纤维产业化、干法纺聚酰亚胺纤维工程化关键技术，实现从无到有。芳纶、超高分子量聚乙烯、玄武岩、聚苯硫醚等高性能纤维实现了我国重要战略物资的国产化。

产品飞越：

多功能高品质产品实现飞越，中国纤维更加关注社会责任、终端消费和未来发展，建立了纤维后道产品开发的技术体系，最终向下游应用及消费者呈现出生态抑菌、全谱发热保暖、抗熔滴阻燃等新型产品；高性能纤维实现飞越，中国纤维秉持家国情怀，自主开发碳纤维、芳纶、高强高模聚乙烯纤维等高性能纤维，支撑国家战略性新兴产业发展; 环境友好纤维实现飞越，中国纤维敢于担当，开发出聚酯、聚酰胺、纤维素等的原液着色、同质异构、生物基、再生循环纤维，推动产业可持续发展。

Technical progress:

Technical Transcendence: The technology transcendence of the key materials preparation has been realized, breaking through the resource constraints and forming China's unique making systems in bamboo fiber, bio-based pentylenediamine, adipic acid and chitosan. The technology transcendence of the functional fiber preparation has been realized including the the preparation and modification technology of grapheme, multi-functional and efficient preparation technology and multi-component copolymerization modification technology. The technology transcendence of the high-performance fiber has been realized. The breakthrough of the industrializing technology of dry-jet wet-spinning for high-performance carbon fiber and the key engineering technology of dry-spinning polyimide fiber achieves the 0 record. The aramid, UHMWPE, basalt, polyphenylene sulfide and other high-performance fibers have realized the domestic production of the important strategic materials.

Progress in products:

Product Transcendence: The transcendence of multi-functional and high-quality products has been realized. Chinese fiber is more concerned about social responsibility, end consumption and future development. A technical system for the fiber back-end product development has been established, which eventually presents eco-antibacterial and full spectrum heating and anti-dripping flame retardant products and other new products for downstream applications and consumers. The transcendence high-performance products has been realized. Following the feelings of the home country, carbon fiber, aramid, high strength and high modulus polyethylene fiber and other high performance fibers have been self-developed to support national strategic emerging industries. The transcendence of environmentally friendly products has been realized. Assuming the sustainable responsibility, the dope-dyed polyester, polyamide, cellulose fibers, bio-based and recycled fiber have been developed to promote the sustainable development of fiber industry.

中国纤维流行趋势 2018/2019

4 四大篇章 · 十大纤维
CHAPTERS · 10 FIBERS

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54	发布篇章三 CHAPTER THREE **纤 · 匠心品牌** FIBER · ELABORATE BRAND	抗形变纤维 DEFORMATION RESISTANCE FIBER 差别化再生纤维素纤维 DIFFERENTIAL REGENERATED CELLULOSE FIBER
70	发布篇章四 CHAPTER FOUR **纤 · 智创工程** FIBER · INTELLIGENT ENGINEERING	高性能碳纤维 HIGH PERFORMANCE CARBON FIBER 高性能对位芳纶 HIGH PERFORMANCE PARA-ARAMID 高性能超高分子量聚乙烯纤维 HIGH PERFORMANCE ULTRA-HIGH MOLECULAR WEIGHT POLYETHYLENE FIBER 高性能聚酰亚胺纤维 HIGH PERFORMANCE POLYIMIDE FIBER

易上染	Easy-dyable
弹性持久	Durable Elastic
易打理	Ease-care
柔软	Soft
吸湿速干	Fast Dying
抗起球	Anti-pill
透气	Breathable
绿色环保	Green & Environmental Protection
分散性好	Dispersion
高强度	High-strength
抗静电	Anti-static
隔热	Heat Insulation
色彩持久	Durable Color
阻燃	Flame Retardant
抑菌	Anti-bacteria
耐高温	Heat-resistant
抗皱	Anti-wrinkle
耐老化	Anti-aging
无重金属析出	No Heavy Metal
高模量	High Modulus
纺前着色	Dope dyed
远红外	Far infrared
电绝缘	Electric insulation
耐化学药品	Chemical resistance
温度调节	Warmth & Cooling
防紫外线	Anti-UV
易加工	Easy Processability
部分替代原生纤维	Virgin Fiber Replacement
高耐（电）压	High (Electricity) Pressure Resistant
耐高低温	High and Low Temperature Resistant

发布篇章一

纤·生态律动

CHAPTER ONE

FIBER · ECOLOGICAL RHYTHM

绿色生态，时尚律动。环境关乎民生，环保成就时尚，如今的时尚是主动承担社会责任，为环保代言。中国纤维从消耗环境到与环境和谐发展，奏响从原料到产品的“绿色纤维”交响乐。原料律动，中国纤维采用绿色材料、清洁加工技术，实现可再生资源基因在纤维载体上的延续；制造律动，设计绿色制造体系，实现废旧纺织品的衣衣循环，减少因遗弃或处理带来的环境问题；产品律动，采用无染技术，赋予纤维丰富色彩的同时节能降耗，改变面料、服装加工体系。

Enjoy the green ecology and fashion rhythm. Environment is about people's livelihood, and environmental protection forges the fashion. Now it is the time for fashion to take the initiative to assume its social responsibility and endorse the environmental protection. From the consuming environment to the harmonious development with the environment, Chinese fiber played the "green fiber" symphony from raw materials to the products. In raw material rhythm, Chinese fiber adopts green materials and clean processing technology to realize the continuation of the renewable resource gene on the fiber carrier. In manufacturing rhythm, we have designed the green manufacturing system to realize the clothes circulation of the waste textile and reduce the environmental issues caused by abandonment or disposal. In the rhythm of the product, the non-dyed technology is utilized to endow the fiber with various colors at the same time saves the energy and consequently the fabric and garment processing system change.

生物基纤维
Biologically Based Fiber

代表品牌
Brand

元丝 ORICELL　Incell 瑛|赛|尔　THINCELL 希赛尔　泰纶

推荐理由
Recommendation Reasons

采用清洁生产技术或先进的生物聚合技术，实现可再生基因在纤维载体上的延续，引领绿色消费。融合舒适与时尚标签的新溶剂法再生纤维素纤维原料100% 来源于自然，100% 分解成二氧化碳和水，实现全生命周期的无限轮回；生物基聚酰胺 56 纤维始于我国原创技术，纤维吸湿性好、柔韧性好、耐低温性能好、易染色、本质阻燃。

It adopts cleaner processing technologies or advanced bio-polymerization technologies to fulfill the continuation of renewable gene on the fibrous carriers and lead the green consumption. The new solvent-based regenerated regenerated cellulose fiber is a blend of comfort and fashion, which is 100% natural and able to completely degrade into carbon dioxide and water, enabling endless reincarnation of all life cycles. Bio-based polyamide 56 fibers originated from demestic original technology, which showshigh water absorption, high flexibility, low temperature resistance, easy-dyeing and the essence of the flame retardant.

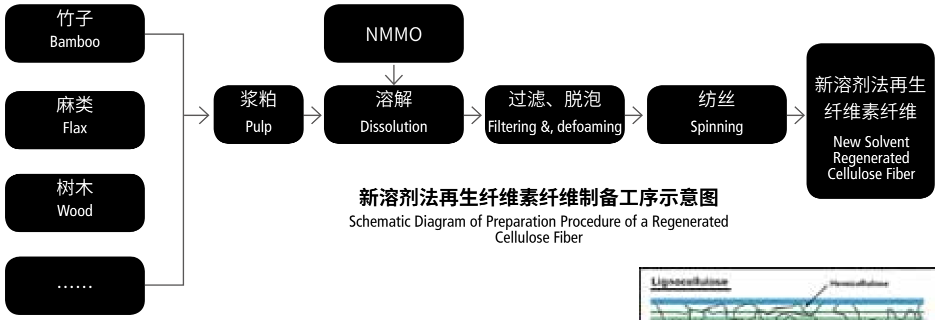
1.1 制备技术
Processing technology

（1）新溶剂法再生纤维素纤维

将再生纤维素溶解于 NMMO/ 水的溶剂体系中，制成再生纤维素溶液，经干喷湿法纺丝制得的新溶剂法再生纤维素纤维。

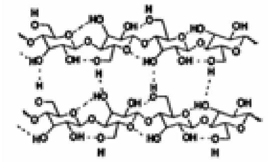
(1) New Solvent RegeneratedRegenerated Cellulose Fiber

The cellulose is dissolved in a solvent system of NMMO / water to prepare a cellulose solution, and then a regeneratedregenerated cellulose fiber prepared by dry- wet spinning.



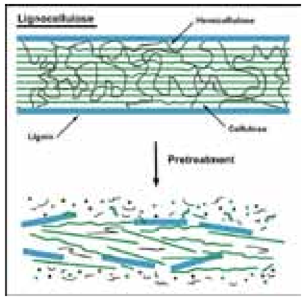
新溶剂法再生纤维素纤维制备工序示意图

Schematic Diagram of Preparation Procedure of a Regenerated Cellulose Fiber



新溶剂法再生纤维素纤维结构

New Solvent Regenerated Cellulose Fiber Structure



新溶剂法再生纤维素纤维预处理

New Solvent Regenerated Cellulose Fiber Pretreatment

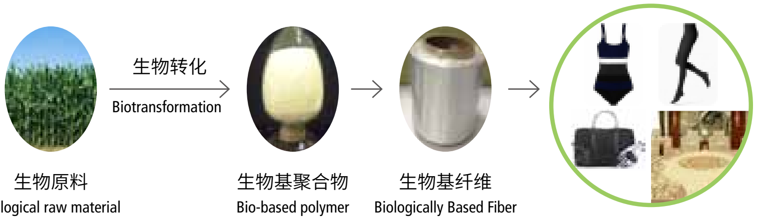
（2）生物基聚酰胺 56 纤维

采用可再生生物基原料，利用生物技术，制备单体原料，再经聚合、熔融纺丝制备得到生物基聚酰胺长丝、短纤或膨体纱。

(2) Bio-Based Polyamide56 Fiber

It utilizes renewable bio-based raw materials to prepare the monomer materials through biotechnology, and then obtain the bio-based polyamide filament, staple fiber or bulked continuous filament by polymerization and melt spinning.

制备示意图
Process of preparation



1.2 纤维及制品特点

Characteristics of Fiber and Product

主要规格：

Main specifications:

（1）新溶剂法再生纤维素纤维

普通棉型：1.11 dtex ～ 1.67dtex

普通中长型：2.20 dtex ～ 3.30dtex

(1) New Solvent Regenerated Cellulose Fiber

Normal cotton type: 1.11 dtex ~ 1.67dtex

Normal Medium-long Type : 2.20 dtex ~ 3.30dtex

纤维横截面

FiberCross-sectionYarn

纱线

Process Flowchart

（2）生物基聚酰胺 56 纤维

短纤：1.65~3.8dtex × 38~76mm（棉型、毛型）；

长丝：FDY、POY、DTY、ATY，22~110 dtex；

地毯用膨体纱（BCF）：556~4400dtex/50-150F

(2) Bio-based polyamide 56 fiber

Staple fiber: 1.65 ~ 3.8dtex × 38 ~ 76mm (cotton type, wool type);

Filament: FDY, POY, DTY, ATY, 22 ~ 110 dtex;

Carpet Bulked Continuous Filament (BCF): 556~4400dtex/50-150F

长丝（FDY）

弹力丝 (DTY)

短纤 (Staple)

膨体纱 (BCF)

标准及认证：

Standards and Certifications:

（1）新溶剂法再生纤维素纤维

《莱赛尔短纤维》（FZ/T52019-2011）

《莱赛尔短纤维》（Q/0783YL001-2015）

(1) New Solvent Regenerated Cellulose Fiber

Lyocell Staple Fiber (FZ/T52019-2011)

Lyocell Staple Fiber (Q/0783YL001-2015)

（2）生物基聚酰胺 56 纤维

参考《锦纶短纤维》（ FZ/T 52002-2012）

《 PA66 切片》（HG/T 4182-2012）

(2) Bio-Based Polyamide56 Fiber

Nylon Staple Fiber (FZ/T 52002-2012)

Nylon66 Chips (HG/T 4182-2012)

纤维性能及制品特点：
Fiber Performance and Product Features:

（1）新溶剂法再生纤维素纤维
New Solvent Regenerated Cellulose Fiber

- 生物基、绿色环保、可生物降解
  Bio-based, green and biodegradable
- 纤维干、湿强度高、吸湿性强、透气性好、亲和舒适
  Fiber has a high dry and wet strengths which is hygroscopic, breathable, affinitive and comfortable.
- 可染性好，易上色，耐水洗，色牢度优良
  Easy to dye and color, resistant to laundry, excellent color fastness
- 织物手感滑爽、类似真丝，原纤化后达到仿桃皮绒效果
  Fabrics feel smooth, and are similar to silk, which are fibrillated to achieve the effect of the peach skin velvet.
- 织物后处理及洗涤尺寸稳定，免烫易打理
  Fabric size remains stable after post-processing and washing, and it is easy to take care, and free of ironing.

新溶剂法再生纤维素纤维与常规再生纤维素纤维性能比较
Comparison of Properties of New Solvent Regenerated Cellulose and Conventional Regenerated Cellulose Fibers

纤维类别 Fiber Category	干强度 Dry Strengthen (cN/dtex)	湿强度 Wet Strength (cN/dtex)	在高档服装应用的舒适度 Comfort in high-end apparel applications
新溶剂法再生纤维素纤维 New Solvent Regenerated Cellulose Fiber	3.50-4.00	3.20-3.70	★★★★★
普通粘胶纤维 Ordinary Viscose Fiber	1.90-2.50	1.10-1.40	★★★★


有棉的柔软
The softness of cotton


环保健康
Environmental Health


有丝绸的舒适
The comfort of silk

（2）生物基聚酰胺 56 纤维
Bio-Based Polyamide 56 Fiber

- 易加工性：熔点接近聚酯，可进行共聚、共混和双螺杆复合纺丝，熔体流动性优良，特别适合纺制超细旦纤维
  Easy to process: Its melting point is close to the polyester, which can be spinned in copolymerization, blending and twin-screw compounding, and is excellent in melt flow, especially suitable for spinning ultrafine fibers
- 吸湿性优良：回潮率 4.5% ~ 6.0%，△ MR ＞ 3.0，吸湿能力是其他聚酰胺纤维的 2 倍
  Good Hygroscopicity: Moisture regain 4.5% ~ 6.0%, MR> 3.0, moisture absorption capacity is 2 times of other polyamide fibers
- 易染色性：常压下低温染色，上色速度快，色牢度高，不易褪色
  Easy to Dye: Suitablefor atmospheric pressure and low temperature dyeing with fast coloring, high color fastness and fading-resistant
- 本质阻燃：纤维及织物的极限氧指数（LOI）＞ 30
  Inherently Flame retardant: Limit Oxygen Index (LOI)> 30 for fibers and fabrics

生物基聚酰胺 56 纤维物理指标
Physical Properties of Bio-Based Polyamide 56 Fiber

性能 Physical Properties	全牵伸丝 FDY Full Draw Yarn FDY	加弹丝 DTY Draw Texturing Yarn DTY	短纤维 Staple fiber	膨体丝 BCF Bulked Continuous Filament BCF
断裂强度 (cN/dtex) Break Load (cN/dtex)	4.0-5.5	3.5-5.0	3.5-5.5	1.9-2.5
断裂伸长 (%) Elongation at Break (%)	25-55	25-50	35-65	40 ± 15
沸水收缩 (%) Shrinkage in Boiling Water (%)	8-12	4-10	—	9-11
公定回潮率 (%) Rate of Moisture Regain (%)	4.5-6.0	4.5-6.0	4.5-6.0	4.5-6.0
弹性回复（10% 形变） Elastic Recovery（10% Deformation)	100	100	—	—
耐磨性能 Abrasion Resistance	★★★★☆	★★★★☆	★★★★☆	★★★★☆

备注：强伸度参照标准 GB/T 14344，回潮率参照标准 GB/T 6503
Note: Stretch referencestandard GB/T14344, moisture regain reference standard GB / T 6503

1.3 应用技术

Application Technology

（1）新溶剂法再生纤维素纤维

染色技术：中温活性染料雷玛素染料最适合染色。

纺纱技术：纺纱时加适量的增磨剂有助于增加纤维的抱合力及可纺性。复精梳、纺纱时注意轻定量、小牵伸、慢车速，避免纤维缠结形成毛粒。蒸纱温度低于 90°C，时间小于 20min。

(1) New Solvent Regenerated Cellulose Fiber

Dyeing technology: the temperature reactive dyes Remazol are the most suitable for dyeing.

Spinning technology: Spinning with an appropriate amount of grinding aid helps to increase the cohesion and spinnability of the fibers. When recombing and spinning, pay attention to light qualification, small drawing and slow speeding to avoid the formation of the entangled hair fibers. Yarn steaming temperature is less than 90°C for less than 20min.

(2) 生物基聚酰胺 56 纤维

短纤可以和棉花，羊毛以及其他合纤混纺，能够有效增强面料的稳定性。采用低温染色，易染深色，色牢度高。

(2) Bio-Based Polyamide 56 Fiber

Staple fiber can be spun with cotton, wool and other blended fibers, which effectively enhances the stability of the fabric. It adopts the low temperature dyeing, suitable for dark dying with a high color fastness.

1.4 纤维应用

Fiber Application

（1）新溶剂法再生纤维素纤维

用于高档时装、内衣、牛仔、家纺、医卫用品以及婴幼儿用品等。

(1) New Solvent Regenerated Cellulose Fiber

For high-end fashion, underwear, jeans, home textiles, medical supplies and baby supplies.

（2）生物基聚酰胺 56 纤维

适用于各类高档服装、功能性防护服装、裤袜及各种背包、帐篷、地毯等家用产品。

(2) Bio-Based Polyamide 56 Fiber

Applicable to various high-end clothing, functional protective clothing, pants, socks and various backpacks, tents, carpets and other household products.

Q&A

Q：新溶剂法再生纤维素纤维的性能优势与其它生物基纤维相比体现在什么地方？

A: 新溶剂法再生纤维素纤维采用新型溶剂体系，溶剂安全、绿色环保、对环境及人体无害。纤维优异的力学性能，使其应用更加广泛。

Q: What are the performance advantages of Lyocell fibers compared to other bio-based fibers?

A: Lyocell fiber uses a new solvent system. The solvent is safe and environmentally protective, and harmless to the environment and human. It has excellent mechanical properties, making it more widely used.

Q：生物基聚酰胺 56 纤维已经连续 2 年入围中国纤维流行趋势，请问这几年来，纤维产品在技术、性能上是否有新的突破？

A: 生物发酵工艺越来越稳定，生物基单体的纯度提高、聚合物品质稳定，纤维性能与染色均匀性提升。目前产品已与内衣品牌、运动户外品牌、地毯品牌、时尚家居品牌等建立了供应链协作体系。

Q: Bio-based polyamide 56 fiber has been selected by China's fiber trend for two consecutive years. Is there any new breakthrough in technology and performance of fiber products in recent years??

A: The biological fermentation process is more and more stable, and the purity of the bio-based monomer is improved, and the quality of the polymer is stable, and the fiber performance and dyeing uniformity have been improved. At present, the products have established supply chains and cooperation lines with underwear, sports outdoor, carpet, fashion home brands and so on.

循环再生无染聚酯纤维

Recycled Spun-dyed Polyester Fiber

代表品牌
Brand

绿宇环保 GRERIAL
JIAREN NEW MATERIALS

推荐理由

Recommendation Reasons

以废旧纺织品及聚酯废品为原料，充分利用废旧资源中的颜色，结合纺前着色技术，实现高值化开发和纤维到纤维、面料到面料的闭环循环。应用领域拓展到服装、家纺等领域。

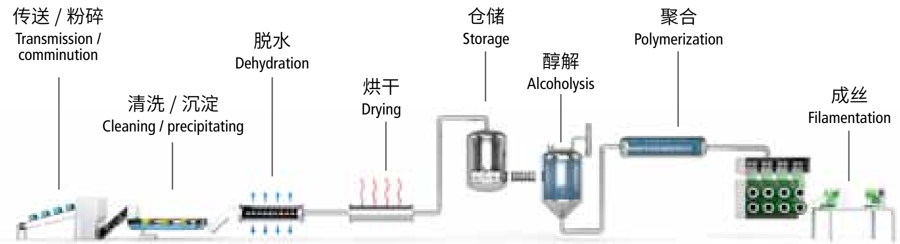
Using waste textiles and polyester waste as raw materials, it fully uses the color of waste resources, combining the spun-dyed technology, to achieve high value of development and the closed loopcircle of the fiber to fiber and fabric to fabric. Applications have been extended to clothing, home textiles and other fields.

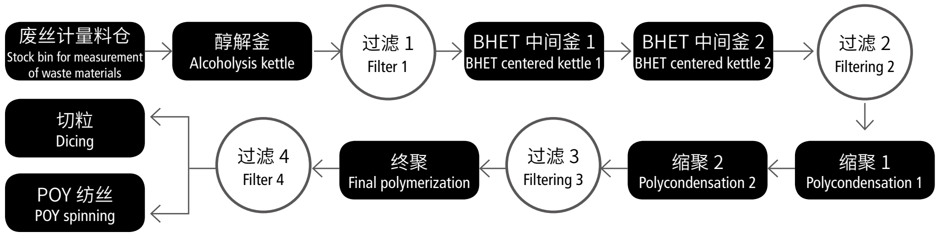
2.1 制备技术

Preparation Technology

聚酯废丝、废块、废边丝等原料经破碎、配重后进行醇解，醇解后的单体及低聚物经酯化、过滤、缩聚得到再生聚酯熔体或者切片，也可直接醇解为 BHET(对苯二甲酸双羟乙酯)，经缩聚得到聚酯熔体或切片；通过在线添加工艺实现原液着色和液相增粘，最后进行熔体直纺或切片纺丝制备差别化再生聚酯长丝。

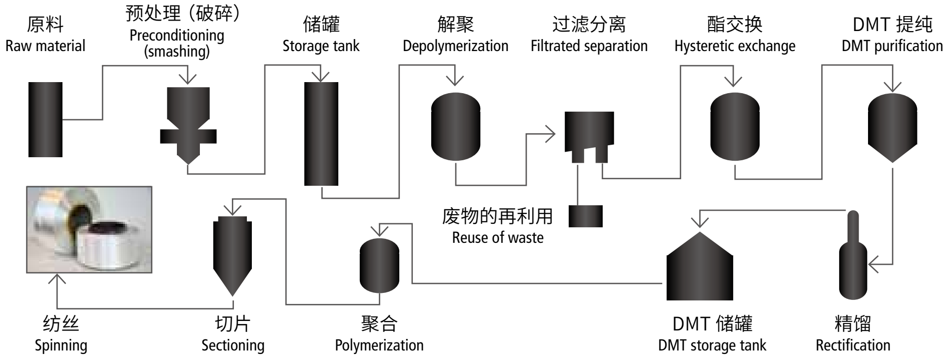
Waste polyester fiber, scrap pieces, scrapfeiber and other raw materials after crushing and weighting will be alcoholyzed to generate the monomers and oligomers which will be made into recycled polyester melt or chips by esterification, filtration and polycondensation, or they can be directly alcoholyzed as BHET (bis-hydroxyethyl terephthalate), to obtain a polyester melt or chips by polycondensation; another pathway is through the online addition process to achieve the dope dyeing and liquid state polycondensation, and then to obtain the differentiated recycled polyester filaments by melt or chip spinning.





化学法—BHET 路线

Chemical Method - BHET route



化学法——DMT 路线

Chemical Method - DMTroute

2.2 纤维及制品特点
Fiber and Product Features

主要规格：
Main Specifications:

品种 Type	规格 Specifications	颜色 Colors	色牢度 Color Fastness
POY、DTY	33D~600dtex/36-576F	黑、白等 Black, white and so on	4.5 级 Grade 4.5
FDY	22~600dtex/24-192F		4.5 级 Grade 4.5


循环再生 POY 长丝
Recycled POY Filament


循环再生 DTY 长丝
Recycled DTY Filament


循环再生 FDY 长丝
Recycled FDY Filament

标准及认证：
Standards and Certifications:

《再生涤纶牵伸丝》(FZ/T 54048-2012)
《再生涤纶预取向丝》(FZ/T 54046-2012)
Intertek 绿叶标志、Oeko-Tex Standard 100、GRS 认证
Regenerated Polyester Drawn Yarns (FZ/T 54048-2012)
Regenerated Polyester Partially Oriented Yarns (FZ/T 54046-2012)
Intertek Green Leave Mark, Oeko-Tex Standard 100 and GRS certification

纤维性能及制品特点：
Fiber Properties and Product Features:

- 使用原液着色技术，绿色环保，无二次污染
  The use of dope dyeing technology is environmentally friendly without secondary pollution
- 色彩持久、色牢度高
  The color lasts longer with a high color fastness
- 纤维品质高，可部分替代原生纤维
  High fiber quality, and it can partially replaces the virgin fiber

2.3 应用技术
Application Technology

可直接用于机织或针织、梭织、经编等各类织物，开发平布类、绒布类、摇粒绒、涤塔夫等风格面料。

Can be directly used for weaving or knitting, woven, warp and other types of fabric to develop the flat cloth, flannel, fleece, polyester taffeta and other fabrics.

2.4 纤维应用
Fiber Applications

服装：运动服、户外服饰等
家纺用品：被套、枕套、床单、窗帘等
户外用品：野营帐篷、背包等
Clothing: sportswear, outdoor clothing, etc
Home Textiles: quilt cover, pillowcase, bed sheets, curtains, etc
Outdoor supplies: camping tents, backpacks, etc

Q&A

Q：废旧衣服怎样进行回收处理?

A: 目前废旧衣服的回收渠道包括以下几个方面：(1) 以政府机关、企业为代表的社会回收；(2) 以公安系统、学校、从事纺织与服装制造企业为主的定向回收；(3) 利用网上预约回收衣物平台；(4) 公益团体组织的回收。

Q: How do you recycle the used clothes?

A: At present, the recycling channels for used clothes include the following aspects: (1) Social recovery represented by government organs and enterprises; (2) Directional recycling mainly by public security system, schools and textile and garment manufacturing enterprises ; (3) Make use of online booking to recycle clothing platform; and (4) Recycle organized by public welfare organizations.

发布篇章二

纤 · 科技跃升

CHAPTER TWO

FIBER · TECHNOLOGICAL UPGRADE

科技为本、产业跃升。科技创造时尚，在时尚中彰显科技之美。中国纤维科技不断跃升，打造新产品，创造新未来。聚酯生态催化技术跃升，中国纤维致力纤维内生科技，通过绿色催化，开辟了聚酯纤维生态化发展的新篇章；石墨烯功能改性技术跃升，纤维与纳米科技融合发展，“石墨烯 + 纺织”让石墨烯从实验室走进百姓生活，实现了石墨烯在纤维领域的规模化应用。

We build up the concept of technology oriented to promote industrial upgrade. Science and technology creates fashion and reveals its beauty in the trend. The science and technology of Chinese fiber rises continuously, new products have been created and a new future is being opened. With the upgrade of polyester ecological catalysis technology a new chapter in the ecological development of polyester fiber is opened. Based on the technology upgrade of graphene functional modification, "graphene + textile " walks the graphene from the laboratory into people's lives to achieve its scale application of the graphene in the fiber applications..

新型生态催化聚酯纤维

New eco-catalytic polyester fiber

代表品牌
Brand

推荐理由

Recommendation Reasons

在大容量聚合工艺及装置的基础上，采用新型生态催化剂，印染织造过程中无重金属析出，绿色环保、安全。特别适用于内衣、婴幼儿服装领域的应用。

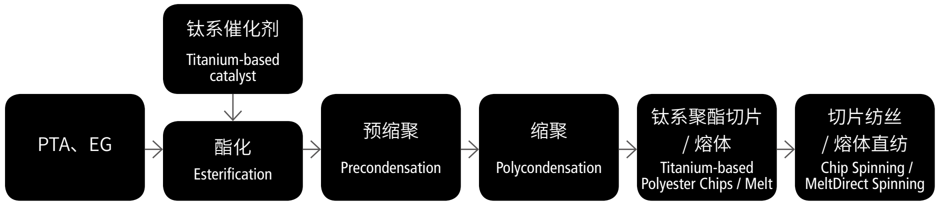
Based on high-capacity polymerization process and equipment, and addition of a new type of ecological catalyst, no heavy metal is precipitated during the fiber printing, dyeing and weaving process, which is environmentally friendly and safe, particularly suitable for underwear and baby clothing.

3.1 制备技术

Preparation Technology

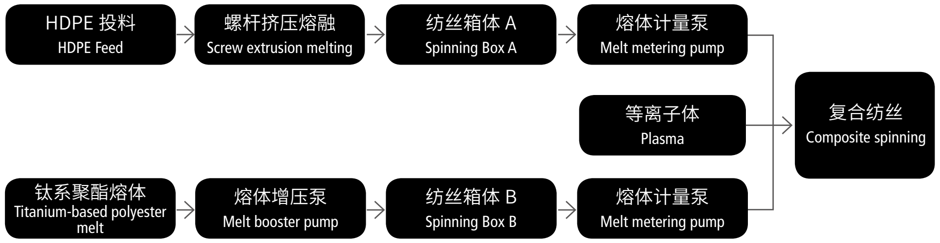
在聚合的过程中加入钛系催化剂，在 250°C下酯化成低聚物，然后在 280°C下缩聚成高聚合度的聚酯，经纺丝后得到钛系聚酯纤维。

Titanium-based catalyst was added during the polymerization, esterified into oligomer at 250 ° C, and then polycondensed into polyesters of high degree of polymerization at 280 ° C to obtain titanium-based polyester fibers after spinning.



钛系聚酯纤维制备流程图

Flow Chart of Titanium-Based Polyester Fiber Preparation



皮芯复合钛系聚酯纤维制作流程图

Flow Chart of Sheath-Core Titanium Polyester Composite Fiber Production

3.2 纤维及制品特点

Characteristics of Fiber and Products

主要规格：
Main Specifications:

钛系聚酯长丝：55-167dtex/36-144 F

钛系聚酯短纤：1.33~1.56dtex × 32/38mm

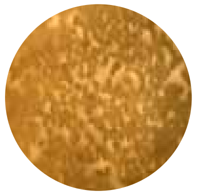
皮芯复合钛系聚酯短纤：2.38dtex × 38mm，皮层为 PE、芯层为钛系 PET

Titanium Polyester Filament:55-167dtex/36-144 F

Titanium Polyester staple Fiber:1.33~1.56dtex×32/38mm

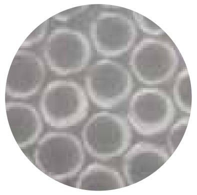
Sheath-Core Composite Titanium Polyester Fiber:2.38dtex×38mm, Sheath is referred as PEand the core is Titanium PET.

钛系聚酯长丝
Titanium Polyester Filament



钛系聚酯长丝截面图
Cross-Section of Titanium Polyester Filament

皮芯复合钛系聚酯短纤
Sheath-Core Titanium Composite Polyester Staple Fiber



皮芯复合钛系聚酯短纤截面图
Cross Section of Sheath-Core Titanium Composite Polyester Staple Fiber

标准及认证:
Standards and Certifications:

《纺织品重金属的测定》(GB/T 17593-2006)

《聚乙烯 / 聚对苯二甲酸乙二醇酯 (PE/PET) 复合短纤维》(FZ/T 52034-2014)

通过 OEKO-TEX Standard 200-2010、ISO 9001、ISO 14001 等认证

Determination of heavy metals in textiles (GB / T 17593-2006)

Polyethylene / polyethylene terephthalate (PE / PET) composite staple fibers (FZ / T 52034-2014)

Certified by the OEKO-TEX Standard 200-2010, ISO 9001 and ISO 14001

纤维性能及制品特点:
Fiber properties and product features:

- 绿色环保、纤维自身不含重金属
  Environmentally friendly, and fiber itself does not contain heavy metals.
- 聚合效率高，纤维品质好
  High polymerization efficiency and good fiber quality.
- 后道染整处理无重金属析出
  No heavy metal is precipitated after dyeing and finishing

3.3 应用技术
Application Technology

产品坯布需单独印染，染整工艺与常规涤纶相同。

皮芯复合钛系聚酯短纤梳理成网后，利用烘燥设备的热风穿透纤网，使之受热并粘合形成热风非织造布。

Fabric should be printed and dyed in a separate manner with the same dyeing and finishing process of the conventional polyester.

After the skin core composite titanium polyester staple is combed into the net, the hot air of the drying equipment is used to penetrate the fiber net, so that it is heated and glued into the hot air nonwovens.

3.4 纤维应用
Fiber Applications

孕妇服装、婴幼儿用品、妇女卫生用品、成人失禁品、衬衫、牛仔面料、麂皮、面膜以及对重金属有严格限制的高端面料

For maternity clothes, baby products, feminine hygiene products, adult incontinence products, shirt, jeans fabric, chamois, mask, and the high-end fabrics that have strict limits on heavy metals.

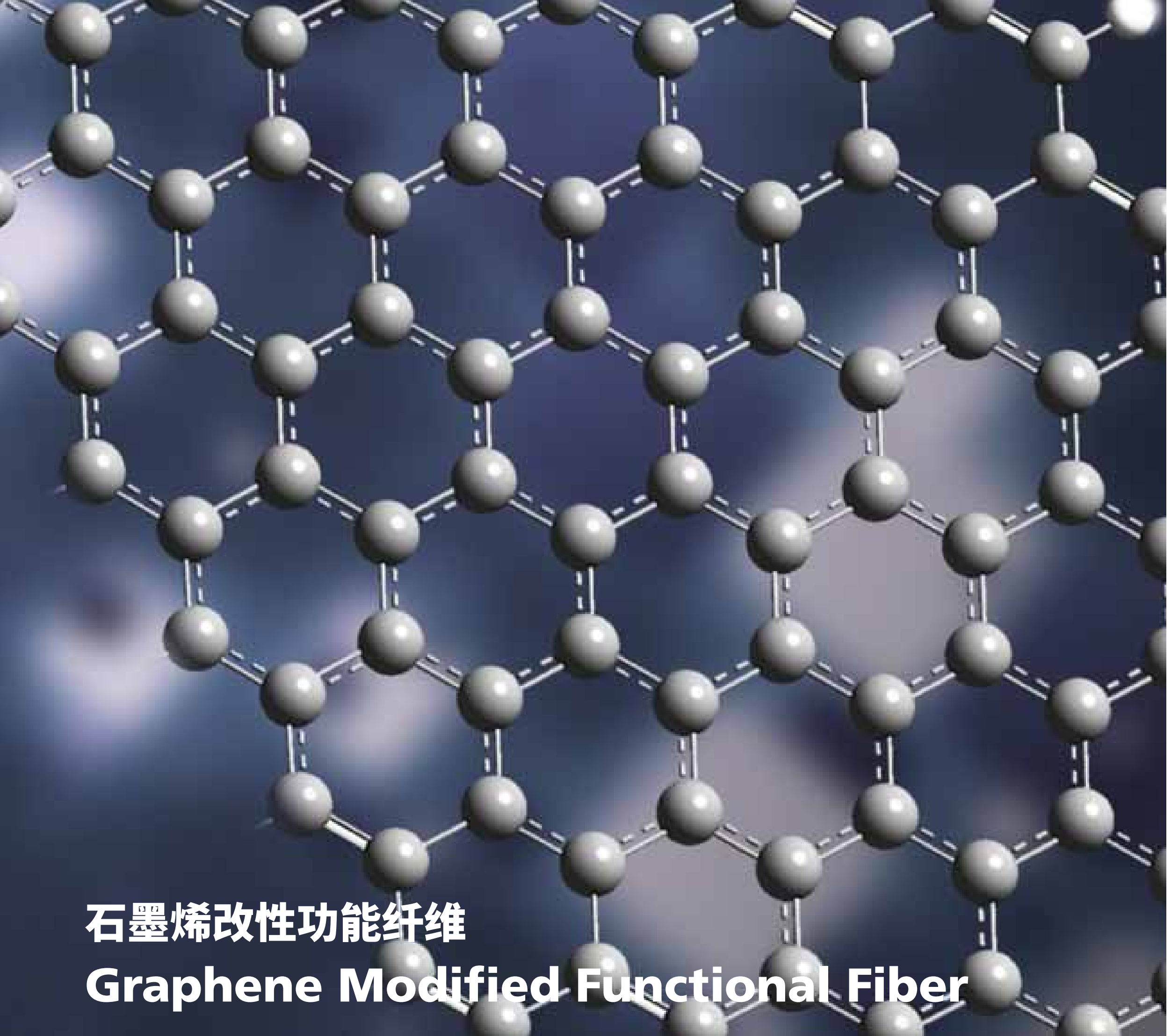
Q&A

Q：从市场和消费者角度，钛系聚酯的优点体现在哪里?

A: 以欧盟为代表的发达国家越来越多的将能否达到绿色纺织品标准作为进入市场的条件，加贴生态标志的商品更受市场欢迎。钛系聚酯采用新型生态催化剂，下游制造和贴身穿着过程中没有重金属析出，不会对环境和人体造成危害，符合生态趋势。

Q: From the market and consumer perspectives,what are the advantages of the titanium polyester?

A: More and more developed countries represented by the EU will set the qualification of meeting the green textile standards as a condition to enter the market. The eco-labeled products are more welcomed by the market. Titanium polyester adopts a new type of ecological catalyst. No heavy metal is precipitated during its downstream manufacturing and wearing, posing no harm to the environment and human body, which is in line with the ecological trends.



石墨烯改性功能纤维
Graphene Modified Functional Fiber

代表品牌
Brand

Healfiber 闲服 KYORENE 烯/纳/斯 PHENAX

推荐理由
Recommendation Reasons

将利用生物质原料或石墨制备出单层率高、片层厚度小的石墨烯，通过共混或共聚与各类化纤复合，制备出高分散、高取向的石墨烯复合功能性纤维，实现低温远红外、抑菌、防紫外、抗静电等复合功能一体化。石墨烯改性功能纤维的规模化生产，带动了石墨烯在高端健康纺织品领域的商业化应用。

Graphene with high single-layer rate and low lamellar thickness is prepared from biomass raw material or graphite, and its composite functional fiberwith highly dispersed and highlyoriented graphene in matrix is prepared by blending or copolymerization with various of chemical fibers, which integrate the complex functions such as low temperature far infrared, bacteriostasis, UV protection and antistatic effects.Large-scale production of graphene-modified fibersleads to the commercial application in the field of high-end healthy textiles.

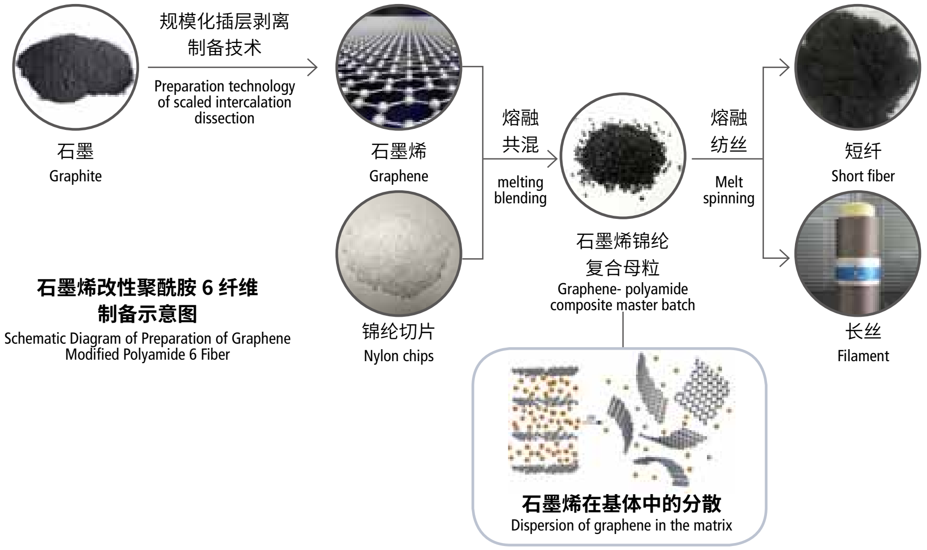
4.1 制备技术
Preparation Technology

采用气相沉积法、化学剥离法、基团配位组装法等技术制备出单层率高的石墨烯，再将石墨烯与不同的基体制备成石墨烯功能母粒，经在线添加与聚乳酸切片、聚酰胺切片等共混纺丝制备出石墨烯功能纤维。

另外，还可将石墨烯与己内酰胺原位聚合，制备石墨烯改性的聚酰胺 6 切片，经熔融纺丝制得石墨烯改性聚酰胺 6 纤维，该纤维更具有低吸湿、高强低伸等物性特点。

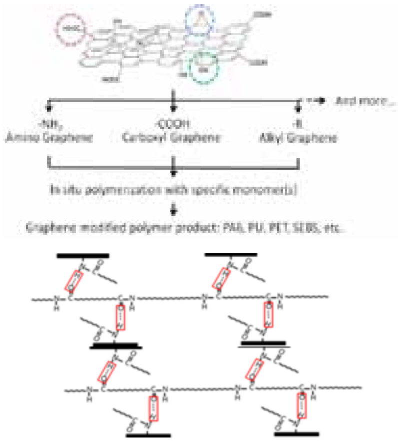
Graphene withhigh monolayer rate can be prepared by physical vapor deposition, chemical exfoliation method and group-coordination assembly method. Then, the obtainedgraphene is composited with different matrix to prepare graphene functional masterbatch, andthe graphene functional fibers is produced through online adding method, blended spinning with polylactic acid and polyamide chips.

In addition, graphene can also be in situpolymerized with caprolactam to prepare graphene-modified polyamide 6 chip, and graphene-modified polyamide 6 fiber is prepared by melt spinning, which has more advantages of low moisture absorption, high strength, low elongation and other physical characteristics.



石墨烯改性聚酰胺 6 纤维制备示意图
Schematic Diagram of Preparation of Graphene Modified Polyamide 6 Fiber

生物质石墨烯制备路线
Preparation Route of Biomass Graphene



原位聚合石墨烯聚酰胺 6 纤维的示意图
Schematic Diagram of In-situ Polymerized Graphene Polyamide 6 Fiber

4.2 纤维及制品特点
Fiber Properties and Product Features

主要规格：
Main Specifications:

石墨烯（生物质）改性聚乳酸纤维：1.56dtex × 38mm

石墨烯改性聚酰胺 6 纤维: 1.5dtex × 38mm(短纤)、70dtex/24F(长丝)

Graphene (biomass) modified polylactic acid fiber: 1.56 dtex × 38 mm

Graphene-modified polyamide 6 fiber: 1.5dtex×38mm(staple fiber)，70dtex/24(Ffilament)


石墨烯（生物质）改性聚乳酸纤维
Graphene (biomass) modified polylactic acid fiber


石墨烯改性聚酰胺 6 纤维
Graphene-modified polyamide 6 fiber

标准及认证：
Standards and Certificates:

（1）石墨烯（生物质）改性聚乳酸纤维

《石墨烯改性聚乳酸纤维》（Q/370000JSQ 034-2018）

（2）石墨烯改性聚酰胺 6 纤维

《锦纶 6 弹力丝》（FZ/T 54007-2009）

《锦纶短纤维》（FZ/T 52002-2012）

(1) Graphene (biomass) modified polylactic acid fiber

Graphene modified polylactic acid fiber (Q/370000JSQ 034-2018)

(2) Graphene-modified polyamide 6 fiber

Polyamide 6 Draw Textured Yarns (FZ/T 54007-2009)

Nylon Staple Fiber(FZ / T 52002-2012)

纤维性能及制品特点：
Fiber Properties and Product Features:

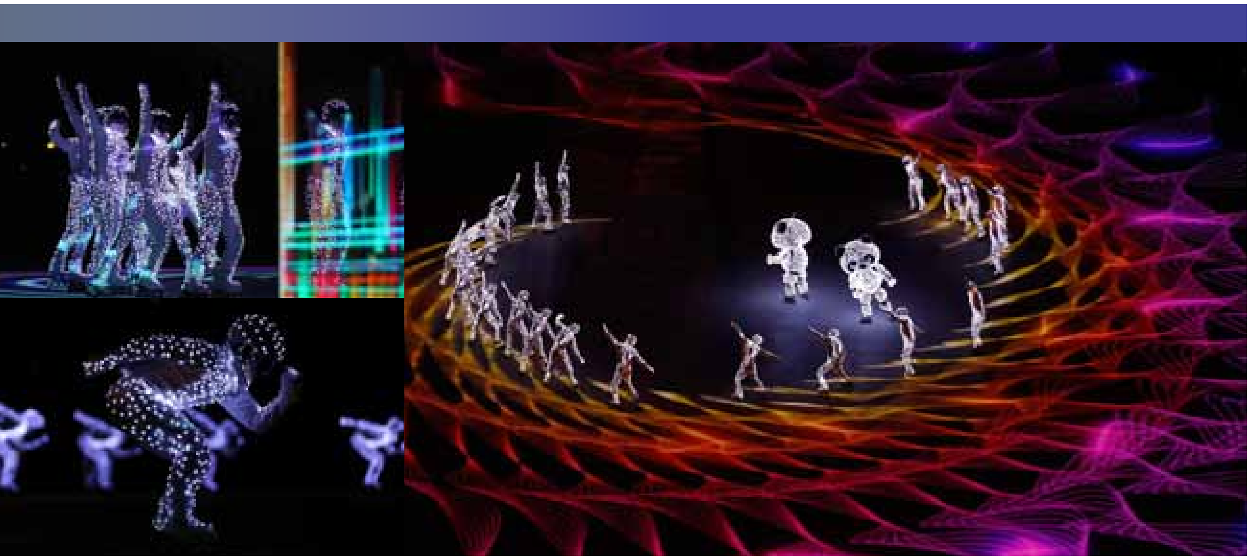
- 低温远红外：促进微循环，远红外发射率 0.88，远红外辐射温升≥ 2.8
  Low temperature far infrared: promote microcirculation, the far infrared emissivity is 0.88, and the far infrared radiation temperature rise ≥2.8
- 抑菌防螨：自洁养肤，防螨率≥ 94.9%
  Anti-mite and antibacterial: nurture the skin and self-clean with an anti-mite rate ≥94.9%
- 抗静电：有利于皮肤生物电平衡
  Antistatic: conducive to skin bioelectric balance
- 阻燃：通过凝聚相阻燃机理，石墨烯可在纤维基体表面形成致密的保护炭层，隔绝热量、气体，实现阻燃效果
  Flame Retardant: Based on the mechanism of the coherent phase flame retardant, graphene can form a dense protective carbon layer on the surface of the fiber matrix to isolate the heat and gases to achieve the flame retardant effect
- 抗紫外：紫外线防护系数 UPF ≥ 105
  UV Protection: UV protection factor UPF ≥ 105

石墨烯（生物质）改性聚乳酸纤维抑菌指标
Antibacterial Properties of Graphene (Biomass) Modified Polylactic Acid Fiber

	大肠杆菌抑菌率 E. coli antibacterial rate	金黄色葡萄球菌抑菌率 Staphylococcus aureus antibacterial rate	白色念珠菌抑菌率 Candida albicans antibacterial rate
洗前 Before	＞ 98%	＞ 99%	＞ 98%
洗后 50 次 After 50 times wash	＞ 98%	＞ 99%	＞ 98%

石墨烯（生物质）改性聚乳酸纤维远红外指标
Far Infrared Performance of Graphene (Biomass) Modified Polylactic Acid Fiber

序号 No.	检测项目 Item	标准参数 Reference	实测指标 Value
1	远红外发射率 Far infrared emissivity (%)	≥ 0.8	0.88
2	远红外辐照温升 Far infrared radiation	≥ 1.4	2.3



4.3 应用技术

Application Technology

建议功能性石墨烯改性纤维用量≥ 50%，以保证面料达到明显功能效果。

Proposed dosage for functional graphene modified fiber ≥ 50% to ensure that the fabric achieves its significant functional effect..

4.4 纤维应用

Fiber Application

可用于特殊防护服装、健康护理服装、医疗护理用品及家纺领域。

It can be used for special protective clothing, health care clothing, medical care products and textile fields.

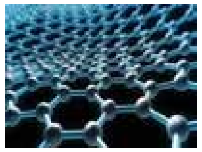
Q&A

Q：石墨烯改性纤维中的石墨烯结构是什么？是否石墨烯都是单层结构？

A: 石墨烯是一种二维碳材料，包括单层、双层和多层石墨烯。单层石墨烯指由一层以苯环结构（即六角形蜂巢结构）周期性紧密堆积的碳原子构成的一种二维碳材料。双层及多层石墨烯指由 2 层或 3 至 10 层以苯环结构周期性紧密堆积的碳原子以不同堆垛方式堆垛构成的一种二维碳材料。根据工艺路线不同，石墨烯层数有所差别，层数越低，技术难度越大。

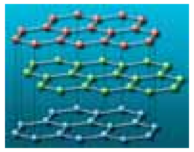
Q: What is the graphene structure in graphene-modified fiber? Are they mono-layers?

A: Graphene is a two-dimensional carbon material including single layer, double layer and multi-layer graphene. Monolayer graphene refers to a two-dimensional carbon material consisting of a layer of carbon atoms that are periodically closely packed in a benzene ring structure (ie, a hexagonal honeycomb structure). Double-layer and multi-layer graphene refer to two-dimensional carbon materials composed of two or three to ten layers of carbon atoms periodically packed closely in a benzene ring structure stacked in different stacking ways. Depending on the process routes, the number of graphene layers is different. The lower the number of layers is, the greater the technical difficulty will be



单层石墨烯
mono-layer grapheme

双层石墨烯
Bilayer graphene



多（少）层石墨烯
Multi-layer graphene
（层间以范德华力结合）
(Van der Waals force between the layers)

发布篇章三

纤 · 匠心品牌

CHAPTER THREE

FIBER · ELABORATE BRAND

传承匠心，铸就品牌。中国纤维以极致、专注、创新的“匠心精神”精雕细琢，保证每一批、每一束、每一根纤维的品质，树立我国化纤业“以质取胜、科技领先”的良好国际形象，推动中国产品向中国品牌转变。追求质之精，中国纤维巧妙融合织态结构，在动与静、快与慢之间释放纤维刚柔保形之美；致力需之致，不忘初心，始终坚持对卓越品质的不懈追求，易纺纤维、即可弃纤维致力于下游客户的个性化加工及消费者的使用便捷。

The craftsmanship should be passed down to build our brands. Chinese fiber works with its perfection spirit in the finest, focused and innovative manner to ensure the fiber quality and set an excellent international image of "winning by quality and leading by science and technology" for Chinese Fiber Industry and promote the transformation of Chinese products to Chinese brands. In the pursuit of quality essence, Chinese fiber takes advantage of the texture structure to create the resilient beauty between the dynamic and static as well as fast and slow states. We are committed to be users' need, and cherish the original aspiration, always adhering to the relentless pursuit of quality. Easy spinning fiber and disposable fiber target the personalized processing of the downstream customers and the consumer convenience.

抗形变纤维
Deformation Resistance Fiber

代表品牌
Brand

推荐理由
Recommendation Reasons

针对纤维及织物变形机理和特点，从分子结构、纤维成分上进行设计，采用同质异构、双组份、合股等手段调控纤维结构，满足纤维抗皱、抗拉、抗压等性能，改进优化或简化工艺，提高织物保形效果。产品体系从聚酯拓展到聚丙烯腈，满足不同领域应用要求。

According to the deformation mechanisms and the characteristics of the fiber and fabric, the fiber is designed based on the molecular structure and fiber composition, and the fiber structure is controlled by the methods of isomerization, bicomponent and plying, which can meet the requirements of anti-wrinkle, stretch resistant, and stress resistant properties. The deformation resistance of fabric can be enfornced by improving or simplifying the process. Product system spreads from polyester to polyacrylonitrile to meet the application requirements in different fields

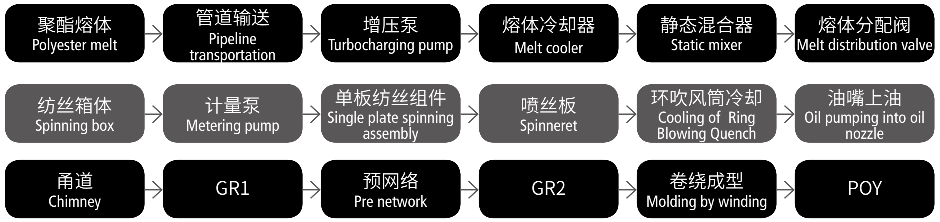
5.1 制备技术
Preparation Technology

（1）阳涤高弹复合聚酯纤维：在加弹工序将阳离子聚酯纤维与 H400 复合制备出高弹复合聚酯纤维，而 H400 由 PET 和 PTT 复合而成，利用两种组分不同的收缩性能，使纤维形成永久的弹簧状卷曲。

High elastic composite polyester fiber: In texturing, cationic polyester fiber and H400 compound were prepared into high elastic composite polyester fiber, while H400 was made of PET and PTT composite. By the use of the different shrinkage properties of the two components, the fiber can form permanent spring-like coil.

（2）细旦多孔蓬松聚酯纤维：在常规聚酯纤维的生产路线上采用低温高透环吹冷却、低摩擦油嘴上油、卷绕成型等特殊工艺制备。

Fine denier porous fluffy polyester fiber: special making techniques including low temperature high-permeability circulating blowing, low friction nozzle oiling and winding molding were employed in the conventional production line of the polyester fiber.



细旦多孔蓬松聚酯纤维工艺流程
Flow chart of Fine denier porous fluffy polyester fiber

（3）高弹性模量聚丙烯腈纤维：将丙烯腈和醋酸乙烯两种原料经特殊聚合，用制得的聚合物进行原液制胶，再通过凝固成型，纺丝干燥、高压定型、切断打包等生产工艺制得。

High elastic modulus polyacrylonitrile fiber: Acrylonitrile and vinyl acetate polymerized through special methods, and the resultant polymers were made into the liquid glue, and then obtain the final products through the solidification molding, spinning drying, high-pressure molding, cutting and packaging and other production processes.

5.2 纤维及制品特点
Fiber and Products Features

主要规格:
Main Specifications:

（1）阳涤高弹复合聚酯纤维：111dtex/108F、122dtex/108F
（2）细旦多孔蓬松聚酯纤维：278dtex/350F
（3）高弹性模量聚丙烯腈纤维：1.65~6.66dtex

High Elastic Composite Polyester Fiber: 111dtex / 108F, 122dtex / 108F
Fine Denier Porous Fluffy Polyester: 278dtex / 350F
High Elastic Modulus Polyacrylonitrile Fiber: 1.65 ~ 6.66dtex

标准及认证：
Standards and Certifications:

（1）阳涤高弹复合聚酯纤维：

《聚对苯二甲酸丙二醇酯 / 聚对苯二甲酸乙二醇酯（PTT/PET）复合弹力丝》（FZ/T 54041-2011）

《阳离子染料可染改性涤纶低弹丝》（FZ/T 54067-2013）

(1) High Elastic Composite Polyester Fiber:

Polytrimethylene Terephthalate / Polyethylene Terephthalate (PTT / PET) Composite Elastic Yarn (FZ / T 54041-2011)

Cationic Dyeable Modified Polyester Drawn Textured Yarns (FZ/T 54067-2013)

（2）细旦多孔蓬松聚酯纤维：

《涤纶预取向丝》（FZ/T 54003-2012 ）

(2) Fine Denier Porous Fluffy Polyester:

Polyester Partially Oriented Yarns (FZ/T 54003-2012)

（3）高弹性模量聚丙烯腈纤维：

《腈纶短纤维和丝束产品标准》（GB/T16602-2008）

(3) High Elastic Modulus Polyacrylonitrile Fiber:

Acrylic Staple and Tow (GB/T16602-2008)

阳涤高弹复合聚酯纤维

High elastic modulus polyester fiber

细旦多孔蓬松聚酯纤维

Fine denier porous fluffy polyester fiber

高弹性模量聚丙烯腈纤维

High elastic modulus polyacrylonitrile fiber

纤维性能及制品特点：
Fiber Properties and Product Features:

（1）阳涤高弹复合聚酯纤维：

- 弹性持久、双色效果、悬垂性好、尺寸稳定性好，手感滑爽（卷曲收缩率≥ 25%，沸水收缩率≥ 6.0%）

High elastic composite polyester fiber: durable elasticity, two-color effect, good draping, excellent dimensional stability and smooth (coil shrinkage ≥ 25%, boiling water shrinkage ≥ 6.0%)

（2）细旦多孔蓬松聚酯纤维：

- 超细、柔软、蓬松回弹性好、吸湿透气、色泽温润。单丝纤度细，接触表面积大，故加弹后所织织物具有良好的柔软性及吸湿快干效果

Fine denier porous fluffy polyester fiber: ultra-fine, soft, fluffy and good elasticity, hygroscopic, breathable and warm color. Fine monofilament, bigger contact surface area, and the textured fabric has good softness and quick drying effect of moisture absorption

（3）高弹性模量聚丙烯腈纤维：

- 膨松柔软、手感滑爽、回弹性好、抗起球抗静电。（断裂强度≥ 3.0cN/dtex，断裂伸长≤ 40%，弹性模量≥ 0.5cN/dtex，高于普通湿法腈纶 50% 以上）

High elastic modulus polyacrylonitrile fiber: bulk soft, smooth, good resilience, elasticity and anti-static. (Breaking strength ≥ 3.0 cN / dtex, elongation at break ≤ 40%, modulus of elasticity ≥ 0.5 cN / dtex, higher than ordinary wet acrylic: 50% or more)

5.3 应用技术

Application Technology

（1）阳涤高弹复合聚酯纤维 :

织造：梭织牵经车速 400m/min 以下，织机车速 450m/min 左右，纬编圆机车速：18 转 / 分钟。

染整 : 可单染阳离子纤维部分，也可阳离子涤纶双染，若要实现明显的双色效果，涤纶部分染色时不建议使用分散性染料。

High elastic composite polyester fiber:

Weaving: tatting and picking speed is 400m/min or less, and weaving machine speed is 450m/min or so, weft knitting machine speed is 18 r/ min.

Dyeing and finishing: either cationic fiber part can be solely dyed, or cationic polyester can be double dyed, if you want to achieve the obvious two-color effect, polyester part dyeing is not recommended to use the disperse dyestuff.

（2）超细柔绒蓬松纤维：

加弹上热箱温度和下热箱温度比常规品种低 10° C 左右，DY 比 K 值比常规低 20% 左右，牵伸一定要拉足，保证染色均匀。

Superfine fleece fluffy fibers:

the temperature of the upper and lower texturing and heating box is about 10 ° C lower than that of the conventional ones, and DY/K is lower than the conventional ones by about 20%. The drawing must be fully performed to ensure the uniform dyeing.

（3）高弹性模量聚丙烯腈纤维：

纺纱生产和染整、织造、后整理参照常规的湿法腈纶。

High elastic modulus polyacrylonitrile fiber:

spinning production, dyeing, weaving and finishing reference to conventional wet acrylic.

5.4 纤维应用

Fiber Application

（1）阳涤高弹复合聚酯纤维：

男装、运动休闲面料

High-elastic composite polyester fiber: men's wear, sports and leisure fabrics

（2）细旦多孔蓬松聚酯纤维：

高档磨毛布面料、针织面料及高密度织物等

Fine denier porous fluffy polyester fiber: high-end sanding fabrics, knitted fabrics and high-density fabrics, etc.

（3）高弹性模量聚丙烯腈纤维：

花式纱、毛衫、仿毛制品、纺羊绒产品

High elastic modulus polyacrylonitrile fiber: fancy yarn, sweater, wool-like products and cashmere products.

Q&A

Q：纤维弹性的种类及与保形性的关系？

A：纤维的弹性就是指纤维变形的恢复能力，常用指标是纤维的弹性回复率或回弹率。纤维的弹性回复率高，则纤维的弹性好，变形回复的能力强，制成的纺织品尺寸稳定性好，服用过程中不易起皱，并且较为耐磨。其次，还可用纤维的弹性模量反映纤维的刚性，纤维的弹性模量大，则织物硬挺，保形效果好。

Q: The type of fiber elasticity and their relationship to shape retention?

A: The elasticity of a fiber refers to the ability of the fiber to recover after being deformed. The commonly used index is the elastic recovery rate or rebound rate of a fiber. If the elastic recovery rate of the fiber is high, then the fiber has good elasticity and strong ability of deformation recovery, the textile has good dimensional stability, uneasy wrinkle and more wear-resistant in the course of wearing. What's more, the elastic modulus of the fiber can also be used to reflect the rigidity of the fiber. If the elastic modulus of the fiber is high, the fabric is stiff and the shape preserving effect is good.

差别化再生纤维素纤维
Differential Regenerated Cellulose Fiber

代表品牌
Brand

Sateri | BV | 三友集团 Sanyou Group | 云鹰 YUNYING

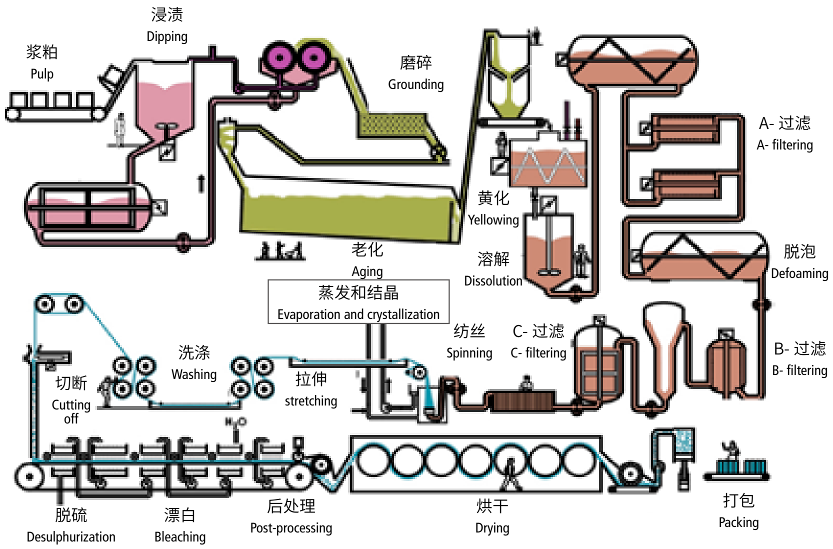
推荐理由
Recommendation reasons

易纺再生纤维素纤维面向专业化定制服务，创造需求，通过整合产业链资源和技术，提升纤维品质，并带动下游纺纱、织布效率提高，实现纱线、面料品质整体提升; 异形超短再生纤维素纤维通过特殊喷丝组件纺丝制得，刚性适中、不易勾结、易冲散、可降解，真正实现即可弃，满足消费者对卫生制品、纸张等现代消费需求。

Easy spinning regenerated cellulose fiber is developed for specialized customservices, it can create demand andimprove the fiber quality through the integration of industrial chain resources and technology,and it can promote efficiency of spinning and weaving in downstream enterprises to achieve the overall improvement of yarn and fabric quality. The special-shaped ultra-short regenerated cellulose fiber is obtained through the spinning by the special spinning components, which has a moderate rigidity and isdifficult to get stuck, easy to break down and degradable. It can be truly realized disposable to meet consumer's demand for modern consumption such as sanitary products and paper.

6.1 制备技术
Preparation Technology

（1）易纺再生纤维素纤维
(1) Easy Spinning Regenerated Cellulose Fiber



易纺再生纤维素纤维制备流程图
Process Flowchart

（2）异形超短再生纤维素纤维

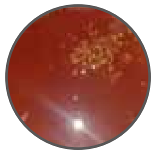
再生纤维素纤维生产工艺中经过“一”字型的喷丝头喷出，在凝固浴中发生双向扩散反应生成初生纤维丝束，再经后处理工序制备。

(2) Special-shaped Ultra Short Regenerated Cellulose Fiber

In the regenerated cellulose fiber production process, the nascent fiber tow isobtained through the "column" shaped spinning jet, which has undergone the two-way diffusion reaction in the coagulation bath, and then is prepared into the final product by the post-treatment process.


浆粕
pulp

→


纺丝液
Spinning liquid

→


纺丝
Yarn

→


纺丝丝束
YarnBundle

→


超短纤维
Ultra Short Fiber

6.2 纤维及制品特点

Fiber and Product Features

主要参数：

Main Parameters:

(1) 易纺再生纤维素纤维：

(1) Easy Spinning Regenerated Cellulose Fiber

纤维规格参数表

Fiber Specification parameter list

产品 Products	规格 Size	单纤强力 Single Fiber Strength	白度值 Whiteness	适用工艺 Application
BVM	1.33dtex × 38mm	≥ 2.5cN/dtex	85+/-1.5	涡流纺专用 Vortex Spinning
BVO	1.33dtex × 32mm	≥ 2.5cN/dtex	85+/-1.5	气流纺专用 Air Spinning
BVR	1.33dtex × 38mm	≥ 2.55cN/dtex	85+/-1.5	环锭纺专用 Ring Spinning
BVF	1.11dtex × 38mm	≥ 2.7cN/dtex	85+/-1.5	高支纱专用 High Count Yarn

（2）异形超短再生纤维素纤维：

1.0~2.64dtex × 3~16mm

干断裂强度≥ 1.80 cN/dtex

干断裂伸长率≥ 14.0%

白度≥ 80%

(2) Special-shaped Ultra Short Regenerated Cellulose Fiber

1.0~2.64dtex×3~16mm

Dry Break Strength≥1.80 cN/dtex

Dry Elongation at Break≥14.0%

Whiteness≥80%

易纺再生纤维素纤维形貌

Profile of Easy Spinning Regenerated Cellulose Fiber

易纺再生纤维素纤维横截面图

Cross Sectional View of Easy Spinning Regenerated Cellulose Fiber

异形超短再生纤维素纤维形貌

Profile of Special-shaped Ultra Short Regenerated Cellulose Fiber

异形超短再生纤维素纤维横截面图

Cross Sectional View of Special-shaped Ultra Short Regenerated Cellulose Fiber

标准及认证：

Standards and Certifications:

（1）易纺再生纤维素纤维

《粘胶短纤维》（GB/T 14463-2008）

通过 ISO、OEKO-TEX Standard 100，STeP by OEKO-TEX，Made In Green by OEKO-TEX 产品标签和 PEFC 森林产销监管链认证

(1) Easy Spinning Regenerated Cellulose Fiber

Viscose Staple Fiber (GB/T 14463-2008)

Certification of ISO, OEKO-TEX Standard 100 , STeP by OEKO-TEX, Made In Green by OEKO-TEX label and PEFC forest chain of custody

（2）异形超短再生纤维素纤维

《粘胶超短纤维》（B/1302W52.4127-2016）

《异型超短纤维》（Q/GHY001-2014）

通过 ISO、Oeko-Tex-100 和 FSC 森林产销监管链认证

(2) Special-shaped Ultra Short Regenerated Cellulose Fiber

Viscose Ultra Short Fiber (B/1302W52.4127-2016)

Special-Shaped Ultra-Short Fibers (Q / GHY001-2014)

Certification of ISO, Oeko-Tex-100 and FSC Forest Chain of Custody

纤维性能及制品特点：

Fiber Properties and Product Features:

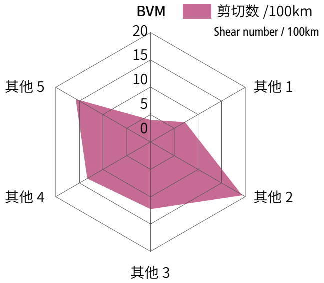
（1）易纺再生纤维素纤维：

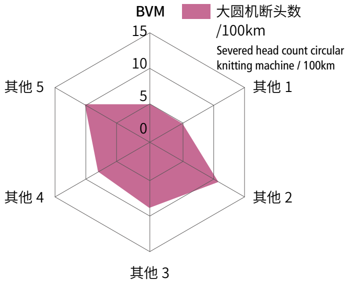
（以下图表数据均以涡流纺专用纤维为例）

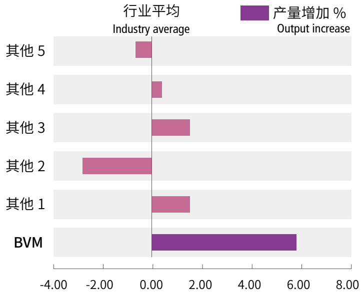
Easy Spinning Regenerated Cellulose Fiber (The following chart data are particularly from vortex spinning fiber)

- 适合高纺速，纺纱织布效率高，断头少，产量提升

Suitable for high spinning speed, high efficiency of spinning and weaving, less breakage and higher yield

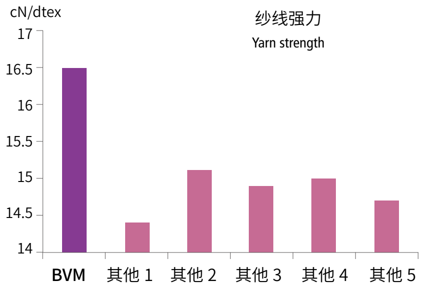






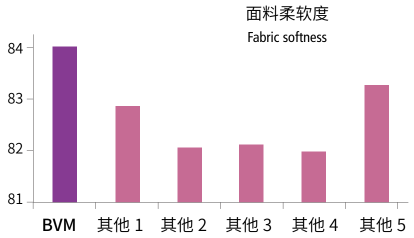
- 纱线强度高，可生产高支纱面料：纱线强力高于同类产品，纺纱、织布断头率显著下降，面料顶破强力高

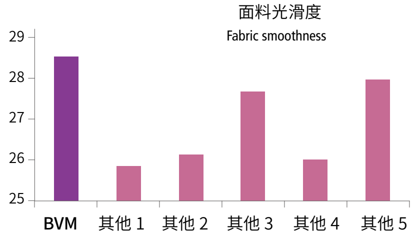
Yarn has high strength which can produce high count yarn fabrics: The yarn strength is higher than similar products. The break rate during the spinning and weaving declines significantly, and the fabric is more difficult to break

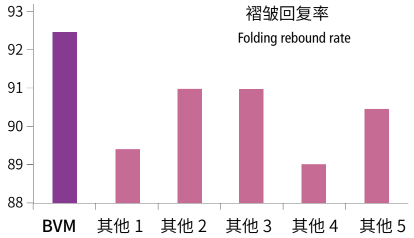


- 面料手感柔软，质感光滑，褶皱回复率好

The fabric is soft and smooth while the wrinkle recovery rate is excellent







- 布面染色稳定，色度一致：纤维素纤维的原料来源于 100% 高纯度溶解木浆，有助于纱线面料品质稳定，能带来更高的布面染色一致性

The fabric is suitable for dyeing with a good color consistency: The raw material of the cellulose fiber derives from 100% high purity dissolved wood pulp, which helps yarn fabric to maintain the quality, bringing higher fabric dyeing consistency

- 面料水洗后尺寸稳定性好，不易变形

Fabric is stable in size after washingandnot easy to be deformed

异形超短纤维分散效果图

Dispersion Diagram of Ultra-Short Fiber

可冲散湿巾的测试（Slushbox 振荡测试仪器）

Flushable Wipes Test (Slushbox Vibration Tester)

（2）异形超短再生纤维素纤维：

Special-shaped Ultra Short Regenerated Cellulose Fiber

- 分散性好：纤维表面的沟槽，利于水分流入使得纤维易分散，终端产品即可冲效果好

Dispersion is good: The groove on the surface of the fiber is conducive to the inflow of water to make the fiber easy to disperse and the end product can be washed well

- 导湿性能优越：纤维表面具有多个纵向沟槽，导湿透气

Excellent wetting performance: the fiber surface has multiple longitudinal grooves, moisture permeable and breathable

- 环保无污染：可 100% 生物降解，即可弃

Environmental pollution: 100% biodegradable, disposable

比木浆纤维素略长，长度适宜，弥补了无纺布中常用材料的短板

It is slightly longer than wood pulp cellulose with suitable lengths to compensate for the disadvantages in the non-woven fabric materials

6.3 应用技术

Application Technology

（1）易纺再生纤维素纤维：

可纯纺也可混纺，能满足高速设备对纤维的要求。

(1) Easy spinning regenerated cellulose fiber: For pure spinning or mixed spinning that meets the requirements of the high-speed fiber equipment.

（2）异形超短再生纤维素纤维：

非织造技术：可与木浆或者是木浆、天丝等混合使用。

后整理工艺技术：可以对非织造布进行亲水、抗静电、抑菌整理等。

产品开发技术：异形超短纤维（15~35）% 与木浆（65~85）% 或者是异形超短纤维（15~30）%、天丝（5~10）% 及木浆做可冲散非织造布，其中异形超短纤维调浓浓度为 1% 左右。

(2) Special-shaped ultra-short regenerated cellulose fibers:

Non-woven technology: mix with wood pulp or wood pulp and Tencel.

Finishing technology: For non-woven fabric in hydrophilic, anti-static, antibacterial treatment.

Product development technology: special-shaped ultra-short fibers (15-35%) and wood pulp (65-85%) or special shaped ultra short fibers (15-30%), Tencel (5-10)% and wood pulp can be prepared into the scouring non-woven fabrics, among which the concentration of the special-shaped ultra-short fibers is about 1%.

6.4 纤维应用

Fiber Applications

（1）易纺再生纤维素纤维：

针织面料：高档针织内衣、女士时装、T 恤

机织面料：牛仔、衬衫、休闲装

家用纺织品：床品

(1) Easy Spinning Regenerated Cellulose Fiber

Knitted fabrics: high-grade knitted underwear, ladies fashion, T-shirt

Machine woven fabrics: jeans, shirt, leisure wear

Household textiles: bedding

（2）异形超短再生纤维素纤维：

产业用领域：用于水冲散型卫生制品（湿巾、卫生巾、纸尿裤）、过滤材料、高档纸张、静电植绒等。

(2) Special-shaped Ultra Short Regenerated Cellulose Fiber

Industrial fields: for scouring sanitary products (wipes, sanitary napkins, and diapers), filter materials, high-end paper, electrostatic flocking, etc.

Q&A

Q：易纺纤维这个概念怎样理解？表示什么意思？

A: 易纺再生纤维素纤维纤维，是指通过产业链整合，与设备、纤维、纺纱专家共同开发，研究适合不同纺纱设备的最优化纤维素纤维解决方案。从纱线的生产效率，纱线和面料品质，纺纱设备维护等多方面进行改进，将纤维开发与下游应用紧密结合，纤维以其优异的性能为下游纺纱带来方便。以涡流纺专用纤维为例，较普通产品、纱线强力提高 11%，纱线剪切数比同类产品降低了 50%，产量提高了 5.5%; 以气流纺专用纤维为例，较普通产品、纱线强力提高 10%，断头数降低 70%。纱线品质、可纺性以及节能的提升，为面料设计及后整理提供了更多选择，也为下游应用带来更多开发潜能。

Q: What is the concept of the easy spinning fiber? What does it mean?

A: Easy spinning fiber means the development and research of the optimized cellulose fiber solutions for different spinning devices by the experts in equipment, fiber and spinning. The fiber is improved in the aspects of the yarn production efficiency, yarn and fabric quality and spinning equipment maintenance to integrate the fiber development and downstream applications closely. The fiber is good for the downstream spinning with its excellent performance.Taking vortex spinning special fiber as an example, compared with common products, its yarn strength is increased by 11%, the yarn cutting number is 50% lower than similar products, and the output is increased by 5.5%. Taking the special fiber for air spinning as an example, Yarn strength is increased by 10% with 70% reduction in the number of the broken ends.

Q：异形超短再生纤维素纤维的性能及市场优势体现在哪里？

A: 异形超短纤维素纤维横截面为"一"字形，弯曲刚度要低于圆形粘胶纤维，在成网和加工过程中，具有比圆形粘胶纤维更好的缠结性能。在适度添加时能够形成折弯勾结现象，却又不会过度紧密，且纤维表面呈现沟槽利于水流进入，易冲散。纤维素纤维的原材料 100% 来源于木浆，纤维使用丢弃后可 100% 降解；用该纤维制成的卫生制品、纸张等，可真正实现即可弃，不给环境带来负担。随着全球经济压力的缓解以及环境压力的增大，可冲散性产品将有更大的市场空间。

Q: What is the performance of the special shaped ultra-short regenerated cellulose fiber and its market advantages?

A: The cross-section of the special shaped ultra-short cellulose fibers is like a horizontal column and the flexural rigidity is lower than that of the round viscose fibers, which has better entanglement performance than the circular viscose fibers during the process of web forming and processing. When added moderately, it can form the bending collusion, but not to be over-close, and the groove on the surface of the fiber will help the water to flow in andmake thefiber brokendown easily. 100% of the raw materials of cellulose fibers are derived from wood pulp, which can be 100% degraded after being discarded. The sanitary products and paper made from the fibers can be truly discarded without any burden to the environment. With the alleviation of the global economic pressure and the increase of environmental pressure, there will be more market space for the disposable products.

发布篇章四

纤 · 智创工程

CHAPTER FOUR

FIBER · INTELLIGENT ENGINEERING

智慧中国、创新发展。作为《中国制造 2025》技术路线的关键战略材料，高性能纤维是国民经济和国防建设的强大支撑力量，也是全球材料领域竞相发展的重点。智创技术，中国纤维挑战装备加工和纤维性能极限，自主开发碳纤维，耐热抗蠕变、抗腐蚀等高性能纤维，使高端产品不再“高不可攀”；智创应用，高性能纤维全方位、高渗透到汽车轻量化、风力发电、土木建筑、船舶绳缆、航空航天、国防军工等尖端领域，成为工程制造革命性提升的新动力。

Make China intelligent and develop innovatively. As a key strategic material in the technology route of Made in China 2025, high-performance fibers are a strong support force for the national economy and defense construction as well as the focus in the global material field. Relying on intelligent technology, Chinese fiber industry challenges the limit of the processing equipment and fiber performance, promoting the self-development of high-performance fibers like carbon fiber, heat and creep resistant, anti-corrosion, which enables high-end products no longer "unattainable". In intelligent applications, high performance fiber has been widely applied in the cutting-edge areas such as automobile lightweighting, wind power, civil engineering, ship ropes, aerospace, defense and military engineering, and thus a new impetus for the revolutionary upgrading of engineering is provided.

高性能碳纤维
High Performance carbon Fibers

代表品牌
Brand

中国建材

威海拓展纤维有限公司
WEIHAI TUOZHAN FIBER Co.,Ltd

HS 恒神股份

推荐理由
Recommendation reasons

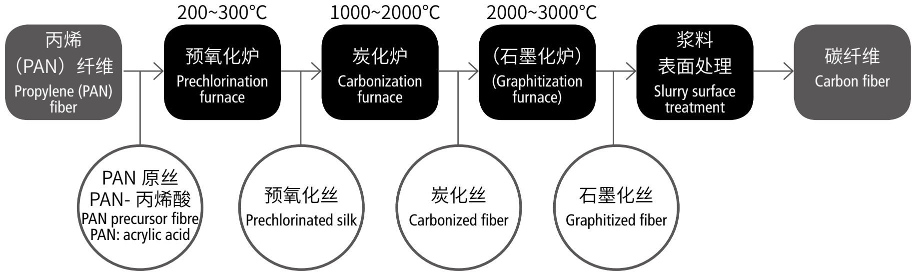
碳纤维是与国家安全和国民经济密切相关的战略性新材料，是“中国制造2025”新材料中高性能复合材料的重要支撑。中国碳纤维企业十年磨一剑，或自主创新攻克干喷湿纺等核心关键技术打破国外垄断; 或引进消化再吸收，实现产品的规模化与低成本化；或面向军工应用专业开发，对军工领域进行稳定、持续供货；最终均实现良性发展，为我国战略装备提供支撑。

Carbon fiber is a new strategic material closely related to national security and national economy, and acts as an important propfor high-performance composite materials in new materialsarea of the "Made in China 2025"plan. Persistence is the key to successfor Chinese carbon fiber enterprises. They persevere intheir efforts either intackling key technological problems in a way of independence innovationto grasp core technologiesof dry-jet wet spinning, which brokethe foreign technology monopoly; or in the introduction, digestion and re-absorption of foreign technologies to realize large-scale and low-cost production; or in technicaldevelopingand stable and continuous supplyfor defense and military applications, eventually achievea healthy development and providesupport services for Chinese strategic equipment.

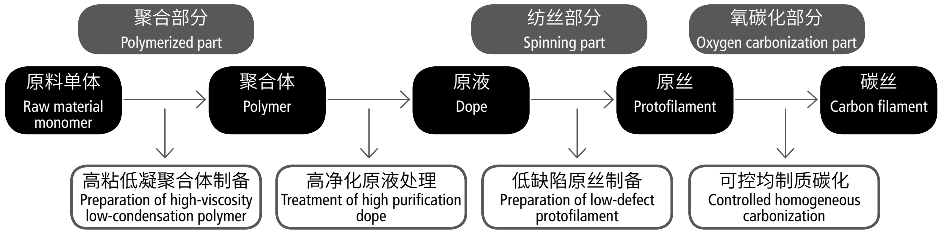
7.1 制备技术
Preparation Technology

原料聚合→纺丝（原丝）→预氧化→碳化→表面处理→上浆→收卷

Polymerization of raw materials → spinning (precursorfiber) → preoxidation → carbonization → surface treatment → sizing → winding



碳纤维制备流程
Preparation Process for Carbon Fiber



碳纤维制备过程中关键点控制
Key Point Control during Carbon Fiber Preparation

7.2 纤维及制品特点
Fiber and Product Features

碳纤维申报规格及物理指标
Carbon Fiber Specifications and Physical Indicators

规格 Specifications	拉伸强度（GPa） Tensile Strength	拉伸模量（GPa） Tensile Modulus	体密度（g/cm^3） Bulk Density	线密度（g/km） Linear Density
碳纤维 GQ4522（高强）：Carbon FiberGQ4522 (HighStrength) 3~24K	≥ 4.9	230	1.80 ± 0.02	800（12K）神鹰、威海拓展 198（3K）恒神
碳纤维 QZ5526 (高强中模)：Carbon FiberQZ5526(High StrengthMiddle Modulus) 6~24K	≥ 5.49	294	1.80 ± 0.02	450（12K）神鹰 223 (6K)、445（12K）威海拓展 226（6K）、435 (12k) 恒神

标准及认证:
Standards and Certifications:

《聚丙烯腈基碳纤维》（GB/T 26752-2011）
《聚丙烯腈基碳纤维原丝》（FZ/T 54065-2012）
《SYT49-12K 碳纤维》（Q/320705WAF04-2017）
《GW 系列聚丙烯腈基碳纤维》（Q/1001WTX 007-2017）
PAN-based Carbon Fiber (GB/T26752-2011)
PAN-based Carbon Fiber Precursor (FZ/T 54065-2012)
SYT49-12K Carbon Fiber (Q/320705WAF04-2017)
GW Series PAN-based Carbon Fiber (Q/1001WTX 007-2017)

纤维性能及制品特点:
Fiber Properties and Product Features:

碳纤维 GQ4522（高强）

Carbon FiberGQ4522 (High Strength)

・碳纤维具有轴向强度和模量高，比性能高，密度低，热膨胀系数小等众多优点，被称为“新材料之王”；其复合材料以其轻质高强、耐高温、抗腐蚀、热力学性能优良等特点广泛用作结构材料

Carbon fiber have High strength and rigidity, light weight, known as the "king of new materials";Its composite material being the structure materials due to the light weight, high strength,corrosion resistance, good thermodynamic property and high modulus of elasticity

碳纤维 QZ5526（高强中模）

Carbon FiberQZ5526(High Strength Middle Modulus)

・碳纤维 QZ5526 其拉伸强度较碳纤维 GQ4522 提升了 20%，模量提升了 28%，实现从高强标模碳纤维到高强中模碳纤维的产品升级。作为复合材料具备质量轻、强度高、弹性模量高的特点，可比传统铝合金结构减重 30%，对武器装备性能提升贡献巨大，被广泛用于制造航空器机体及发动机、导弹外壳等。作为功能材料耐高温、耐烧蚀

Compared with carbon fiber GQ4522, the tensile strength of carbon fiber QZ5526 increased 20% , modulus increased 28%, realized the carbon fiber upgrade from high strength standard modulus to high strength middle modulus.As a composite material: light quality, high strength and elasticity modulus, lighter than the traditional aluminum alloy structure by 30%. Enhanced the performance of weapon eqiupment, aircraft and its engin, missile casings.As a functional material: high temperature, burning and erosion-resistant

7.3 应用技术
Application Technology

使用碳纤维过程中，建议佩戴防护眼镜和口罩，保护眼睛，避免碳毛吸入。

（1）编织：注意控制纤维毛丝量和硬度，纤维偏硬容易受力不均造成布面不平整。

（2）缠绕：强度必须在 4900MPa 以上；注意控制毛丝量，否则容易造成受力不均产品破裂；丝束纤维必须无叠边，无加捻，便于缠绕。

（3）湿法预浸料：保证纤维无加捻、叠边、丝裂现象，纤维毛丝量必须少，否则容易产生裂缝。

In the process of using carbon fiber, it is recommended to wear protective glasses and masks to protect eyes and avoid carbon wool inhalation.

(1) Weaving cloth: pay attention to controlling the amount and hardness of the fiber yarn, hard fiber will leadto uneven force, ultimately touneven cloth.

(2) Winding: the strength must be above 4900MPa; pay attention to controlling the amount of wool yarn, otherwise it will easily lead to the rupture of the product duo to the uneven force; the tow fiber must have no overlap and twist easily for winding;

(3) Wet prepreg: fiber twist, stack edge, fiber splitis forbidden, reduce the broken filaments as far as possible, otherwise Cracks are easily occurred.

7.4 纤维应用
Fiber Application

碳纤维 GQ4522（高强）

1. 航空飞行器结构件、风力叶片、碳芯电缆、体育器械等民用领域。
2. 高端装备、建筑加固、新能源汽车、碳碳复合材料等工业领域。

Carbon Fiber GQ4522 (High Strength):

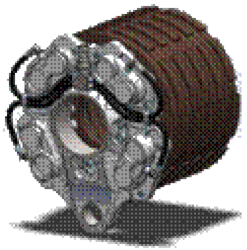
1. inthe structure parts of the civil aircraft, wind blades, carbon core cables, sports equipment and other civilian areas.
2. in high-end equipment, building reinforcement, new energy vehicles, carbon-carbon composite materials and other industrial fields;

碳纤维的使用可有效提高容器爆破压力，降低气瓶重量

Carbon fibers can improve the burst pressure of the container, reducing the weight of the cylinder.

碳 / 碳复合材料具有耐高温，高温力学性能优良的特点，在多晶拉制炉热场系统、刹车盘等部件上使用

Carbon / carbon composites have many advantages including high temperature toleration and good mechanical properties under high temperatures, applying to polycrystalline drawing furnace thermal field systems, brake discs and other components.



碳纤维较高的拉伸模量可为超大风力叶片主梁提供足够的刚度

The high tensile modulus of the carbon fiber will provide sufficient rigidity for the super-large wind blade girder.

碳纤维筋、碳纤维增强水泥、碳纤维路面格栅、碳纤维增强木材应用在土木工程领域

Carbon fiber reinforcement, carbon fiber reinforced cement, carbon fiber pavement grille, carbon fiber reinforced wood are used in civil engineering.

碳纤维的使用是汽车轻量化的重要解决方案

The use of carbon fiber is an important solution to develop lightweight cars.

碳纤维 QZ5526（高强中模）

作为结构增强材料，被广泛用于航空器机体及发动机、导弹外壳及高端体育休闲等领域。

Carbon Fiber QZ5526 (High Strength Middle Modulus)

As a structural reinforcement material, it is widely used in aircraft body and engine, missile shell and high-end sports and leisure fields.

Q&A

Q：推荐产品的优势体现在哪里？

A: 技术方面，实现了干喷湿纺的关键技术突破和核心装备自主化，建成了具有完全自主知识产权的千吨级干喷湿纺碳纤维产业化生产线及配套公用工程设施，整体达到国际先进水平。2017 年“干喷湿纺千吨级高强 / 百吨级中模碳纤维产业化关键技术及应用”项目荣获国家科技进步一等奖。产品方面：通过纤维成形过程中缺陷控制、炭化过程的均质化控制，产品各项性能指标均达到日本东丽水平。主要应用于航天航空及高端民用领域，打破了国外对我国的技术及产品封锁。

Q: What are the advantages of the recommended products?

A: In terms of technology, the company achieved breakthroughs in key technologies for dry-jet wet spinning and self-supply of the core equipment, and built an industrialized production line of kiloton wet dry-jet carbon fiber with complete independent intellectual property rights and supporting public utility facilities, which have reached the international advanced level. In 2017, "Key Technology and Application of Industrialization of Dry-jet Wet-spinning Kilo-ton High-strength / One-hundred-ton Medium-scale Carbon Fiber" won the first prize of national scientific and technological progress. In terms of products, the product performance indicators have reached the level of Japan's Toray through the fiber forming process defect control and carbonization process of homogenization control. It is mainly used in aerospace and high-end civilian areas, breaking the foreign blockade on technology and products to China.

Q：碳纤维 T300、T700、T800、T1000 的区别以及应用领域？

A: T 是指碳纤维的品级，通常以拉伸强度指标作为衡量标准，数值越大代表品级越高。T300 的拉伸强度一般为 3.53Gpa，T700 为 4.90Gpa，T800 的拉伸强度达到 5.49Gpa，T1000 为 7.02Gpa。因其强度不同，应用领域有所侧重。T300、T700 主要应用在民用领域，T800 在导弹发射管、固体火箭发动机壳体、卫星和飞船上以及汽车轻量化、建筑增强等方面应用广泛；T1000 主要用于国防、航空航天等尖端技术领域。

Q: What are the differences among carbon fiber T300, T700, T800 and T1000, and their application areas?

A: T refers to the grade of carbon fiber, usually based on tensile strength as a measure; the greater value represents the higher grade. The tensile strength of T300, T700, T800, T1000 is generally 3.53Gpa, 4.90Gpa, 5.49Gpa, 7.02Gpa respectively. Carbon fiber application areas differ based on its different strengths. T300 and T700 carbon fibers are mainly used in the civil fields. T800 carbon fibersare widely used in missile launch tubes, solid rocket motor housings, satellites and spacecraft as well as vehicle lightweight and building enhancement. T1000 carbon fibersare mainly used in cutting-edge technologies such as defense and aerospace fields.

高性能对位芳纶
High Performance Para-aramid

代表品牌
Brand
泰普龙 ®

推荐理由
Recommendation reasons

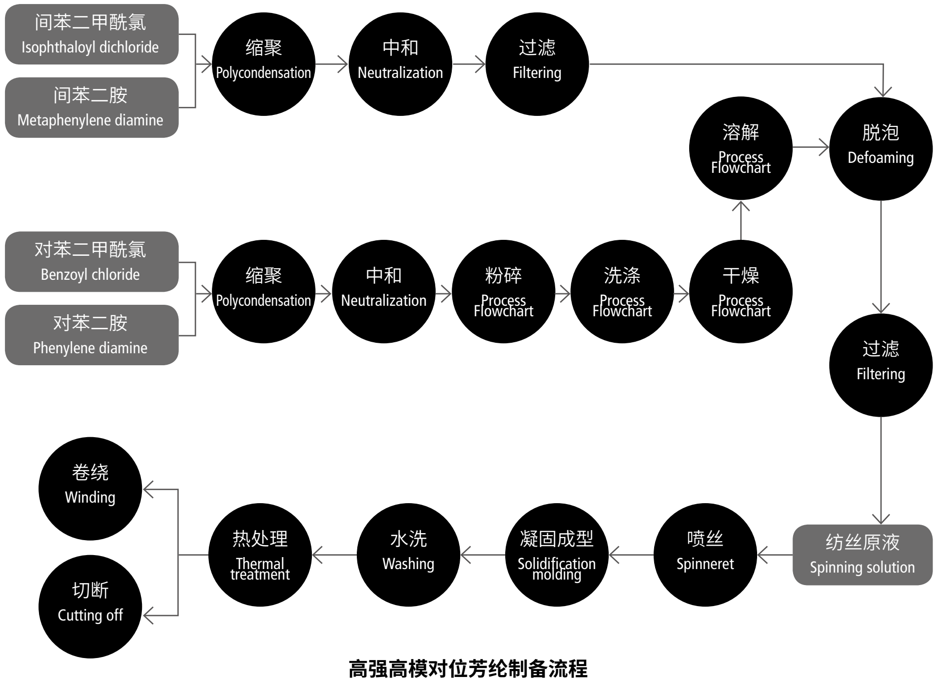
突破高强高模对位芳纶原料制备及存放、高均匀、稳定化纺丝、耐苛刻环境装备及产业化关键技术，打破了高端应用长期受制于国外的情况，对提升我国国际竞争力具有里程碑意义。产品在光缆增强材料、轮胎帘子布、防护材料、运动器材、交通等领域得到应用，并逐步向其它高端应用领域延伸。

Key technologies breakthroughs have occurred in the respects of raw materials preparation and storage, high uniform and stable spinning, harsh environmental tolerating equipment and industrializationof the high strength and high modulus para-aramid, which brokethe long-term high-end applications subject to foreign technology and meant as a milestone in enhancing the international competitiveness of China. Products areused in the fiber reinforced materials, tire cord fabrics, protective materials, sports equipments, transportation and other fields, and gradually extended to other high-end applications

8.1 制备技术
Preparation Technology

将对苯二胺和对苯二甲酰氯通过低温溶液缩合聚合制备聚合物，其聚合体再溶解在浓硫酸中进行液晶溶液纺丝而制得。

Spinning materials were prepared by p-phenylenediamine and terephthaloyl chloride via low temperature solutioncondensation polymerization and then dissolved in concentrated sulfuric acid solution to obtain spinning dope, finally spun by liquid crystal spinning method to obtain the product.



高强高模对位芳纶制备流程
Preparation Process of High Strength and High Modulus Para-aramid

8.2 纤维及制品特点
Fiber and Product Features

纤维规格：
Fiber Specifications:
220~8050dtex

标准及认证：
Standards and Certifications:
《对位芳纶长丝》（Q0601 THX004-2015）
Para Aramid Filament (Q0601 THX004-2015)

纤维性能及制品特点:
Fiber Performance and Product Features:

- 碳高强度：比强度是优质钢材的 5~6 倍、玻纤的 3 倍、高强尼龙的 2 倍
High strength: specific strength is 5 ~ 6 times ashigh-quality steel, 3 times asthe glass fiber , 2 times as the high strength nylon

- 碳高模量：比模量是优质钢材或玻纤的 2~3 倍、高强尼龙的 10 倍
High modulus: specific modulus is 2 to 3 times as the high-quality steel or glass fiber, 10 times as the high-strength nylon

- 碳高热稳定性：连续使用温度范围为 -196 °C ~204 °C，起始分解温度 537.8°C
High thermal stability: temperature range for continuous use is -196 °C ~ 204 °C ,where the initial decomposition temperature is 537.8 °C

泰普龙 Taparan® 长丝物理指标
Physical Properties of Taparan® Filament

物理指标 Physical Properties 规格 Specifications	拉伸强度 (cN/dtex) Tenacity at break	最大载荷 (N) Broken strength	断裂伸长 (%) Elongation at break	模量 (GPa) Elastic Modulus
840dtex/560F	24.36	201.25	3.63	100.54
930dtex/560F	24.77	232.82	3.93	95.87
1100dtex/667F	24.24	264.68	3.84	94.32
3160dtex/1330F	18.9	606	3.21	118

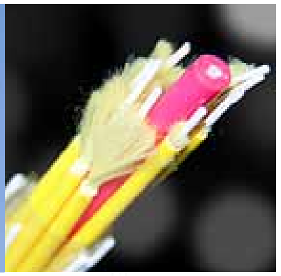
8.3 应用技术
Application Technology

纺纱技术：在纤维表面增加特种油剂可增加纤维丝束抱合力和耐磨性（光缆领域）；使用水溶性油剂以便改善丝束复合性能（防弹复合领域）。

产品开发技术：加工成方平机织布，水洗定型后提高织物的复合性能，再进行涂覆处理后压板，用于制作各类防弹材料。

Spinning technology: The addition of special oils to the fiber surface increases the cohesion and abrasion resistance of the fiber tow (in the field of optical cables) and the use of water-soluble oils improves the tow properties (for bullet resistant composites).

Product development technology: it can be processed into a basket woven fabric, and the fabric composite property improves after water laundry, and then coated and pressed for the production of various types of bullet-proof materials.



8.4 纤维应用
Fiber Applications

光缆、建筑补强、高强度缆绳、防割手套、防弹衣、防弹头盔等防护领域。

与树脂、橡胶等材料复合，可大幅度减轻构件重量，适用于制作飞机、高速列车内外增强、汽车胶管等。

It can be used in cable, buildingreinforcement, high-strength cables, cut-resistant gloves, body armor, bullet-proof helmets and other areas of protection.

When Compoundedwith resin, rubber and other materials, it greatly helps toreduce the weight of components, suitable for the production of aircraft, inside and outside enhancements of high-speed train, automotive hoses,etc.

Q&A

Q：高强高模对位芳纶具有那些优势?

A: 泰普龙对位芳纶以其高强度及优良的耐热性在军警防护领域得到广泛的应用，如防弹衣用 UD 布，防弹头盔用机织布，战训服及战术手套用有色纱线等，以其制作的面料，具有耐高温、高强度、低收缩（≤ 4%）的特点，更适合保护消防官兵的生命安全。此外，可作为线缆骨架增强材料对光通信信号的保真度及线缆的抗拉性起着极高的保护作用。

Q: What are the advantages of the high strength and high modulus para-aramid?

A:Taparanpara-aramid is widely used in military and police protection fields due to its high strength and excellent heat resistance, such as UD cloth for bullet-proof vests, woven cloth for bullet-proof helmets, colored yarn for war vests and tactical gloves and so on. The fabric made from it has the characteristics of high temperature resistance, high strength and low shrinkage (≤4%), and is more suitable for protecting the life and the safety of fire officers and soldiers. In addition, it can be used as a highly recognized cable frame reinforcement to protect the optical communication signal fidelity and cable tensile.

高性能超高分子量聚乙烯纤维

High Performance Ultra-high Molecular Weight Polyethylene Fiber

代表品牌
Brand

神鹤科技

推荐理由

Recommendation Reasons

采用新型环保溶剂，实现新型干法纺丝技术及装备的国产化，工艺流程缩短，纺丝温度降低，节能超过 30%；产品克服了常规超高分子量聚乙烯纤维耐热性差、易蠕变等缺点，并结合原液着色技术解决染色难的问题，拓宽应用范围。

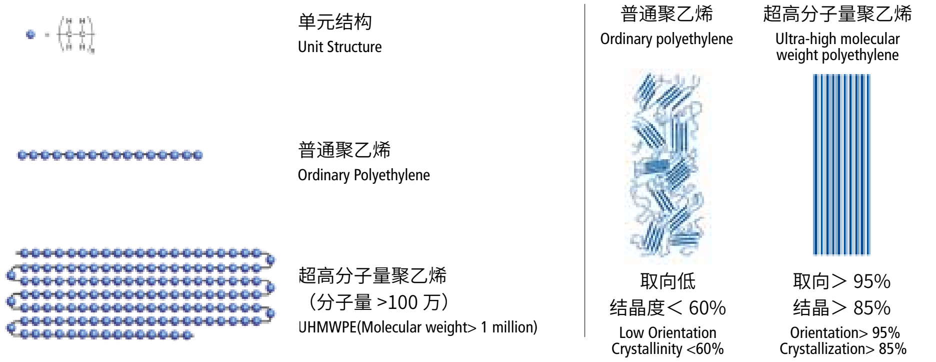
New environmentally friendly solvents are employed and the localization of technologies and equipmentsofnew type of dry spinninghas been realized, whichcontribute toa shorter process, lower spinning temperatures, and lower energy consumption by 30%; The shortcomings of conventional ultra-high molecular weight polyethylene fibersuch aspoor heat resistance and creeping inclination and so on, have been overcomein this recommended product, and problems in dyeing can be also solved by dope dyeing method, thus the products applications have been expanded.

9.1 制备技术

Preparation Technology

将超高分子量聚乙烯粉末与抗氧剂及其它添加助剂、交联剂、着色剂等与易挥发溶剂按照一定比例进行混合，混合均匀后配制成浓度为 7% 左右的纺丝溶液，经过螺杆挤出、纺丝后，在纺丝甬道内惰性气体保护下，去除挥发溶剂，最后通过多级超倍热牵伸制得成品纤维。

The ultra-high molecular weight polyethylene powder was mixed with antioxidants and other additives, crosslinkers, colorants and other volatile solvents by certain ratio to prepare spinning solutions (concentration of about 7%), whichthen were extruded and spun by the screw extrusion and spinning. The volatile solvent is removed under the protection of inert gas inside the spinning shaft, and finally the finished fiber is obtained through multi-stage hyper-heat drawing.



9.2 纤维及制品特点

Fiber and Product Features

主要规格:
Main Specifications:

440~1670dtex/240~960F

标准及认证:
Standards and Certifications:

参考《超高分子量聚乙烯纤维》(GB/T 29554-2013)

发明专利《耐热抗蠕变超高分子量聚乙烯恒强纤维及其制备方法》(CN104695038A)

Reference:Ultra High Molecular Weight Polyethylene Fiber (GB / T 29554-2013)

Invention patent heat-resistant and anti-creep ultrahigh molecular weight polyethylene constant strength fiber and its preparation method (CN104695038A)

纤维成品丝
Finished fiber yarn

纤维性能及制品特点：
Fiber Performance and Product Features:

- 原液着色，无需印染后处理，颜色丰富，绿色环保
Dopedyeing with no post dyeing processing, various colors, and environmentally friendly

- 耐热性好，抗蠕变
Good heat and creep resistance

密度低
Low Density

强度高
High Strength

模量高
High Modulus

抗冲击
Anti-Shock

耐腐蚀
Erossion-Resistant

耐热抗蠕变原液着色超高分子量聚乙烯纤维物理指标
Physical index of Heat-resistant and Creep Resistance Dope Dyed Ultra-high Molecular Weight Polyethylene Fiber

检测项目 Test Item	数据 Data
强度 Strength（cN/dtex）	＞ 30
模量 Modulus（cN/dtex）	＞ 1300
蠕变速率 Creep Rate （在 70℃，300MPa 应力条件下）	＜ 5.5 × 10-6%/ 天

9.3 应用技术
Application Technology

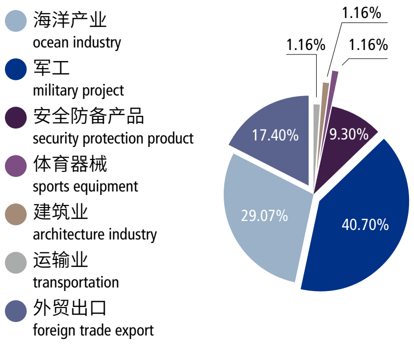
产品后加工温度不超过 200℃。

Post processing temperature of product does not exceed 200℃ .

9.4 纤维应用
Fiber Application

光缆、电缆增强、风力发电叶片、远洋缆绳、船舶缆绳、海洋钻井平台系泊缆绳以及大型雷达罩等。

Fiber products can be used as optic cables, cable reinforcement, wind turbine blades, offshore cables, marine cables, offshore drilling mooring lines and large radomes.



超高分子量聚乙烯纤维国内需求结构
Domestic Demand Structure of UHMWPE Fibers

Q&A

Q：产品与常规超高分子量聚乙烯相比，优势体现在哪里？

A：本产品通过技术提升，并结合原液着色技术，免除超高分子量聚乙烯纤维的后道染色；通过研究开发超高倍拉伸的专用设备及关键技术，使纤维的强度和模量达到国际先进水平；大大提高了抗蠕变性能，实现在光缆增强、船舶缆绳、海洋钻井平台的专业化应用，拓展产品应用领域。

Q: Compared with the conventional ultra-high molecular weight polyethylene, what are its advantages?

A:The post dyeingof ultra high molecular weight polyethylene fibershas been eliminated in this product by technologyupgrades and the dope dyeing technology; The strength and modulus of fiber reaches the international advanced levelby the research and development of ultrahigh drawing equipment and key technologies; The creep resistanceof fiber has been greatly improved, and the applications on the enhancement of optical cables, marine cables, offshore drilling platform areashave been realized andother specializedapplicationshas also been expanded.

高性能聚酰亚胺纤维
High Performance Polyimide Fiber

代表品牌
Brand

H!Nanofiber 江西先材

推荐理由
Recommendation reasons

创新性采用聚酰亚胺共聚加共混的纺丝原料，使用大规模针尖阵列静电纺丝技术、热溶法造孔及隔膜增强技术，开发纳米级聚酰亚胺纤维及其电池隔膜，实现规模化、均匀化、稳定化生产。

It innovatively uses blendpolyimide copolymersasrawspinning materials.And the large-scale multi-tip array electrospinning, hot-melt pore-forming anddiaphragmreinforcement technology are used to develop nano-scale polyimide fibers and its batteries diaphragm, and to achieve the large-scale, uniform and stable production.

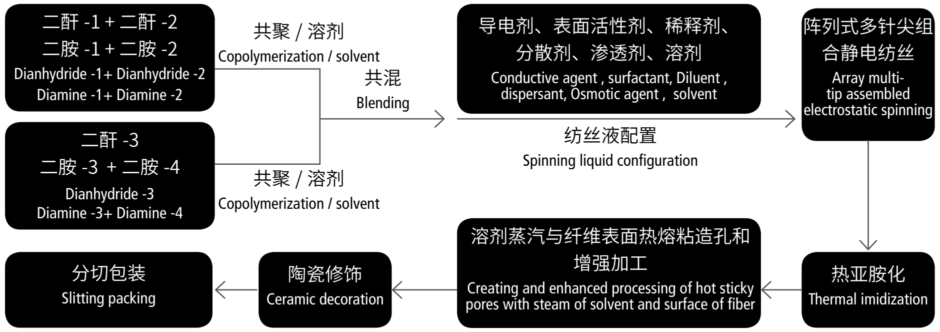
10.1 制备技术
Preparation Technology

通过静电纺丝技术制备的纳米级聚酰亚胺纤维，在 350° C 高温下部分熔融粘结，形成均匀致密的多孔膜结构，再经陶瓷微米颗粒表面涂敷修饰，形成耐高温、高倍率和长寿命的高性能锂电池隔膜。

刚性和柔性聚酰亚胺混纺形成的纳米纤维非织造布，在高温溶剂气氛中轻度溶解和粘结，形成孔隙率在 90% 以上的、耐高温、高通量、气液两用的高效过滤膜。

The nano-sized polyimide fibers prepared by the electrospinning technique are partially melt-bonded at a high temperature of 350 °C to form a uniform and dense porous membrane structure, which is then coated and modified on the surface of the ceramic micro-particles to form a lithium battery separator of high-temperature-resistance, high-magnification, long-duration and high-performance.

Nano-fiber nonwovens formed by the blending of rigid and flexible polyimides are lightly dissolved and bonded in a high-temperature solvent atmosphere to form an efficient and high-throughout filter membrane of 90% or above porosity and high-temperature toleration for both gas and liquid detection.



纳米级聚酰亚胺纤维膜生产制备工艺流程
Preparation of Nano-Scale Polyimide Fibrous Membrane

10.2 纤维及制品特点
Fiber and Product Features

主要规格：
Main Specifications:

（1）纳米级聚酰亚胺纤维

长度 1~500 微米，直径 300~800 纳米，纤维分散性好。

(1) Nano-scale Polyimide Fiber

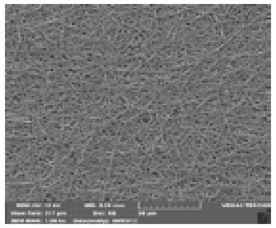
Length:1 ~ 500 microns, diameter :300 ~ 800 nm with good fiber dispersion.

（2）纳米级聚酰亚胺纤维电池隔膜

PI-20 隔膜，孔隙率 80%，厚度 40 微米；
PI-60 隔膜，孔隙率在 50%，厚度 25 微米；
PI-T 隔膜，孔隙率在 45%左右，厚度 15-20 微米；
PI-G-T 隔膜，孔隙率 35-40%，厚度 5-8 微米。

(2) Nano-scale Polyimide Fiber Battery Separator
PI-20 separator with porosity of 80% and thickness of 40 microns;
PI-60 separator with porosity of 50% and thickness of 25 microns;
PI-T separator with the porosity of about 45% and the thickness of 15-20 microns;
PI-G-T separator with porosity of 35-40% and thickness of 5-8 microns.

纤维成品图
Fiber Product



静电纺纳米纤维复合滤材电镜图
Electron Micrograph of ElectrospunNanofiber Composite Filter

标准及认证:
Standards and Certifications:

《聚酰亚胺纳米纤维电池隔膜》(企标 Q/PI001-2017)
《聚酰亚胺纳米纤维电池隔膜》(企标 Q/PI002-2017)
Polyimide Nanofiber Battery Separator (Enterprise Standard Q / PI001-2017)
Polyimide Nanofiber Battery Separator (Enterprise Standard Q / PI002-2017)

纤维性能及制品特点:
Fiber Performance and Product Features:

(1)纳米级聚酰亚胺纤维:

Nano-scale Polyimide Fiber

- 耐高低温：分解温度大于 550° C，零下 260° C 的液氦中仍具有良好的柔韧性

High and low temperature resistance: Decomposition temperature is greater than 550 °C, and it still has good flexibility in minus 260 °C liquid helium

- 耐老化：在空气中长期使用温度为 200 ～ 300° C

Anti-aging: Can be used at the air temperature of 200 ~ 300 °C for a long period

- 体积电阻率为 10^{17}Ω/cm (属 F 至 H 级绝缘材料)

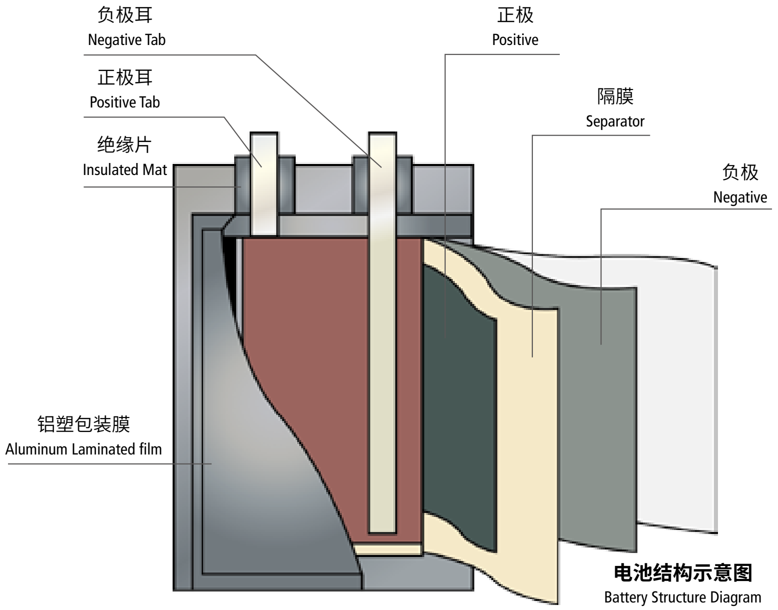
Volume resistivity is 1017Ω/cm (F to H grades)

- 电击穿强度介于 100-300 kV/mm 之间，属高耐（电）压材料

Electrical breakdown strength is between 100-300 kV / mm as a high (electricity) pressure resistant materials

(2)纳米级聚酰亚胺纤维电池隔膜:

Nano-scale Polyimide Fiber Battery Separator



电池结构示意图
Battery Structure Diagram

4C 充放电循环 9600 次能量保持率 62% 以上

Energy retention rate is 62% or more after 9600 cycles of charge and discharge at 4°C

具有高低温特性（使用温度 -160° C~350° C)，高温 900° C 热针刺不起火不爆炸

High and low temperature toleration (temperature between 160 ° C and 350 °C), and no fire and explosion occur at the hot acupuncture of temperature 900 °C

(3)纳米级聚酰亚胺纤维滤材:

Nanoscale Polyimide Fiber Filter

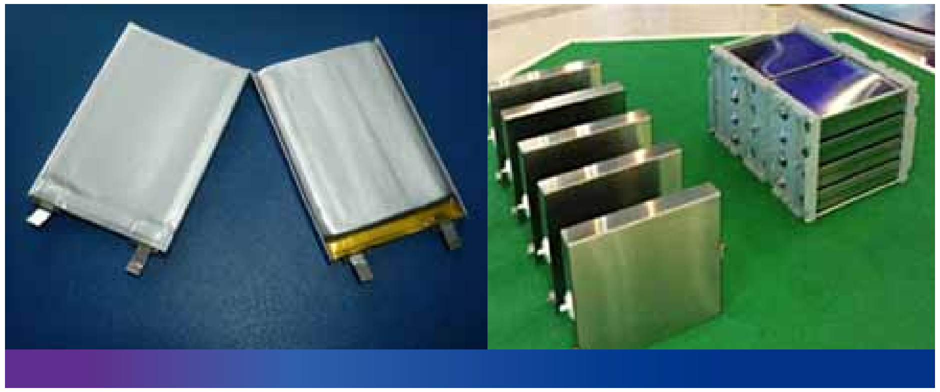
对 0.3 μ m 颗粒的过滤效率达到 99%，风阻小于 200Pa

The filtration efficiency of 0.3μm particles reaches 99%, and the wind resistance is less than 200Pa

10.3 应用技术
Application Technology

(1) 制作之前可以在 > 100°C条件下，对 PI 隔膜烘烤 2~3 小时。
(2) 电芯烘烤温度 > 100°C，烘烤 24 小时 (如有水分测试，测试到无水分即可)。
(3) 电解液注液量是传统隔膜注液量的 5%~8%。
(4) 恒压横流正常化成后，再加两次循环。

(1) The PI separator membrane can be baked at more than 100°C for 2 to 3 hours prior to production.
(2) The cell baking temperature is more than 100 °C for 24 hours (if there is moisture test, no water shall be detected).
(3) Electrolyte injection volume is the traditional separation injection of 5% to 8%.
(4) After the normalization of the constant pressure and flow, two cycles should be added.



10.4 纤维应用

Fiber Application

（1）纳米 PI 纤维：用于锂电池、锂离子动力电池的电池隔膜、水净化过滤器、油水分离器等

（2）电纺纳米纤维复合滤材：用于防雾霾口罩、建筑物新风系统、汽车及空调空气格等

(1) Nano-PI fiber: for the separators, water purification filters and oil-water separators driven by lithium batteries and lithium ion batteries

(2) Electrospunnanofiber composite filter: for anti-haze mask, building ventilation system, automotive and air conditioning air grid

Q&A

Q：随着清洁能源的普及以及动力电车的发展，对电池的要求越来越高，纳米级聚酰亚胺纤维用于电池隔膜，有哪些优势，能给电池带来什么性能？

A: 电池隔膜主要是隔离正、负极，使电池内的电子不能自由穿过，其离子传导能力直接关系到电池的整体性能。用纳米级聚酰亚胺纤维制备的电池隔膜具有耐高低温，抗老化、耐辐射、高孔隙率等特点，其微孔自闭保护作用，使电池在过度充电或者温度升高的情况下能限制电流的升高，防止电池短路引起爆炸。该隔膜的使用大幅提高了电池的安全性和使用寿命。

Q: With the popularization of clean energy and the development of power trolley, the requirements on the battery are getting higher and higher. What are the advantages of using nano-sized polyimide fiber for the battery separator?

A: The battery separator is mainly to separate the positive and negative poles so that the electrons in the battery cannot freely pass through. Its ion conductivity is directly related to the overall performance of the battery. The battery separator prepared with nano-sized polyimide fiber has the characteristics of high and low temperature resistance, anti-aging, radiation resistance and high porosity and the like, and its micro-pore automatic block protection will limit the current rise when the battery is overcharged or the temperature is increased to prevent the battery explosion from the short circuit. The use of this membrane greatly improves the battery's safety and service life.

中国纤维流行趋势 2018/2019

31 个入围产品 RECOMMEND PRODUCTS

一、产业用纤维
Industrial Fiber

目前，产业用纤维的加工总量约占我国纤维加工量的四分之一。纤维科技的发展，以及纤维性能与功能的不断完善，使产业用纤维的发展攀升到新的高度：存优补缺，赋予制品抗紫外、阻燃等功能。具有突出性能和功能纤维，广泛应用于海洋、汽车、航空等领域，为消费者带来全方位的安全保障。

Currently, the processing amount of industrial fiber accounts for around a quarter of that of all fiber in our country. The development of fiber technology and the continuous improvement of its properties and functions show that industrial fiber has developed into a new height, with its functions including keeping advantages and making up for shortcomings, making products ultraviolet resistant and flame retardant, and so on. The fiber having outstanding properties and functions is widely used in fields such as ocean, automobile and aviation, bringing consumers all-around safety guarantee.

1. 原液着色抗紫外高强聚酰胺 6 纤维

特点：高强度、颜色鲜艳（不易褪色）、环保、抗紫外

规格：933~1400dtex/96~210F

应用技术：工业布、渔网用彩色丝：高温定型不能超过 30 分钟，温度不超过 130 度；绳索用彩色丝：常温下使用，不能高温定型。

应用领域：绳索、织带、渔网

品牌：秋雪

申报企业：江苏海阳化纤有限公司

2. 地毯用阻燃聚丙烯纤维

特点：阻燃、强度高、热卷曲伸长率高

规格：1250~3000dtex/144F

应用技术：染整与常规工艺相同，更易上色，不需要阻燃涂层处理

应用领域：家居地毯、商用地毯、车船用地毯、工艺地毯和更高要求的航空地毯等

品牌：四通化纤

申报企业：浙江四通化纤股份有限公司

1. Dope Dyed Ultraviolet-ResistantHigh-strength Polyamide 6 Fiber

Features: high strength, bright color (little color fading), environmental protection and ultraviolet resistance

Specification: 933~1400dtex/96~210F

Applied technology: colored fiber used for industrial fabric or fishing net: for high temperature setting, time is no more than 30 minutes, and temperature is no more than 130 degrees; colored fiber used for rope: it must be used at normal temperature, and no high temperature setting can be done.

Application field: rope, braid, fishing net

Brand: Qiuxue

Declaring Enterprise: Jiangsu Haiyang Chemical Fiber Co., Ltd.

2. Flame Resistant Polypropylene Fiber Used for Carpet

Features: flame resistance, high strength, high heat-crimp elongation rate

Specification: 1250~3000dtex/144F

Applied technology: samedyeing & finishing as conventional process, easier coloring,no need of flame resistant coating treatment

Application field: home carpet, commercial carpet, vehicle & boat carpet, craft carpet and aviation carpet with higher requirement.

Brand: Sitong Chemical Fiber

Declaring enterprise: Zhejiang Sitong Chemical Fiber Co., Ltd.

二、弹性纤维
Elastic Fiber

弹起来，更时尚。在运动风潮盛行的当下，对弹性纤维的要求没有最高，只有更高。经特殊改性和工艺设计的弹性纤维，克服了传统弹性纤维的缺点，防脱散、不卷边、不发黄，在为人们提供舒适穿着体验的同时亦兼顾了时尚新概念。

Bouncing up makes it more fashionable. At this era when exercise tide is prevalent, requirement on elastic fiber can only be higher but not the highest. Elastic fiber with special modification and process design overcomes the shortcomings of traditional elastic fiber, resisting run, not crimping, and not yellowing, and it presents a new concept, fashion, while offering people comfortable wearing experience.

1. 低温热粘合氨纶

特点：在较低温度（120°C -130°C）和短时间内（20s-40s），表面发生热熔并与其它化纤发生粘连，温度降低后粘连点被固定，面料具有弹性的同时还具备防脱散性能。

规格：11~33dtex

应用技术：在面料生产过程中，蒸汽定型温度为 120°C -130°C，时间为 20s-40s；染色温度< 90°C，保温时间≤ 40min

应用领域：高端防脱散丝袜、高端内衣、随意裁面料（无需锁边）

品牌：奥神
申报企业：连云港杜钟新奥神氨纶有限公司

2. 抗紫外氨纶

特点：织物在强太阳光照射下，不易发黄劣化、降解、断丝

规格：44dtex/3F 、78dtex/5F

应用技术：采用合理的氨纶牵伸比，减少布面疵点；染整过程中，合理控制定形温度与定形速度

应用领域：可应用于圆机、经编、包纱，织造内衣、泳衣、袜子等领域

品牌：千禧
申报企业：浙江华峰氨纶股份有限公司

1. Low-temperature Heat-bonded Spandex

Features: at a lower temperature (120°C -130°C) and within a short time(20s-40s), it adheres with other chemical fiber with its surface appearing hot melting; after the temperature goes down, the adhering points are fixed, so that the fabric has both elasticity and run resistance.

Specification: 11~33dtex

Applied technology: during fabric production, the temperature for steam setting is 120°C -130°C , the time is 20s-40s, dyeing temperature is less than 90°C , and the holding time is no more than 40min.

Application field: high-end run-resistant stocking, high-end underwear, randomly trimmed fabric (no need for overlock)

Brand: Aoshen
Declaring enterprise: LDZ New Aoshen Spandex Co., Ltd.

2. Ultraviolet Resistant Spandex

Features: when exposed to strong sunlight, fabric is not prone to yellow, degrade, or have broken yarn.

Specification: 44dtex/3F, 78dtex/5F

Applied technology: using reasonable spandex draw ratio to reduce fabric defects; during dyeing and finishing, reasonably controlling setting temperature and speed

Application field: circular knitting, warp knitting, covering yarn, woven underwear, swimwear, socks.

Brand: Millennium
Declaring enterprise: Zhejiang Huafeng Spandex Co., Ltd.

三、仿真纤维
Imitated Fiber

集多种高新纤维材料与技术融合设计的仿真纤维，在拥有合成纤维保型特征的同时，打造仿真纤维的光泽、手感和性能，从视觉和触觉上冲击消费者的购买欲望，实现肌肤亲近自然的梦想。

Integrating multiple high and new fiber materials and technology fusion design, simulated fiber builds its unique gloss, hand feeling and properties while possessing shape maintenance feature of synthetic fiber, so as to draw consumers' purchasing desire from senses of vision and touch and help people realize dream of skin being close to nature.

1. 仿麻聚酯纤维

特点：仿麻效果、抗皱性好、色牢度好、亲肤舒适性大大提高

规格：DTY55~83dtex/36F

应用技术：染整温度 120°C时，双色效果更明显。

应用领域：针织裙裤、家居服、袈裟等服饰以及家居饰品

品牌：豪丽丝
申报企业：厦门翔鹭化纤股份有限公司

2. 竹节可控聚酯纤维

特点：较高的亲水性、舒适性、加工过程竹节可控、产品无须染色便可呈现独特的花色，节能无污染

规格：50~150dtex/36~288F

应用技术：后道经编方面，倍捻超喂在 56%-78%，倍捻速度 700m/min 以上，要注意坯布前后处理时对温度的掌握。

应用领域：时装面料、运动休闲面料、花边、窗帘、汽车用布、沙发布、墙布等

品牌：金鸡牌（桐昆集团浙江恒盛）、的真特（嘉兴胜邦）
申报企业：桐昆集团浙江恒盛化纤有限公司；嘉兴胜邦科技有限公司

1. Linen-like Polyester Fiber

Features: like linen effect, good wrinkle resistance and color fastness, greatly improved skin comfort

Specification: DTY55~83dtex/36F

Applied technology: when the temperature for dyeing and finishing is 120°C , two-color effect is more obvious.

Application field: woven pantskirt, homewear, cassock, home decor

Brand: Haolisi
Declaring Enterprise: Xiamen Xianglu Chemical Fiber Co., Ltd.

2. Bamboo Joint Controlled Polyester Fiber

Features: higher hydrophily and comfort, bamboo joints being controllable in processing course, having unique design and color without being dyed, energy saving, and no pollution

Specification: 50~150dtex/36~288F

Applied technology: for the next warp knitting, the overfeeding of double twisting is 56%-78%, the speed of double twisting is no less than 700m/min, and care is taken to get hold of temperature during gray fabric treatment.

Application field: fashion fabric, fabric for sports and leisure wear, lace, curtain, Auto. fabric, sofa fabric, wall fabric etc

Brand: Golden Cock (Zhejiang Hengsheng Company of Tongkun Group), Dezhente (Jiaxing Shengbang)
Declaring enterprise: Tongkun Group Zhejiang Hengsheng Chemical Fiber Co., Ltd. ; Jiaxing Shengbang Technology Co., Ltd.

四、安全防护纤维
Safety Protection Fiber

纺织服装的功能不再局限于保暖与美观，已升级为在家居、公共场所和工作环境等领域为人们提供全方位的有效防护。阻燃、抗静电纤维等品种通过分子设计及复合纺丝技术，改变了纺织品易燃问题，减少纺织品燃烧熔滴的危险性及燃烧时有毒气体的释放，改善纤维产生静电的问题，减少纺织品静电带来的危险，有效保障人身安全。

Textile and garment don't only function as warmth and beauty anymore, nowadays, they have been upgraded to provide people with all-around effective protection in such fields as home, public place and working environment. Antiflaming fiber, antistatic fiber and other fiber can solve the problems of textile being flammable and fiber generating static through molecular design and composite spinning technology, so as to reduce the molten drops and poisonous gas generated when textile combustion and the danger caused by textile static, and effectively guarantee personal safety.

1. 功能性阻燃耐熔滴聚酯纤维

特点: 无毒、低烟、耐熔滴、不污染环境、永久阻燃等

规格: 1.56~3.33dtex × 38~76mm

应用技术: 染色稳定较常规聚酯温度稍低

应用领域: 应用于健康、安全防护功能的高档装饰布、针织童装布、平布、工装布等

品牌：德福伦
申报企业：上海德福伦化纤有限公司

2. 中空阻燃聚酯纤维

特点: 永久阻燃效果、断裂强度较高、品质均匀、织物蓬松柔软

规格:

阻燃中空系列：3.33~6.67dtex × 60mm

常规短纤系列：1.56~8.89dtex × 38~65mm

应用技术: 参考常规涤纶产品

应用领域: 阻燃窗帘、幕布、汽车内饰材料、航空毯等

品牌：白斯特
申报企业：中国石化仪征化纤有限责任公司

3. 皮芯复合导电聚酯纤维

特点: 抗静电性能强、易织造、面料有起泡风格

规格: 166dex/16F

应用技术: 可与各种纤维混纺，适应阳离子及分散染料

应用领域: 防静电工装

品牌：周导
申报企业：江苏中杰澳新材料有限公司

1. Functional Antiflaming Molten Drop Resistant Polyester Fiber

Features: no poison, low smoke, molten drop resistance, no environmental pollution, permanent flame resistance

Specification: 1.56~3.33dtex×38~76mm

Applied technology: stable dyeing, the temperature being lower than that for conventional polyester

Application field: high-range decorative fabric functioning as health and safety protection, fabric for knitted children's clothes, plain cloth, tooling cloth

Brand: Defulun
Declaring Enterprise: Shanghai Different Chemical Fiber Co., Ltd.

2. Hollow Antiflaming Polyester Fiber

Features: having permanent antiflaming effect, breaking strength being higher, quality being even, fabric being fluffy and soft

Specification:

Hollow Antiflaming series: 3.33~6.67dtex×60mm

Conventional staple series: 1.56~8.89dtex×38~65mm

Applied technology: refer to conventional polyester product

Application field: antiflaming curtain, screen fabric, Auto. interior material, aviation carpet

Brand: Baiside
Declaring enterprise: Sinopec Yizheng Chemical Fiber Co., Ltd.

3. Core-sheath Conductive Polyester Fiber

Features: strong antistatic property, being easy to weave, fabric having blistering style

Specification: 166dex/16F

Applied technology: it can be blended with various fiber, adapting to positive ion and disperse dye.

Application field: antistatic working uniform

Brand: Zhoudao
Declaring Enterprise: Jiangsu ZJA New Materials Co., Ltd.

五、功能纤维
Functional Fiber

将大自然的不同素材与传统纤维共聚或共混经熔融纺丝或湿法纺丝，改变已有纤维分子结构、表面结构，精心设计、匠心打造，提升产品功能，实现纤维完美升级。开发具有抑菌、透气凉爽、防紫外线等功能产品，让人们尽享舒适与健康。

Different elements of nature are copolymerized or blended with traditional fiber to change the molecular structure and surface structure of existing fiber through melt spinning or wet spinning, so as to improve product function and realize perfect upgrade of fiber through meticulous design. Products having functions including anti-bacteria, being breathable and cooling, and anti-ultraviolet are developed to make people enjoy comfort and health.

1. 抗紫外凉感聚酯纤维

特点: 高效抗紫外、可见光透过率高、亲水、绿色环保、触感凉爽、性能持久

规格: 22~33dtex/24F

应用技术: 抗紫外凉感聚酯纤维含量至少50%

应用领域: 户外制品、薄型防晒衣

品牌：安仕
申报企业：浙江银瑜新材料股份有限公司

2. 凉感聚乙烯复合纤维

特点: 手感柔软凉爽，具有疏水性和抑菌防霉功能

规格: 83~333dtex /36~144F

应用技术: 与粘胶纤维、锦纶交织，织物的定型、染色温度均应在 120°C以内

应用领域: 用于凉席、运动服、家纺等领域

品牌：PEPA
申报企业：凯泰特种纤维科技有限公司

3. 细旦抑菌聚丙烯纤维

特点: 抑菌、除味、环保、轻质、保暖

规格: 122dext/72F

应用技术: 整烫温度≤ 130°C，时间≤ 2min

应用领域: 贴身衣物、袜子、鞋面

品牌：蒙泰丝
申报企业：广东蒙泰高新纤维股份有限公司

1. Anti-ultraviolet Cool-feel Polyester Fiber

Features: efficient ultraviolet resistance, high visible light transmittance, being compatible with water, environmental protection, feeling cool, permanent property

Specification: 22~33dtex/24F

Applied technology: the content of Anti-ultraviolet Cool-feel Polyester Fiber is no less than 50%.

Application field: outdoor products, thin sunscreen clothes

Brand: Anshi
Declaring Enterprise: Zhejiang Yinyu New Materials Co., Ltd.

2. Cool-feel Polyethylene Complex Fiber

Features: feeling soft and cool, having functions of hydrophobicity and bacteria & mould proof

Specification: 83~333dtex /36~144F

Applied technology: it is interweaved with viscose and chinlon, the temperatures for fabric setting and dyeing are no more than 120°C .

Application field: summer sleeping mat, sports wear, home textile

Brand: PEPA
Declaring enterprise: Kaitai Special Fiber Technology Co., Ltd.

3. Fine Denier Anti-bacteria Polypropylene Fiber

Features: anti-bacteria, taste removal, environmental protection, light weight, keeping warm

Specification: 122dext/72F

Applied technology: pressing temperature≤130°C time≤2min

Application field: underwear, socks, shoe upper

Brand: Mengtai Fiber
Declaring Enterprise: Guangdong Modern High-tech Fiber Co., Ltd.

4. 光谱蓄热纤维

特点： 热源广泛，随时吸收阳光、灯光以及人体自身的热量；快热感强，效果持久、温暖舒适。

规格：

光谱蓄热聚酯中空短纤：1.33/3.33dtex×38/60mm（有硅、无硅）

光谱蓄热聚酯长丝：83dtex/72F、167dtex/144F

光谱蓄热聚酰胺6短纤：1~15dtex×38~130mm

应用技术：

光谱蓄热聚酯中空短纤：

无硅和有硅可按一定比例混合梳理铺网做成絮片，有硅产品还可开松做填充用。

光谱蓄热聚酯长丝：可与其他纤维交织，也可单独使用；为保证织物发热效果，可将光谱蓄热聚酯纤维用于底纱或者面纱，染色及后整理上与常规产品相同。

光谱蓄热聚酰胺6短纤：纺纱方面，当短纤比例高于30%时，需要密切关注纤维及纺纱设备的静电处理、纺纱车间温湿度；织造方面，该短纤较其他纤维具有高断裂伸长率，制作梭织产品时要考虑径向缩率；染整方面，参考常规锦纶短纤。

应用领域： 户外服装、特种服装、填充物、家纺制品、保健医疗制品等

品牌：白斯特（仪征）、火绒（恒逸）、全谱蓄热（恒天中纤）

申报企业：中国石化仪征化纤有限责任公司；浙江恒逸石化有限公司；恒天中纤纺化无锡有限公司；上海安凸阻燃纤维有限公司

4. Spectrum Thermal Storage Fiber

Features: having extensive thermal sources, able to absorb heat of sunshine, lamplight and human body, strong fast-hotness, long-lasting effect, being warm and comfortable

Specification: Spectrum Thermal Storage polyester hollow short fiber: 1.33/3.33dtex×38/60mm (with silicon, without silicon), Spectrum Thermal Storage polyester filament: 83dtex/72F,167dtex/144F,Spectrum Thermal Storage polyamide 6 staple: 1~15dtex×38~130mm

Applied technology: Spectrum Thermal Storage polyester hollow short fiber: the product with silicon and that without silicon can be mixed proportionally, streamlined and netted to form flocculus, the product with silicon can also be opened to be used for filling;

Spectrum Thermal Storage polyester filament: it can be interweaved with other fiber and can also be used separately; in order to ensure the heating effect of fabric, it may be used in ground yarn or veil, with the same dyeing and finishing with conventional products;Spectrum Thermal Storage polyamide 6 short fiber: for spinning, when the proportion of short fiber is more than 30%, close attention should be paid to the fiber and spinning device static treatment and the temperature and humidity of spinning workshop; for weaving, because this short fiber has higher breaking elongation than other fiber, the radial shrinkage rate should be considered when woven products are manufactured; for dyeing and finishing, refer to the conventional polyamidestaple.

Application field: outdoor clothing, special clothing, filler, home textiles, healthcare products

Brand: Baisite (Yizheng), Huolong (Hengyi), Quanpu Xure (Hengtian Zhongxian)

Declaring Enterprise: Sinopec Yizheng Chemical Fiber Co., Ltd. ; Zhejiang Hengyi Petrochemical Co., Ltd. ; CHTC Sino Fiber Wuxi Co., Ltd. ; Shanghai Antu Antiflaming Co., Ltd.

六、轻柔纤维
Soft Fiber

轻柔，充满想象与美好的情感，轻柔纤维挑战纤维加工技术和纤维细度极限，使纤维产品更加轻薄、柔韧，将轻柔的特质在制品中充分呈现。轻柔纤维制品既节省了原材料的使用，又克服了重力对人体的约束，表现轻盈，给身心自然的呵护，特别是用于终端服装领域，给服装柔软丝滑、轻盈细腻的质感与风姿。

Softness is full of imagination and beautiful feelings. Challenging fiber processing technology and fiber fineness limit, soft fiber makes fiber products more light, thin and flexible and makes the traits of softness fully appear in products. Soft fiber products not only save the use of raw materials but also show lightness and give human body and mind natural care overcoming the restraint of gravity on human body, especially when it is used in terminal clothing, it make clothing show quality and charm of being soft, silky, light and exquisite.

1. 细旦高强聚酰胺 6 纤维

特点：强度高、弹性好、手感糯滑、耐磨性突出，良好的耐蛀、耐腐蚀性能

规格：FDY22dtex/24F

应用技术：后加工时，需注意织造张力的控制，避免丝条磨毛或断裂；注意控制染色速度，避免染色不匀

应用领域：主要用于梭织、大圆机、经编、针织面料等

品牌：凯邦
申报企业：福建凯邦锦纶科技有限公司

2. 细旦（异形）循环再生聚酯纤维

特点：可代替原生熔体直纺涤纶 DTY、FDY

规　格：DTY110~495dtex/96~288F；FDY73dtex/24F

应用技术：参考原生常规细旦产品

应用领域：制作各种高端、环保服饰面料，如：高品质运动服装、毛巾等

品牌：永银
申报企业：江苏永银化纤有限公司

3. 细旦循环再生聚酯纤维

特点：纤维手感柔软、绿色环保

规格：FDY22dtex/12F，DTY15~22dtex/12~24F

应用技术：要注意生产张力，因纤度比较细，张力不易过大；统一批次的产品必须同时使用，禁止混批使用

应用领域：用于服装、针织品、床上用品等

品牌：如盛
申报企业：苏州如盛化纤有限公司

1. Fine Denier High-strength Polyamide 6 Fiber

Features: high strength, good elasticity, smooth feel, outstanding abrasion resistance, good anti-moth and anti-corrosion property

Specification: FDY22dtex/24F

Applied technology: when post processing, attention should be paid to controlling weaving tension to avoid strand sanding or breaking; attention should be paid to controlling dyeing speed to avoid uneven dyeing.

Application field: woven fabric, fabric made by circular knitting machine, warp knitted fabric, knitted fabric etc

Brand: Kaibang
Declaring Enterprise: Fujian KaiBang Polyamide Technology Co.,Ltd.

2. Fine Denier (shaped) Recycled Polyester Fiber

Features: able to replace native melt direct spinning DTY and FDY polyester fiber

Specification: DTY110~495dtex/96~288F; FDY73dtex/24F

Applied technology: refer to native conventional fine Denier products

Application field: various high-end and environmentally friendly dress and fabric such as high-quality sportswear, towel etc

Brand: Yongyin
Declaring enterprise: Jiangsu Yongyin chemical Fiber Co., Ltd.

3. Fine Denier Recycled Polyester Fiber

Features: feeling soft, being green and environmentally friendly

Specification: FDY22dtex/12F, DTY15~22dtex/12~24F

Applied technology: attention should be paid to production tension and the tension can't be too strong due to its fineness; the products with the same batch must be used at the same time; using products with different batches at the same time is prohibited.

Application field: clothing, knitwear, bed linen etc

Brand: Rusheng
Declaring enterprise: Suzhou Rusheng Chemical Fiber Co., Ltd.

七、生物基纤维

Bio-based Fiber

生物基纤维原料来源于自然，是未来资源发展的绿色通道；生物基纤维产品最终也回归自然，形成永续且生生不息的良性循环。生物基纤维与人体亲和，具有抑菌、生物降解等特性，充分体现了可再生资源的综合利用与现代纤维加工技术的完美融合。

The raw materials of bio-based fiber come from nature and it is a green channel for future resource development; bio-based fiber products return to nature eventually, so a benign cycle is formed which is sustainable and endless. Bio-based fiber has features of anti-bacteria and biodegradation, fully embodying the perfect fusion of the comprehensive utilization of renewable resource and the modern fiber processing technology.

1. 凉感聚乳酸纤维

特点：触感凉爽、优良的加工性能、织物悬垂性好

规 格：短纤：1.67dtex × 38mm；长丝：83dtex/72F

应用技术：可以与棉、粘胶、天丝等纤维进行混纺；采用分散染料，最佳染色的温度在110°C左右

应用领域：内衣、童装、运动服等服装面料，家纺产品，面膜、卫生用品等

品牌：ECOSPIRE
申报企业：恒天生物基材料工程技术（宁波）有限公司

2 原液着色聚乳酸纤维

特点：天然抑菌、亲肤、吸湿排汗、绿色健康、可完全生物降解

规 格：短纤 1.32dtex × 38mm；长丝55dtex/36F

应用技术：染色时，需要使用低温分散型染料，采用阶段升温工艺，每个温度停留时间不能长，最高温度不可高于110°C。

应用领域：内衣、袜子、家纺用品及无纺布领域

品牌：御丝
申报企业：河南省龙都生物科技有限公司；上海德福伦化纤有限公司

3. 三维卷曲聚乳酸纤维

特点：可生物降解、抑菌、高弹性回复率、本质阻燃

规格：三维立体结构 3.3~6.6dtex × 18~51mm

应用技术：建议填充比例占 20%-50%

应用领域：纺织品、卫材、填充材料、造纸领域等

品牌：长江
申报企业：恒天长江生物材料有限公司

4. 牛角瓜纤维

特点：中空度 85%，纯植物，100% 自然降解，具有蚕丝的光泽、羊绒的轻柔、棉花的舒适、天然亲肤，透气透湿

规格：16~26 μ m × 31~-35mm

应用技术：可混纺与纯纺，常规工序

应用领域：服装、家纺、油脂吸附材料、军品领域

品牌：魔树牛角瓜
申报企业：上海魔树生物科技有限公司

1. Cool-feel Polylactic Acid Fiber

Features: feeling cool, good processing property, fabric having good drapability

Specification: Staple: 1.67dtex×38mm; filament: 83dtex/72F

Applied technology: it can be blended with such fiber as cotton, viscose and lyocell; disperse dyes should be adopted, the best dyeing temperature is around 110°C .

Application field: fabric for underwear, children's wear and sportswear; home textiles, facial mask, health products etc

Brand: ECOSPIRE
Declaring Enterprise: Hengtian Bio-based Materials Engineering Technology (Ningbo) Co., Ltd.

2. Dope Coloring Polylactic Acid Fiber

Features: natural anti-bacteria, skin care, moisture absorption and sweat releasing, green and healthy, full biodegradation

Specification: staple 1.32dtex×38mm; filament 55dtex/36F

Applied technology: when dyeing, low-temperature disperse dyes and stepwise heating process need be used, the stay time at each temperature can't be long, and the highest temperature may not be higher than 110°C .

Application field: underwear, socks, home textiles and non-woven fabric

Brand: Yusi
Declaring enterprise: Henan Longdu Biotechnology Co., Ltd ; Shanghai Different Chemical Fiber Co., Ltd.

3. Three-dimensional Crimp Polylactic Acid Fiber

Features: biodegradable, anti-bacteria, high elastic recovery rate, nature antiflaming

Specification: three-dimensional structure 3.3~6.6dtex×18~51mm

Applied technology: suggested filling proportion is 20%-50%.

Application field: textiles, sanitary materials, filling materials, papermaking

Brand: Changjiang
Declaring enterprise: Hengtian Changjiang Biomaterial Co., Ltd.

4. Mudar Fiber

Features: hollowness of 85%, pure plant, 100% natural degradation; having gloss of silk, softness of cashmere and comfort of cotton; natural skin care, air and water vapor permeability

Specification: 16~26 μm×31~-35mm

Applied technology: it can be used for both blend and pure spinning, with conventional working procedures

Application field: clothing, home textiles, grease absorbing materials, military products

Brand: Mushu Niujiaogua
Declaring enterprise: Shanghai Mushu Biotechnology Co., Ltd.

八、原液着色纤维
Dope Coloring Fiber

通过纤维技术解决纺织产业链的环保问题是纺织产业链应对环保压力的方式之一。无染纤维改变传统染色工艺，在纺丝成型的过程中实现纤维染色，极大的降低了染色后加工的能耗和污染。同时融合功能化、细旦化技术，赋予纤维抑菌、凉感等功能。纤维制品耐洗、耐晒色牢度高、染色均匀，织物色彩丰富、风格独特。

Solving environmental issue in textile industry chain through fiber technology is one of modes by which textile industry chain copes with environmental pressure. Non-dyeing fiber changes traditional dyeing process and realizes fiber dyeing during the process of spinning forming, so as to largely reduce energy consumption and pollution of dyeing post-processing. Meanwhile it blends functional and fine denier technology and gives fiber properties of anti-bacteria and cool-feel. Fiber products resist washing and drying and have high color fastness and even dyeing; fabric is rich in colors and has unique style.

1. 原液着色竹材再生纤维素纤维

特点：抑菌、吸湿、亲肤、抗紫外、手感柔软

规格：0.89~5.56detx 及各种切长

应用技术：纺纱时注意慢打轻梳，碱处理时宜采用低碱短时间工艺，定型时温度不宜超过 180 度

应用领域：服装、家纺、袜子等

品牌：竹丽尔
申报企业：河北吉藁化纤有限责任公司

2. 抑菌原液着色聚酰胺 6 纤维

特点：抑菌、亲肤、环保、产品种类多样

规格：DTY (33~83dtex/12~48F)*2（合股丝）

应用技术：不推荐单独使用，可与其他纤维混纺，该产品的含量建议≥ 30%；后整理过程中，不能使用强氧化试剂，以免影响抑菌效果; 半成品存放在阴凉避光处，染色后储存。

应用领域：内衣、袜子、鞋垫、绷带、医用服饰及医用口罩等

品牌：达洁纶
申报企业：广东新会美达锦纶股份有限公司

1. Dope Dyeing Bamboo Cellulose Fiber

Features: anti-bacteria, moisture absorption, skin care, anti-ultraviolet, feeling soft

Specification: 0.89~5.56detx and various cut length

Applied technology: when spinning, it's necessary to hit slowly and comb gently it; when alkali treatment, low alkali short time process had better be adopted; when setting, the temperature had better be no more than 180 degrees.

Application field: clothing, home textiles, socks etc

Brand: Zhulier
Declaring Enterprise: Hebei Jigao Chemical Fiber Co., Ltd.

2. Anti-bacteria Dope Coloring Polyamide 6 Fiber

Features: anti-bacteria, skin care, environmental protection, diverse product variety

Specification: DTY (33~83dtex/12~48F)*2 (joint strand fiber)

Applied technology: using it alone is not recommended; it can be blended with other fiber with its content being no less than 30%; during after finishing, no strong oxidant can be used, to avoid influencing anti-bacteria effect; semi-finished products should be stored in a shady and cool place after dyeing.

Application field: underwear, socks, insole, bandage, medical clothing and mask etc

Brand: Dajielun
Declaring Enterprise: Guangdong Xinhui Meida Nylon Co., Ltd.

3. 细旦原液着色聚酰胺6纤维

特点：原液着色、环保无污染、色牢度高

规格：44~78dtex/12~48F

应用技术：定型温度控制在170°C -185°C，并适当超喂；后处理酸碱度中性为宜，pH值7左右；整理前胚布去油彻底，定型温度不宜过高

应用领域：汽车内饰、高档服装、户外休闲纺织用品等

品牌：华鼎锦纶
申报企业：义乌华鼎锦纶股份有限公司

4. 凝胶染色聚丙烯腈纤维

特点：无需染整、成本低，色牢度高

规格：1.6~6.6dtex

应用技术：纺纱、染整、织造、后整理参照常规的湿法腈纶

应用领域：毛衫、内衣、休闲面料

品牌：白山牌
申报企业：吉林奇峰化纤股份有限公司

5. 细旦凉感原液着色聚酯纤维

特点：光滑凉爽、舒适透气、抗静电、色彩绚丽

规格：22detx/12F

应用技术：直接用于织造，无需染色

应用领域：服装面料、夏季凉席、沙发垫、枕头罩、汽车内饰等

品牌：金霞
申报企业：浙江金霞新材料科技有限公司

3. Fine Denier Dope Coloring Polyamide 6 Fiber

Features: dope dyeing, environmental protection, no pollution, high color fastness

Specification: 44~78dtex/12~48F

Applied technology: setting temperature should be kept within 170°C -185°C , with appropriate overfeeding; when after finishing, PH degree is taken as neutral, with PH value being around 7; before finishing, the gray cloth should be completely free of oil, and the setting temperature should not be too high.

Application field: Auto. interior decoration, high-end clothing, outdoor recreation textiles etc

Brand: Huading Jinlun
Declaring Enterprise: Yiwu Huading Nylon Co.,Ltd.

4. Gel Dyeing Polyacrylonitrile Fiber

Features: no need for dyeing and finishing, low cost, high color fastness

Specification: 1.6~6.6dtex

Applied technology: for spinning, dyeing and finishing, weaving and after finishing, refer to conventional wet acrylic fiber

Application field: sweater, underwear, leisure fabric

Brand: Baishan
Declaring Enterprise: Jilin Qifeng Chemical Fiber Co., Ltd.

5. Fine Denier Cool-feel Dope Coloring Polyester Fiber

Features: being smooth, cool, comfortable, breathable, static resistant, and colorful

Specification: 22detx/12F

Applied technology: it is directly used for weaving, with no need for dyeing.

Application field: apparel fabric, summer sleeping mat, sofa mat, pillow case, Auto interior decoration etc

Brand: Jinxia
Declaring Enterprise: Zhejiang Jinxia New Materials Technology Co., Ltd.

九、循环再生纤维
Recycled Fiber

循环再生纤维对废弃资源进行综合利用，融合共聚、在线添加等改性技术，制造出媲美于原生品质的新型功能纤维，在得到消费者情感认可、满足消费者高端需求的同时，极大地减轻了废旧纺织品对环境造成的压力，实现循环、低碳与高附加值的统一。

Recycled fiber is a new functional fiber comparable to native quality, made by utilizing waste resources comprehensively and integrating such modification technologies as copolymerization and online addition. It largely reduces the pressure caused by waste textiles to environment while getting consumer emotion acceptance and meeting consumer high-end demand, and this realizes unification of cycle, low carbon and high added value.

1. 原液着色循环再生聚酯纤维

特点: 强度高、无需印染、绿色环保、可再生

规格: 1.56dtex × 38mm

应用技术: 产品后整理或者混纺时参考原生产品

应用领域: 纱线、机织布、针织布、无纺布等

品牌：立峰牌
申报企业：福建省长乐市立峰纺织有限公司

2. 循环再生聚酰胺 6 纤维

特点: 绿色环保、可再生

规格: 44.4~55.6dtex/24F

应用技术: 可与其他纤维混纺；染色过程中应充分洗油，避免染色条痕；后期整理时，应避免长时间的日光和紫外线照射

应用领域: 用于织袜、包纱、经编等具有环保理念的纱线

品牌：恒申
申报企业：长乐恒申合纤科技有限公司

3. 蓬松保暖循环再生聚酯纤维

特点: 手感柔软、膨松保暖、压缩回弹性优良

规格: 2dtex × 25mm

应用技术: 适用于各类充绒充棉机，可与羽绒、其他纤维混充

应用领域: 用于玩具、床上用品、沙发、靠垫和服装填充料等

品牌：云绒
申报企业：杭州海科纤维有限公司

1. Dope Coloring Recycled Polyester Fiber

Features: high strength, no need for dyeing, being green, environmentally friendly and renewable

Specification: 1.56dtex×38mm

Applied technology: for after finishing or blending, refer to native products

Application field: yarn, woven fabric, knitted fabric, non-woven fabric etc

Brand: Lifeng
Declaring Enterprise: Fujian Changle Lifeng Textile Co., Ltd.

2. Recycled Polyamide 6 Fiber

Features: being green and environmentally, renewable

Specification: 44.4~55.6dtex/24F

Applied technology: it can be blended with other fiber; oil washing should be done completely during dyeing to avoid dyeing streak; when after finishing, long-time sunlight and ultraviolet irradiation should be avoided.

Application field: yarn having environmental protection idea such as knitted sock, covering yarn and warp knitting

Brand: Hengshen
Declaring Enterprise: Changle Highsun Synthetic Fiber Technologies Co., Ltd.

3. Fluffy Heating Recycled Polyester Fiber

Features: feeling soft and fluffy, keeping warm, having good compression returning rate

Specification: 2dtex×25mm

Applied technology: applicable to various velvet and cotton filling machines, able to be mixed with feather and other fiber for filling.

Application field: toy, bedding, sofa, cushion, clothing stuffing etc

Brand: Yunrong
Declaring Enterprise: Hangzhou Haike Fiber Co., Ltd.

十、智能纤维
Smart Fiber

智能纤维是一种能对温度、光、电产生感应的纤维，利用微胶囊技术，实现纤维颜色变化、温度双向调节和适应性，纤维颜色在有色与无色之间反复变化，可以在温度振荡环境中反复循环使用，为人体提供舒适的“衣内微气候”环境，使人体始终处于一种舒适的状态。

Smart fiber is one which can produce induction to temperature, light and electricity; microcapsulary technology is used to realize fiber color change and the two-way adjustment and adaptation of temperature, therefore, fiber can change from being colored to being colorless frequently, be reused repeatedly in the environment with a changing temperature, provide people with comfortable environment of “clothing inside climate”, and make human body always lie in a comfortable state.

1. 温感变色再生纤维素纤维

特点: 温感变色，可实现“有色—无色”状态的颜色变化

规格: 83~330dtex/24~60F

应用技术: 可以单独使用或与各种纤维交织；后整理温度不高于100°C，不可做漂白；洗涤时适宜使用中性或弱碱性的洗涤用品；产品可直接应用于面料，不建议进行二次染色；服装制品室内悬挂晾干，禁止暴晒，不可干洗

应用领域: 个性服饰，运动服装，婴幼儿服装，医疗包扎纱带、创可贴（可通过颜色变化显示伤口是否感染），医疗健康服装等

品牌：白鹭
申报企业：新乡化纤股份有限公司

2. 相变调温聚丙烯腈纤维

特点: 双向调温、柔软膨松、易染、色泽鲜艳、耐光、抑菌

规格: 1.67dtex × 38mm

应用技术: 1、使用过程中需注意调温相变点的选择，夏季需要凉感则熔融相变点应在28~30 度，冬季需要热感则结晶相变点应在20~25 度。2、染整及后处理时，加工温度不高于 140°C，避免相变材料的损耗。

应用领域: 保暖内衣、贴身衣物、絮片填充

品牌：焓赛尔
申报企业：北京宇田相变储能科技有限公司；大庆腈纶厂

3. 相变调温聚丙烯纤维

特点: 面料柔软、智能双向调温

规 格: 短纤：3.33dtex × 51mm； 长丝：333dtex/60F

应用技术: 加工温度< 130°C

应用领域: 短纤主要应用于絮片，长丝应用于保暖服装

品牌：焓赛尔
申报企业：北京宇田相变储能科技有限公司；湖北博韬化纤有限公司

1. Temperature-sense Discoloring Cellulose Fiber

Features: temperature-sense discoloring, being able to realize color change from being colored to being colorless

Specification: 83~330dtex/24~60F

Applied technology: it can be used alone or interweaved with various fiber; the temperature for after finishing is no more than 100°C , no bleaching is allowed; it’s better to use neutral or alkalescent detergents to wash it; it can be applied in fabric directly, secondary dyeing isn’t recommended; clothing should be hung and dried in the air indoor, and should not be exposed to strong sunshine or washed in a dry way.

Application field: personal clothes, sportswear, infant clothes, medical wrapping galloon, band aid (able to show whether wound is infected through color change), medical and health clothing etc

Brand: Bailu
Declaring Enterprise: Xinxiang Chemical Fiber Co., Ltd.

2. Phase Change Thermoregulation Polyacrylonitrile Fiber

Features: two-way thermoregulation, being soft, fluffy, easy dyeing, colorful, light and bacteria resistant

Specification: 1.67dtex×38mm

Applied technology: 1. it’s necessary to pay attention to choice of phage change and thermoregulation point during use; in summer when cool feel is needed, phase change point for melting should be 28~30 degrees; in winter when hot feel is needed, phase change point for crystallization should be 20~25 degrees. 2. When dyeing & finishing and after finishing, the processing temperature should not be higher than 140°C to avoid loss of phase change materials.

Application field: thermal underwear, lingerie, flocculus filling

Brand: Hansaier
Declaring enterprise: Beijing Yutian Phase Change Energy Storage Technology Co., Ltd.； Daqing Acrylic Plant

3. Phase Change Thermoregulation Polypropylene Fiber

Features: fabric being soft, intelligent two-way thermoregulation

Specification: 3.33dtex×51mm; filament: 333dtex/60F

Applied technology: processing temperature < 130°C

Application field: staple is mainly applied in flocculus, filament is mainly applied in thermal clothing

Brand: Hansaier
Declaring enterprise: Beijing Yutian Phase Change Energy Storage Technology Co., Ltd.; Hubei Botao Chemical Fiber Co., Ltd.

2019 春夏原液着色纤维色彩流行趋势

COLOR TREND OF DOPE-DYED FIBERS IN SPRING & SUMMER OF 2019

2018 年 1 月 10 日，北京服装学院（纤维时尚工作室）联合中国化学纤维工业协会（流行趋势研究与推广工作室）、国家纺织化纤产品开发中心联合研究分析并发布了 2019 春夏原液着色纤维色彩流行趋势。

用色彩装饰自身是人类最冲动、最原始的本能。无论古代还是当下，色彩在服饰审美中都起着举足轻重的作用。2019 年春夏是多彩变化的世界，作为绿色环保纤维，满足人们对于色彩的需求的同时，原液着色纤维具有减少排污、降低能耗的特点，同时在色牢度及面料回弹性方面较传统工艺有明显优势。2019 年春夏的原液着色纤维以环境友好的形象，向我们展示着她的绚丽缤纷。

On January 10, 2018, Beijing Institute of Clothing Technology (Fiber Fashion Studio) worked with China Chemical Fibers Industry Association (Trend Research & Promotion Studio) and National Textile Chemical Fiber Product Development Center for joint analysis about the color trend of dope-dyed fibers in the spring and summer of 2019.

Color-decoration is the most impulsive and primitive instinct of human beings. No matter in ancient times or nowadays, colors play an important role in aesthetics of clothing. The spring and summer of 2019 will be full of colors. As a kind of environment-friendly fiber that meet people's demand for colors, dope-dyed fiber boasts reduction of pollution discharge and energy consumption, and also has obvious advantages in color fastness and fabric rebound resilience as opposed to traditional technique. The dope-dyed fibers in the spring and summer of 2019 will display its colorful profusion in an environment-friendly image.

PANTONE 16-6324 TCX

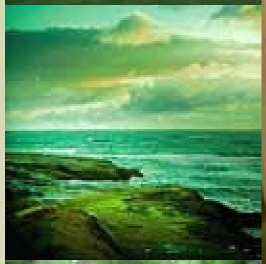
PANTONE 19-0230 TCX

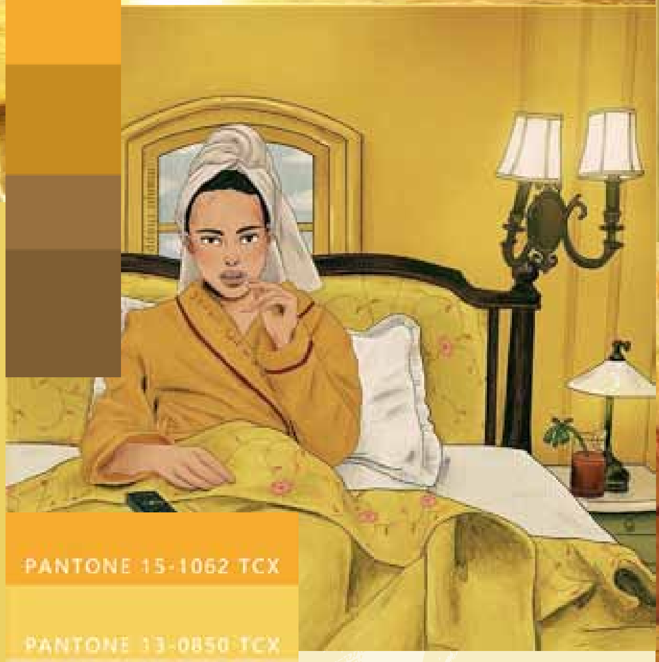
PANTONE 15-0538 TCX

绿色 Green

就像复苏与新生是春夏不变的主题，各式各样的绿色也是春夏不变的记忆。无论是刻意的描绘还是不经意的流露，在 2019 年的春夏中，绿色依然不会缺席。青梅色明媚、清新；深草绿沉静、孤高；花园绿深沉、浓郁；马蹄莲绿，浑厚、重浊；绿洲绿雅致、明朗；坚果绿硬朗、粗犷。2019 春夏的绿，像其纤维本身的特性一样，持续带给人们对大自然的向往。

Just as revival and renascence are permanent theme of spring and summer, all kinds of green colors also remain the same memory in this period. Whether for painstaking depiction or inadvertent manifestation, in the spring and summer of 2019, green colors will not be absent. Plum green is radiant and fresh, gardening green dark and flourishing, calla green vigorous and opaque, oasis green elegant and bright, nut green rough and tough. The green colors in the spring and summer of 2019, as the features of fiber itself, continue arousing people's yearn for the nature.





PANTONE 15-1062 TCX

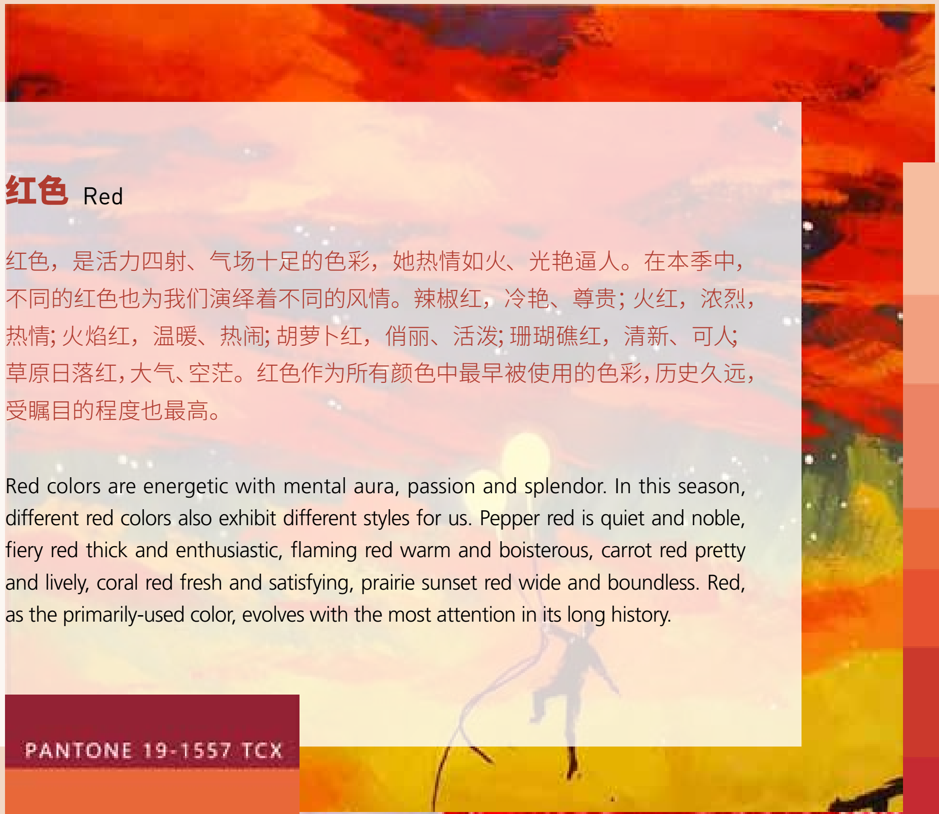
PANTONE 13-0850 TCX

PANTONE 12-0824 TCX

黄色 Yellow

黄色不仅象征着奢华与高贵，还给人以活力和希望。2019 春夏，相比于纯正的柠檬黄，一些橘黄、棕黄将受到更多关注。青铜棕，厚重、暗淡；橄榄棕，厚实、沉稳；金黄，华贵、奢侈；金融黄，愉悦、兴奋；小苍兰黄温暖，柔和；苍白香蕉黄，透亮、明媚。作为色环中最明亮、最辉煌的色彩，黄色色调的变化，带来不一样的感受。

Yellow not only symbolizes luxury and nobility, but also provides people with vigor and hope. In the spring and summer of 2019, compared with pure citrine, orange, tan and the like will draw more attention. Bronze brown is thick and dark, olive brown solid and calm, golden gorgeous and luxurious, financial yellow pleasant and exciting, freesia yellow warm and gentle, pale banana yellow transparent and enchanting. As the brightest and the most glorious color in the chromatic circle, the changes of yellow colors provide different senses.



红色 Red

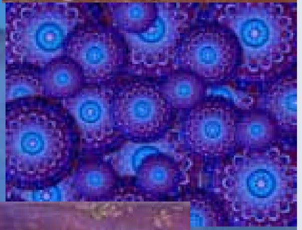
红色，是活力四射、气场十足的色彩，她热情如火、光艳逼人。在本季中，不同的红色也为我们演绎着不同的风情。辣椒红，冷艳、尊贵；火红，浓烈，热情；火焰红，温暖、热闹；胡萝卜红，俏丽、活泼；珊瑚礁红，清新、可人；草原日落红，大气、空茫。红色作为所有颜色中最早被使用的色彩，历史久远，受瞩目的程度也最高。

Red colors are energetic with mental aura, passion and splendor. In this season, different red colors also exhibit different styles for us. Pepper red is quiet and noble, fiery red thick and enthusiastic, flaming red warm and boisterous, carrot red pretty and lively, coral red fresh and satisfying, prairie sunset red wide and boundless. Red, as the primarily-used color, evolves with the most attention in its long history.

PANTONE 19-1557 TCX

PANTONE 17-1462 TCX

PANTONE 16-1442 TCX



PANTONE 18-4252 TCX

PANTONE 14-4317 TCX

PANTONE 18-3838 TCX

紫色和蓝色 Purple & Blue

蓝色是最冷的颜色，是大海与天空中的永恒。纯净的蓝色里，可以看到理智、文静、洁净与安祥 。而紫色是波长最短的可见光波，是不冷不热的中间色，色彩饱和度很高，给人的感觉是高雅而神秘，妖冶又尊贵。而紫色到蓝色渐变的系列色彩，在本季则被宠爱有加。紫外光色，优雅、孤傲；紫菀紫，浪漫、端庄；彩蛋紫，梦幻、惊喜；羊绒蓝，轻柔、细腻；石窟蓝，淡泊、幽静；紫菀蓝，典雅、温婉。

Blue is the coldest color, manifesting the eternal in the sea and the sky. In pure blue colors, you can see rationality, quietness, cleanness and serenity. Purple light has the shortest wavelength among all the visible lights. Purple is a mild medium color with high saturation degree with the sense of elegance and mystery, coquet nobility. The series of colors gradually varied from purple to blue are prevailing in this season. The ultraviolet light color is elegant and aloof, aster blue romantic and demure, Easter Egg purple dreamy and surprising, cashmere blue soft and delicate, grotto blue indifferent and tranquil, aster blue gentle and elegant.

无彩色系 Achromatic colors

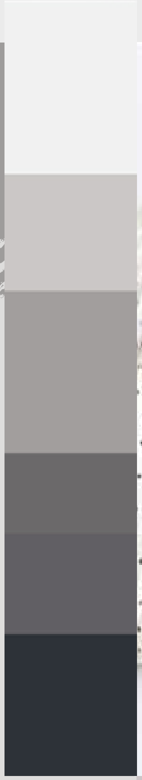
尽管是春夏期间，但人们对无彩色系的热情并没有因此而减退。无彩色系被称为万能色，可以与在色彩搭配中和谐地与任何彩色搭配。它们既低调，亦锋芒；既是一个空间中的对立，又在互相的交织中变得中庸且谦让。透露着寂静和深沉的纯黑色、透露着纯真和洁净的亮白色，透露着秩序和坚硬的埃菲尔铁塔灰、透露着迷茫的雾灰、以及透露着空灵和飘逸的风铃灰，这些色彩都将活跃在 2019 年春夏，继续演绎永恒的经典。

Though being in spring and summer, people's fever for achromatic colors has not come down. Achromatic colors are called universal colors, which can harmoniously match with any chromatic colors. They are low-pitched spearheads that are antagonistic to each other in a moderate and modest manner in the interlacing between both. The pure black for silence and depth, bright white for innocence and clean, the Eiffel Tower grey for order and rigidness, the fog grey for confusion, as well as the wind-bell grey for ethereality and elegance, will be active in the spring and summer of 2019, continuously performing eternal classic styles.

pantone 11-0601 TCX

pantone 15-3802 TCX

pantone 18-5210 TCX



2019 春夏原液着色纤维流行色
Color Palettes

SS2019 纤维素纤维流行趋势

MOMENTUM OF CELLULOSE FIBER IN SPRING & SUMMER OF 2019

SS2019 我们聚焦四个主题，分别是运动休闲 ATHLEISURE，优雅居家 HOMEWEAR，摩登都市 CITY 和悦动节拍 VIBES。

In spring and summer of 2019, we focus on four themes, namely,ATHLEISURE for sports and leisure, HOMEWEAR for home dressing outside, CITY for urban vogue and VIBES for entertainment tempo.

运动休闲

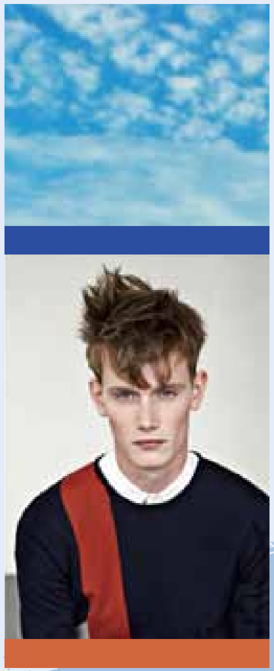
ATHLEISURE

运动休闲风不止是一种时尚趋势，更是一种生活态度。它代表着自由随性，活泼动感。成为每一季节不可缺少的一个品类。

运动休闲最早是来源于健身房，当人们结束运动之后，不再去更换服装而只是简单的搭一个外套就出门，将运动和日常的服装组合搭配，成为时尚的一部分。你可以是运动背心搭配大衣，运动服搭配 LV，Gucci 的时装包，都毫无违和感。

一些运动界的大佬像是耐克，阿迪达斯最早从功能性运动起步，渐渐他们将生活感受，外部环境融入科技感十足的运动装，使之变得更加有态度，有活力。而一些看似外围的品牌，像是 Zara，H&M，Mango 则从更年轻，更时尚的角度看运动，将流行色，配饰搭配运动感受，糅合成运动休闲这个特殊的品类。使得运动休闲更多彩，更柔软舒适但兼具动感。

纤维素纤维在其中扮演了重要的角色，特别是在女装的部分，它的流动感，光泽感和柔软感完全符合运动休闲这个主题，在带来舒适感的同时，也保存了面料的科技时尚功能。纤维素纤维使得运动装变得易于穿着，从最初追求最尖端的功能性，回归到舒适，有质感的穿衣体验。



ATHLEISUREembodies not only a fashion trend, but also an attitude toward life. With the representation of freedom and liveliness, it becomes an indispensable category in every season.

A THLESURE was derived from the fitness room. When people finished sports, they do not need to change clothes any more, but simply go out with a coat. It combines the clothes for sports and for daily life to become a part of fashion. You can wear a singlet with coat, sportswear with LV or Gucci fashionable bags, without any sense of disharmony.

Some sports giants, like Nike and Adidas, firstly started their business from functional sportswear.They gradually integratedlife experience and external environment to the sportswear with strong technology sense and made the latter more stylish and energetic. Meanwhile, some seemingly peripheral brands, such as Zara, H&M and Mango, treated sportswear from a younger and more fashionable angle, matched popular colors and accessories with sports feelings and created the special kind of ATHLEISURE, which makes sports and leisure more colorful, flexible, comfortable and dynamic.

Cellulose fiber plays an important role in it, especially in women's wear. Its fluidity, luster and softness are all in line with the theme of sports and leisure. While bringing comfort, it also preserves the scientific fashionable function of fabrics. Cellulosic fibers make the sportswear easy to wear, evolving from its initial pursuit of sophisticated functionalityto the comfortable dressing experience with tactile sensation.

面料成分：
Fabric composition:

100% 纤维素纤维
100% Cellulose fiber
纤维素纤维 / 棉
Cellulose fiber / cotton
纤维素纤维 / 涤纶
Cellulose fiber / terylene
纤维素纤维 / 锦纶
Cellulose fiber /chinlon
纤维素纤维 / Cordura 锦纶
Cellulose fiber / corduracinlon
弹性设计
Elastic design

梭织 / 针织：
Tatting / knitting:

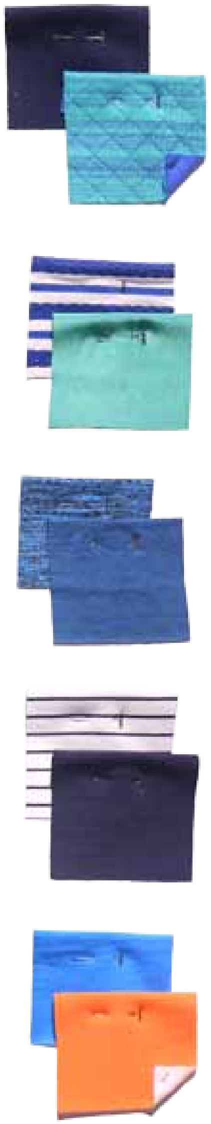
单面平纹针织布 / 双面针织布
Single-faced plain-knitted fabric / double-faced knitted fabric
抓绒布
Fleece
提花针织布
Jacquard loom
流动 / 科技感强的布面结构
Fabric structure with strong dynamic and technical sense

颜色：
Colors:

主流颜色
Mainstream colors
中性色
Neutral colors
跳跃的新色 / 色块拼接
Saltatory new colors / color splicing

重点：
Key point:

针织布
Knitted fabric



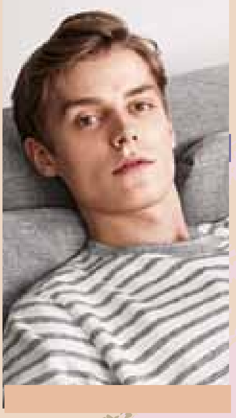
优雅居家

HOME

这是一个越来越重要的产品领域，居家服装近年来发生了很大的变化，并成为舒适休闲的代名词。在家中，人们选择简单、实用、方便的穿着方式，不用特地换装，他们就可以轻松自在地约朋友聊天、外出吃早饭，逛超市，遛狗等。现在大部分的品牌都已经拥有了自己的居家产品线。

最早的居家服是源于女性在家干的家庭杂务或者快速跑腿时穿的服装，当时只是一件简单的印花睡裙或者是舒适的可水洗织物。随着时代的发展，这样在家中穿的服装渐渐地发展成为一种既美观又耐用的家常便服，成为了家庭主妇衣橱中不可缺少的服装。它们兼具时尚性和舒适性，满足人们想自由地宅在家的愿望，同时也可以在家中约朋友下午茶。现在，居家服已经从最开始的随意，不修边幅，演变为自我彰显的最亲近手段，完成了华丽转型。更多的人希望即使在家的休闲时光也要保持优雅，时髦，甚至他们还希望能够穿着家居服走出去，享受属于自己的休闲空间。

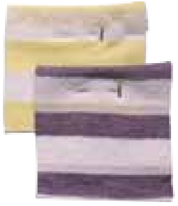
由于需求的不断升级，居家服的材料也发生了很大的改变，从最早的棉，演变为更优雅，更柔顺，更闪耀的材料，从而符合更多的场景需求。而纤维素纤维将在这个领域大放异彩，它比其他纤维更富有流动性，柔软性也是一流。通过与不同的纤维混纺，与不同特性的纱线交织，大大改善了居家服的时尚感，带来了全新的舒适享受。

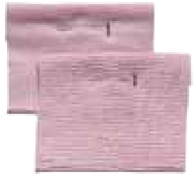


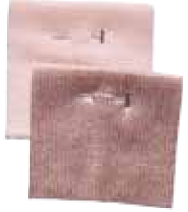
It is an increasingly important product field. Home clothing has changed a lot in recent years and therefore become a synonym for comfort and leisure. At home, people choose a simple, practical and convenient way of dressing. Instead of intentionally changing clothes, they can comfortably chat with friends, go out for breakfast, go shopping and walk dogs. Most famous brands now have their own home product lines.

The earliest homewear was derived from women's clothes when doing household chores or going on errands quickly. It wasjusta printing fabric or comfortable washables. With the development of the times, such clothes that were dressed at home has gradually developed into beautiful and durable homemade casual wear, and become an indispensable garment in housewives' wardrobe. Being both fashionable and comfortable, they can meet the desire of people to stay home freely orto invite some friends to afternoon tea at home. Now, the home wear has evolved from being random and sloven to the most intimate means ofself-manifestation, with the magnificent transformation. More people expect to remain elegant and fashionable in leisure times at home, and even want to go out in their home clothes and enjoy their own leisure space.

Owing to the continuous upgrading of demand, the materials of home clothes have also changed a lot, evolving from the earliest cotton to more elegant, more sparkling and softer materials, and thus meeting the needs of more scenarios. Cellulosic fiber will display its charm in this field for being more fluid and softer than others. Blended with different fibers and interwoven with yarns of different natures, it greatly improves the vogue sense of home clothing and brings new experience of comfort.







面料成分：
Fabric composition:

100% 纤维素纤维
100% Cellulose fiber
纤维素纤维 / 棉
Cellulose fiber / cotton
纤维素纤维 / 丝
Cellulose fiber / silk
纤维素纤维 / 麻
Cellulose fiber / linen
纤维素纤维 / 涤纶
Cellulose fiber / terylene
金银丝点缀
Gold & silver filaments
弹性设计
Elastic design

梭织 / 针织：
Tatting / knitting:

平纹汗布
Plain-wovenjersey
缎纹布
Satin-woven cloth
提花布
Jacquard cloth
条纹布
Striped cloth
格子布
Lattices
明暗相间的变色效果
Light-shade-interwovendiscoloration

颜色：
Colors:

中性色
Neutral colors
糖果色
Candy colors
深邃的色调
Deep hues

重点：
Key point:

休闲时光
Leisure times

摩登都市

CITY

从 80 年代开始，正装悄然发生了改变，从职业、严肃、刻板变得更加轻松自在，更有魅力，被时尚所认可。柔软、流畅的线条进入了日常的服装中。直到今天，我们仍可以说当今的服装是阿玛尼在 80 年代风格的延展，材料的柔顺性和舒适性并没有改变，而是朝着这个方向不断升级发展。可以说，在 80 年代，纤维素纤维就已经应用于这一系列的服装中，这种舒适，轻松，流畅的面料风格一经开启就从未被抛弃。

早先“展现权力”是职业装的设计理念，无论是僵硬的夹克，挺括的衬衫还是夸张的垫肩都充分表达了这一主题。而从乔治 • 阿玛尼（Giorgio Armani）开始，工作装转向了另一个标准，优雅，流动，富有魅力。同样的，舒适性也被提到了更重要的位置。设计师开始寻找更简单，更随性，更灵活的设计。服装变成了第二层皮肤，通过去除限制性肩垫，展现自然形状的肩膀来，用流体和柔软的织物来摆脱厚重的衬布，创造出轻盈的轮廓，这种通勤风格的职业装为日常活动提供了更多的舒适和自由。

纤维素纤维以更流畅和舒适的形式重新定义了正装的概念，由于这种纤维的使用，男性化的女士套装更具魅力和女人味，灵活流畅的面料展现了曲线美。通勤风格的正装相比职业装来说更随意，但比平日所穿的休闲装更正式，他们不仅在职场上能游刃有余地展现白领女性在办公室的魅力，也满足了她们在上班前、下班后以及平日社交场合所的穿着需求。

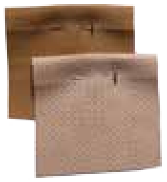
同时通勤职业装的季节性也变得相对模糊，通过纤维素纤维与其他产品的混纺交织，充分满足各个季节的需求，例如夏天，纤维素纤维与亚麻混纺带来凉感，爽滑感。而冬天，纤维素纤维与羊毛混纺，舒适保暖。

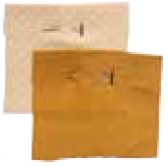
Since 1980s, suits have quietly evolved from professional, serious and stereotyped to comfortable, unrestrained and attractive, recognized by the fashion circle. Soft and smooth lines are applied to daily clothes. Until now, we can still say that today's clothing is the extension of Armani's style in 1980s. The flexibility and comfort of materials are not changed but upgraded continuously in this direction. It can be said that in 1980s, cellulose fiber has been applied to a series of garments. Such a comfortable, relaxed and smooth fabric style has never been abandoned from the beginning.

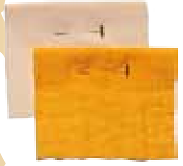
The primary idea of "showing power" is the design concept of career apparel. Rigidjackets, stiff and smooth shirts and exaggerated shoulder pads fully express such a theme. Since the time ofGiorgio Armani, the workwearis alternatively adapted to another standard, elegance, dynamic and charming. Meanwhile, comfort is also mentioned to be more important. Designers began to seek simpler, more casual and more flexible designs. Clothes became people's second layer of skin. Showing the natural shape of shoulders by removing the restriction of shoulder pads and getting rid of heavy lining cloth with fluid-shaped soft fabric for creation oflightsome outline, such a kind of commuting-styledworkwear provides more comfort and freedom for people's daily activities.

Cellulose fiber redefines the concept of suits in a more smooth and comfortable form. Because of the use of such fiber, the masculine women's suit is more attractive and feminine, with itsflexible and smooth fabric showing the curvilinear beauty. The commuting-styled suit is more casual than workwear, but more formal than casual clothes in daily life. The commuting-styled suitcan not only skillfully exhibit white-collar women's charm in offices, but also meet their dressing demands before work, after work and on social occasions.

Meanwhile, the seasonal features of commuting-styled workwear have become relatively vague. By blending and interweaving cellulose fiber and other products, the workwear meets the needs of all seasons. For example, in summer, cellulose fiber and linen are blended for cool and smooth feelings; in winter, cellulose fiber and wool are blended for comfort and warmth.







面料成分：

Fabric composition:

100% 纤维素纤维

100% Cellulose fiber

纤维素纤维 / 棉

Cellulose fiber / cotton

纤维素纤维 / 涤纶

Cellulose fiber / terylene

纤维素纤维 / 羊毛

Cellulose fiber / wool

弹性设计

Elastic design

梭织 / 针织：

Tatting / knitting:

经典的图案

Classic pattern

3D 立体效果（女性服装）

3D stereoscopic effect (women's wear)

罗马布

Pont-de-Roma

颜色：

Colors:

主流颜色

Mainstream colors

中性色

Neutral colors

暖色的搭配

Matching of warm colors

重点：

Key point:

套装

Suit

悦动节拍

Vibes

打破旧规则建立新秩序。越来越多的人不满足于现有沉闷的，常规的搭配，他们开始寻求能够代表他们独立个性的服装。奢侈品品牌也开始根据市场新需求做出了改变，勇敢尝试新风格，使用多色彩的叠加，冲击，带来全新的视觉刺激，建立新的美学体系。

最早的改变从Gucci，从巴黎世家开始，他们抛弃了传统的设计，大胆的采用了各种混搭。帆布鞋配合时装大衣，冬装配短裤，拖鞋外穿，一开始被世人不容，但渐渐地发生了转变，越来越多的年轻人为这种新秩序疯狂，主流时尚也开始接受这样多彩，百变的风格。

在这个主题里，不同颜色和纹理在混乱中寻找和谐的搭配，复古服装风格与更现代的作品混合在一起。针对年轻的群体，推崇打破常规，前瞻性的设计理念。没有不妥协的风格，没有确切的季节。在这个主题中，印花，提花，蕾丝，平纹针织面料，颜色复合在一起。纤维素纤维与其他纤维如棉，羊毛，亚麻，聚酯混合带了不同肌理叠加的效果，不同的材料碰撞也带来了全新的色彩可能。

Break the old rules and set up the new orders. More and more people are not satisfied with the current boring, regular clothes matching. They have begun to seek clothes that can represent their independent personality. Luxury brands have also started to make changes based on new market demands, bravely try new styles, use multi-color overlay and impact, bring new visual stimulation and establish new aesthetic system.

The earliest change is started from Gucci and Balenciaga. They abandoned traditional designs but boldly adopted a variety of mix-up. Canvas shoes are matched with fashion coat and winter wear with shorts, while slippers are worn as fashion shoes. People refused such a mode, but gradually changed their minds. More and more young people became crazy about such a new order, while mainstream fashion began to accept such an ever-changing colorful style.

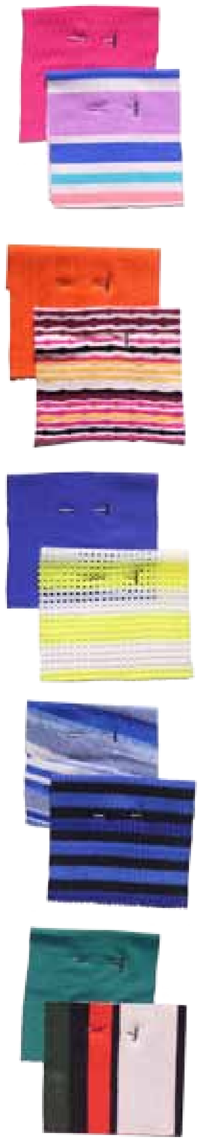
In such a theme, different colors and textures find harmony in disorder, retro costume style is mixed with more modern works. Oriented to young group, they praise highly for the design concept of breaking the conventional and looking forward. There is neither an uncompromising style nor an exact season. In such a scheme, various colors are blended in printing, jacquard, lace, and plain-knitted fabrics. Cellulose fiber is mixed with other fibers, like cotton, wool, linen and polyester, with unique texture superposition effect. The collision between different materials provides possibilities for brand new colors.

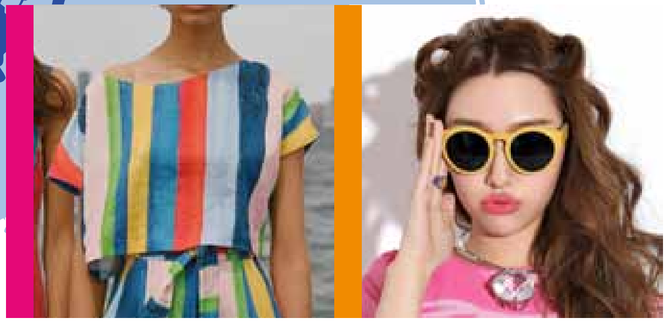
面料成分：
Fabric composition:

100% 纤维素纤维
100% cellulose fiber
纤维素纤维 / 棉
Cellulose fiber / cotton
纤维素纤维 / 涤纶
Cellulose fiber / terylene
纤维素纤维 / 锦纶
Cellulose fiber / nylon
弹性设计
Elastic design

梭织 / 针织：
Tatting / knitting:

平纹汗布
Plain-woven jersey
抓绒布
Fleece
提花针织布
Jacquard loom
条纹
Stripe





颜色：
Colors:

流行颜色
Popular colors
色彩暴击
Criticalstrikes of colors

重点：
Key point:

颜色的冲击
Impact of colors

作者：I love Viscose

纤维及下游趋势预测

FIBER AND DOWNSTREAM TREND AND ELEMENTS ANALYSIS

党的十九大提出我国现代化建设既是创造更多的物质财富和精神财富来满足人民日益增长美好生活的需要，也是提供更多优质生态产品以满足人民日益增长的优美生态环境需要。化纤产业的发展正是迎合了这种现代化建设需求，从增品种、提品质、创品牌上不断突破，实现“纤维改变生活”的美好愿景。

It was proposed at the 19th CPC National Congress that China’s modernization is not only to create more material and spiritual wealth to meet the needs of people's growing demand for better life, but also to provide high-quality eco-products to meet people's growing needs for beautiful ecologic environment. The development of chemical fiber industry is to cater to such requirements for modernization, make constant breakthrough in increasing varieties, improving quality and creating brands, and thus achieving the splendid vision that "fiber changes life".

一 . 纤维新材料预测

FIBER NEW MATERIAL FORECAST

阻燃纤维的现状与发展趋势

Fire-retardant Fibers in Reality and under Development

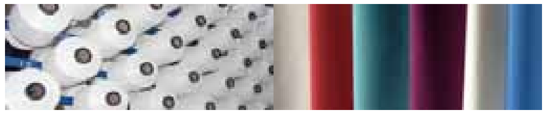


图 1 阻燃聚酯长丝及织物

Fig 1. Fire-retardant polyester filament and textiles

纺织品是关系到国计民生的重要基础材料，其应用范围已从人们的日常生活扩展到工业、农业、医疗防卫、航空航天、交通运输、军事等诸多领域，但随着应用领域的扩大，纤维制品也成为引发各类室内外火灾的主要隐患之一。近年来，由纺织品引燃或助燃给人们的生命和财产安全带来了巨大的损失，已经成为严重的社会问题。国内外对阻燃纤维及其纺织品进行了大量的研究工作，欧盟、美国、日本等很多国家都已通过严格的法律、法规，要求在某些特定场所必须使用具有阻燃功能的纤维或织物。随着我国阻燃法规和标准的颁布与强制实施，将促进环保无毒型和永久高阻燃性纤维及其制品的研究、开发与应用。

一、阻燃纤维的分类

阻燃纤维主要包括本质阻燃纤维与改性阻燃纤维。

本质阻燃纤维主要有无机纤维和有机高性能纤维，其中无机纤维包括玄武岩纤维、玻璃纤维、石英纤维、硼纤维、陶瓷纤维等；有机高性能纤维包括芳纶、聚酰亚胺纤维、聚苯硫醚纤维、芳砜纶和聚四氟乙烯纤维等。

改性阻燃纤维主要是指通过物理或化学改性后而获得的具有良好阻燃性能的纤维，如阻燃涤纶、锦纶、维纶及纤维素纤维等，其主要制备方法包括共聚切片纺丝法、共混纺丝法、复合纺丝法及涂覆法等。

阻燃纤维由于其独特的性能，在民用、军用及产业用等领域具有广阔的应用前景，它不仅可用于汽车、火车、飞机用阻燃纺品，而且还可以用于航天航空阻燃复合材料，宾馆、饭店等公共场所的装饰纺织品，医院、军队、森林救火防护服及家纺产品等。

As basic materials, textiles are of vital importance to national economy and people’s livelihood, with applications spreading already from daily life into such fields as industry, agriculture, medical treatment and defense, aviation and aerospace, communications and transportation, and military. With the increase in applications, however, fiber products have also become one of the main hidden dangers triggering various fires indoors and outdoors. For recent years, fires ignited or fueled by fiber products have caused huge losses to people’s lives and properties, already becoming a serious social problem. A great deal of research into fire-retardant fibers and their textiles has been carried out at home and abroad. Strict laws and regulations have been passed in many countries such as European Union members, the USA and Japan, requiring that fire-resisting fibers or fabrics must be used in certain particular places. As laws and regulations on fire resistance are promulgated and enforced in our country, the research, development and application of environment-friendly, non-toxic and permanently highly fire-retardant fibers and their products will be pushed forwards.

二、阻燃纤维发展现状

1. 阻燃聚酯纤维

阻燃聚酯早在上世纪 80 年代就已经工业化，90 年代中期，由塞拉尼斯开发的磷系阻燃单体，成功用于传统纺织品。杜邦、赫斯特、东洋纺等公司以有机、无机阻燃剂及复配阻燃体系，采用共聚、共混法相继实现阻燃聚酯纤维产业化。东丽纤维研究所（中国）有限公司以共聚共混相结合工艺制得了阳离子可染阻燃聚酯纤维。德国巴斯夫公司采用共聚合的方法获得的阻燃聚酯可用于生产纤维，杜拉纤维技术公司开发的阻燃聚酯工业丝其强度达到 5.8 cN/dtex,。意大利 Ital Match Chemicals、荷兰帝斯曼及日本 ADEKA 公司均有阻燃聚酯纤维的相关专利报道。近年来我国阻燃聚酯纤维发展迅速，四川大学、青岛大学、北京服装学院及东华大学等科研院所均有阻燃聚酯纤维的研究报道或授权专利。四川东材科技集团股份有限公司纤维级阻燃聚酯切片，江苏盛虹集团、上海石化、仪征石化、上海德福伦的阻燃聚酯长丝或短纤维均实现了规模化生产，并实现了出口创汇，其中上海石化生产的阻燃聚酯工业丝强度达到 6.0cN/dtex。但是，目前阻燃聚酯纤维的抗熔滴、抑烟等性能仍有待进一步提高。

One. Classification of fire-retardant fibers

Fire-retardant fibers mainly include inherent and modified fire-retardant fibers. Inherent fire-retardant fibers mainly are inorganic fibers and organic high-performance fibers, where, inorganic fibers include basalt fibers, glass fibers, quartz fibers, boron fibers, ceramic fibers etc, while organic high-performance fibers include aramid fibers, polyimide fibers, polyphenylene sulfide fibers, polysulfonamide fibers, polytetrafluoroethylene fibers etc.

Modified fire-retardant fibers mainly refer to the highly fire-retardant fibers obtained after physical or chemical modification, such as fire-retardant polyester, nylon, vinylon and cellulose fibers, with their main preparation methods including co-polymer chip spinning, blended spinning, composite spinning and coating.

Thanks to their unique features, fire-retardant fibers have the bright prospect of being applied in civil, military and industrial fields. They can be used not only as fire-retardant textiles in automobiles, trains and airplanes, but also as composite materials in aviation and aerospace, as decorative textiles in such public places as hotels and restaurants, and as protective clothes and textile products in hospitals, military facilities and fire-fighting entities.

Two. Present condition of development in fire-retardant fibers

1. Fire-retardant polyester fibers

Fire-retardant polyester was already industrialized as early as in 1980s. In middle 1990s, the phosphorous fire-retardant monomer developed by Celanese had been successfully used in conventional textiles. Such companies as DuPont, Hearst, and Toyobo had achieved one after another the industrialization of fire-retardant polyester, with organic and inorganic fire retardants and compounding fire-resistance system, using the methods of co-polymerization and blending. TORAY Fibers Research Center (China) has developed cationic dyeable fire-retardant polyester fibers with the technology that combines co-polymerization and blending. German's BASF has used the method of co-polymerization to obtain the fire-retardant polyester that can be used to produce fibers. The industrial yarn of fire-retardant polyester developed by Durafiber possesses the strength of up to 5.8 cN/dtex. Italy's Ital Match Chemicals, Holland's DSM, and Japan's ADEKA have all been reported to have patents on fire-retardant polyester fibers. For recent years, fire-retardant polyester fibers have developed rapidly in our country, as such scientific research institutes as Sichuan University, Qingdao University, Beijing Institute of Fashion Technology, and Donghua University have all been reported as studying fire-retardant polyester fibers or being granted patents. The fiber-grade fire-retardant polyester chips by Sichuan EM Technology Co., Ltd, and the fire-retardant polyester filament or spun by Shenghong Group in Jiangsu, by Sinopec Shanghai, by Sinopec Yizheng, and by Shanghai Different Chemical Fiber Co., Ltd., have seen scale production, generating profits from exportation, where, the industrial yarn of fire-retardant polyester produced by Sinopec Shanghai has its strength reaching 6.0cN/dtex. At present, however, the functions of fire-retardant polyester fibers such as anti-dripping and smoke suppression have yet to be improved.

2. 阻燃聚酰胺纤维

阻燃聚酰胺研究多集中于树脂领域，且以共混阻燃为主，巴斯夫、罗地亚、帝斯曼等公司均有代表性阻燃塑料产品。但阻燃聚酰胺纤维因制备技术难度高，仅有瑞士 EMS 公司宣布研发出共聚阻燃聚酰胺纤维，却未有市售产品。我国共聚型阻燃聚酰胺纤维研究主要集中在高校和研究所，尚未实现产业化。东华大学与广东新会美达股份有限公司合作开发出阻燃聚酰胺 6 纤维，然而长效耐水洗性受限。神马公司的 B890UN 牌号以及其他公司的少数阻燃聚酰胺产品，该类产品通过机械共混的方式加入磷系或其他无卤阻燃剂，其阻燃性能均能达到 UL94 V-0 等级。上海安凸塑料添加剂公司也有皮芯型阻燃聚酰胺 6 纤维的报道。上海凯赛生物科技有限公司开发的生物基聚酰胺 56 纤维具有本质阻燃性能，极限氧指数大于 32，纤维强度≥ 4.5cN/dtex，广泛应用于阻燃服装与装饰领域。

3. 阻燃再生纤维素纤维

Fire-retardant regenerated cellulose fibers

国外阻燃纤维素纤维及其制品的研究领先于国内，且早已实现再生纤维素纤维的产业化。奥地利 Lenzing 公司、芬兰 Kemira 公司、日本旭化成等公司采用共混法实现了阻燃再生纤维素纤维的产业化，其纤维在防护服、针织物及家用纺织品得到了广泛的应用。国内有关研究院所和企业也相继开展了阻燃再生纤维素纤维研究，青岛大学、天津工业大学及恒天海龙股份有限公司采用自主研发的硅系、磷系及磷氮系阻燃剂，制备了性能良好的阻燃粘胶纤维；唐山三友集团化纤有限公司、吉林化纤股份有限公司采用磷系阻燃剂，开发出磷系阻燃粘胶纤维；北京赛欧兰阻燃纤维有限公司，研发出新一代环保型硅 - 氮系阻燃粘胶纤维。但目前阻燃粘胶纤维的强度、阻燃耐久性等仍有待进一步提高。

图 2 阻燃维纶军用服

Figure 2. Military uniforms made of fire-retardant vinylon

2. Fire-retardant polyamide fibers

The research of fire-retardant polyamide is mainly focused on the field of resin, featuring the dominance of blending and fire resistance, with such companies as BASF, Rhodia, and DSM all having typical fire-retardant plastic products. Due to the great technical difficulty in preparing fire-retardant polyamide fibers, however, only Switzerland's EMS has announced that co-polymerized fire-retardant polyamide fibers have been developed, which are still not available on the market. The research of co-polymerized fire-retardant polyamide fibers is concentrated on universities and research institutes in our country, and their industrialization has not been achieved. The cooperation between Donghua University and Guangdong Xinhui Meida has resulted in fire-retardant polyamide 6 fiber being developed, but its long-term washing durability is limited. Phosphorus-based or other non-halogen fire retardants are added in a mechanically blended way to such products as branded as B890UN by Shen Ma and a few of fire-retardant polyamide products by other companies, all of which can reach the level of UL94 V-0 in their functions of fire resistance. Shanghai Antu Masterbatch Co.Ltd., is also reported to have fire-retardant polyamide 6 fibers of sheath-core type. The bio-based polyamide 56 fibers developed by Shanghai Cathay are inherently fire-retardant, with its limited oxygen index higher than 32, and its fiber strength ≥4.5cN/dtex, being widely used in the fields of fire-retardant clothes and decorations.

3. Fire-retardant regenerated cellulose fibers

The research of fire-retardant cellulose fibers and their products in foreign countries are well ahead of that in our country, and already saw the industrialization of regenerated cellulose fibers long ago. Such companies as Austria's Lenzing, Finland's Kemira, and Japan's Asahi Kasei have achieved the industrialization of fire-retardant regenerated cellulose fibers, with their fibers widely applied in protective clothes, fabrics and household textiles. Relevant domestic research institutes and enterprises have also successively carried out the research of fire-retardant regenerated cellulose fibers. Qingdao University, Tianjin Polytechnic University, and CHTC Helon Co., Ltd have prepared high-performance fire-retardant viscose fibers with the silicon-based, phosphorus-based and nitrogen phosphorus-based fire retardants that are developed on their own. Tangshan Sanyou Group Chemical Fibers Co., Ltd, and Jilin Chemical Fibers Co., Ltd have developed phosphorous-based fire-retardant viscose fibers with phosphorous-based fire retardants. SOL Flame-Retardant Fiber Co., Ltd in Beijing has developed a new generation of environment-friendly silicon-nitrogen-based fire-retardant viscose fibers. At present, however, the strength and fire-resisting durability of the fire-retardant viscose fibers still need to be further improved.

4. Fire-retardant vinylon

It is currently only in our country, Japan and North Korea that there is industrialized production of vinylon, but neither Japan nor North Korea has any fire-retardant vinylon product. Our country's fire-retardant vinylon mainly refers to that developed by Sichuan University in 1980s in collaboration with Sinopec SYW Chemical. At the beginning of this century, the former General Logistics Military Supplies Research Institute started organizing Sichuan University and Sinopec SYW Chemical to develop high-strength vinylon. Based on this, the Military Supplies Research Institute has continued organizing Sichuan University

4. 阻燃维纶

维纶目前只有我国、日本和朝鲜有工业化生产，但是日本和朝鲜均无阻燃维纶产品。我国的阻燃维纶主要是由四川大学在 80 年代与四川维尼纶厂合作研发的，本世纪初原总后军需所开始组织川大和川维研制高强维纶，在此基础上，军需所继续组织四川大学和上海全宇生物科技遂平有限公司自主研发了集酸源、碳源和气源为一体的高效无卤低烟无毒的阻燃剂，并开发出阻燃维纶制备成套工艺技术，成功制得极限氧指数达 29，纤维强度≥ 7.5cN/dtex，且可染色的高强阻燃维纶。阻燃维纶与其他阻燃纤维混纺面料，已应用于武警雪豹突击队、猎鹰突击队、武警航空作战大队、武警救援部队、火箭军作战服、解放军维和部队（见图 2）；并研发了公安阻燃战训服，并为厂矿、外军提供了含高强阻燃维纶的阻燃面料，性能优于美国杜邦公司的 NomexIIIA 面料、可以印制迷彩图案、且价格仅为其 2/3 ～ 1/2。

三、阻燃纤维发展趋势

随着人类安全意识的不断增加和阻燃法规的不断健全，阻燃纺织品的开发力度将会不断增大，特别是永久性阻燃纺织品将会成为市场的新热点。阻燃改性聚合物纤维的研究可能呈现出如下的发展趋势。

1. 长效环保型高品质阻燃纤维

长效环保高品质阻燃纤维是未来的发展趋势，例如，环保长效阻燃、抗熔滴、抑烟一体化的熔纺纤维，高强环保长效阻燃的湿法纺纤维。阻燃聚合物可加工性、阻燃性、抗熔滴性、抑烟性及力学性能的平衡是未来阻燃纤维研发方向。

2. 功能复合型阻燃纤维

阻燃拒污、阻燃拒水、阻燃抗静电、阻燃抗菌等复合功能纤维是未来的发展趋势。

3. 绿色环保型阻燃纤维

开发高效、无毒、无卤、无烟、无熔滴的阻燃纤维是未来的发展趋势。

4. 舒适型阻燃纤维

就舒适型阻燃纤维而言，应同时具有阻燃性、热湿舒适性、良好的加工性等。

5. 高技术型阻燃纤维

高技术型阻燃纤维分子结构独特，无须添加阻燃剂或通过改性，本身就具耐高温阻燃的性能，且具有较高的附加值和良好的经济效益，是未来阻燃纤维的发展方向。

结语

市场对阻燃纤维的需求量日益增加，化纤企业既要加大力度开发新型阻燃纤维，又要改进技术与装备，提高现有阻燃纤维的综合品质，满足民用、军用和产业用对高端阻燃纺织品的要求。

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and Shanghai Full Woo Biotechnology Co., Ltd so that a highly effective halogen-free low-smoke non-toxic fire retardant that integrates acid source, carbon source and gas source into one has been independently developed, and a complete set of technological process for preparing fire-retardant vinylon has taken place, with its limited oxygen index successfully reaching 29, fiber strength ≥7.5cN/dtex, leading to dyeable high-strength fire-retardant vinylon. The fabrics made by blending fire-retardant vinylon and other fire-retardant fibers have been used for Armed Snow Leopard Commando, Falcon Commando, Armed Combat Aviation Brigade, Armed Rescue Troops, Combat Rocket Army and PLA Peacekeeping Force (see figure 2). Uniforms used for fight-oriented training in public security have been developed, and the fabrics containing high-strength fire-retardant vinylon have been provided for factories, mines and military facilities, featuring higher performance than NomexIIIA fabrics by Dupont in the USA, able to have colorful patterns printed on, at a price that is only 1/2 to 2/3 of their counterparts'.

Three. Trends in the development of fire-retardant fibers

As mankind is more aware of safety and the regulations on fire resistance are constantly improved, the development of fire-retardant textile products will be increasingly intensified, and in particular, permanent fire-retardant textiles will become the new hotspot in the market. The research of fire-retardant modified polymer fibers may feature the following trends of development.

1. Long-term environment-friendly high-quality fire-retardant fibers

The future trends in development will be towards long-term environment-friendly high-quality fire-retardant fibers, for instance, the melt-spun fiber that integrates environment-friendly long-lasting fire resistance, anti-dripping, and smoke suppression into one, and the wet-spun fiber that is environment-friendly and enduringly fire-retardant. The research of fire-retardant fibers as fire-retardant polymers will develop in the future towards the balance between the qualities of being easily processed, being fire-retardant, avoiding dripping, and suppressing smoke, and other mechanical properties.

2. Functionally combined fire-retardant fibers

The fibers that combine the functions of resisting fire, resisting dirt, resisting water, resisting static electricity, and protection against bacteria will be on trend in the future.

3. Green environment-friendly fire-retardant fibers

There will be a developmental trend in the future towards highly effective, non-toxic, halogen-free, smokeless, and anti-dripping fire-retardant fibers.

4. Comfortable fire-retardant fibers

As far as comfortable fire-retardant fibers are concerned, the qualities of resisting fire, feeling comfortable under hot and wet conditions, and being easily processed should be maintained at the same time.

5. High-tech fire-retardant fibers

High-tech fire-retardant fibers have a unique molecular structure, without the need for addition of fire retardant or modification, inherently able to endure high temperature and resist fire, having higher additional values, providing good economic benefits, and setting the future trend in the development of fire-retardant fibers.

Conclusion

the market demand for fire-retardant fibers is increasingly rising. Chemical fiber enterprises need to not only intensively develop new fire-retardant fibers, but also improve techniques and equipment, enhance the existing comprehensive qualities of fire-retardant fibers, and satisfy the requirements of civil, military and industrial applications for high-end fire-retardant textiles.

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绿色、生态、循环再生纤维的研究与发展方向
Study and development of green, ecological, and regenerated fibers

1. 国外发展背景

随着社会的发展和科技的进步，生态文明理念和绿色消费观念日益深入人心，“十九大”提出构建人类命运共同体，坚持绿色发展、低碳发展、生态发展理念。绿色、生态和循环再生纤维的制造和使用成为社会责任的体现，受到广泛重视。

绿色体现于纤维的清洁生产过程、无害可降解等赋予全生命周期的环境友好特征。生态体现于纤维及其纺织品制造和使用的安全及环境友好特征。生物基纤维、可生物降解纤维、原液着色纤维、无重金属聚酯纤维充分体现了这些特点，成为国外研发、生产和应用的热点。

以废旧聚酯瓶和废旧纺织品为主要原料的循环再生纤维，正从废弃物一次性再利用为主的“开环循环”向“纤维到纤维、制品到制品的闭环循环”转变，再生产品达到或接近原生纤维品质。

欧美等发达国家相继推出生态纺织品的相关检测认证标准，如欧盟生态标签（Eco-label）和Oeko-Tex Standard 100，并不断修订生态纺织品认证标准，对生态纺织品提出日趋严格的环保要求。绿色、生态和循环再生纤维正在成为兼有社会效益和经济效益的新兴产业。

2. 国内产业研究方向

国内当前正处于产业发展初期，产量增速虽然较高，但由于需求总量偏小，产业进入快速增长阶段需技术、产品、品牌、政策环境等多个要素协同推进。通过重点产品的技术突破，提升品质、降低成本，形成规模生产和应用示范，是带动产业发展的重要路径。重要的研究方向包括以下几个方面。

1. Background information about foreign development

With social development and scientific advancement, the idea of ecological civilization and the concept of green consumption have increasingly been rooted into people’s mind. In 19th Party Congress of China, the idea of building a community of common destiny, insisting on green development, low-carbon development, and ecological development was proposed. Social responsibility is reflected in the manufacturing and use of green, ecologic and regenerated fibers, which has drawn wide attentions.

Green is reflected in the clean process of fiber production. Harmless and degradable features are indicative of a whole environment-friendly life cycle. Ecology is reflected in the environment-friendly features in the manufacturing and application of fibers and their textiles. Bio-based fiber, biodegradable fiber, dope-dyed fiber, and heavy metal-free polymer fiber fully embody these features, becoming the hotspot abroad in R&D, production and application.

The regenerated fiber for which the major raw materials are old and waste pet bottles and old and waste textiles, is changing from the “open-loop recycling” dominated by reusing rejected materials once and for all to the “closed recycling in a fiber-to-fiber and product-to-product manner”, with regenerated products reaching or close to the quality of original fibers.

Relevant specifications for examination and certification have been successively introduced in developed countries in Europe and America, for example, EU’s ecological labels (Eco-label) and Oeko-Tex Standard 100, and the specifications for certification of ecological textiles are constantly revised, bringing increasingly strict new environmental requirements for ecological textiles. Green, ecological and regenerated fibers are becoming the emerging industry combining social benefits with economic benefits.

2. Trend in study of domestic industries

It is currently at the beginning stage of industrial development in the country. Although output growth is fast, it is necessary to synergistically push forwards many elements such as technology, products, brands, and policies if the industry enters a fast growing phase, because total demands are relatively low. The important way of leading industrial development is to make technological breakthrough for key products, enhance product quality, lower costs, and establish scale production and demonstrative applications. The important trends in research include the following aspects:

（1）生物基纤维的低成本规模化制备技术

新溶剂法再生纤维素纤维、聚乳酸纤维、聚酯 PTT 纤维、聚酰胺 56 纤维为代表性品种。

其中，新溶剂法再生纤维素纤维重点突破绿色制浆及浆纤一体化技术、高效低耗规模化制备技术，开发高品质纤维，抗原纤化、阻燃等功能纤维新品种。聚乳酸纤维重点突破大容量连续聚合直接纺丝、非粮食资源乳酸制备、立构复合提高耐热性等技术，开发高品质细旦纤维、耐热纤维、原液着色纤维等新品种。

同时，开发生物基纤维纺织染整加工技术等，推动生物基纤维在服装、家纺和产业用纺织品等领域的高水平应用。

（2）量大面广品种的原液着色纤维制备技术

原液着色聚酯（PET）纤维、聚酰胺纤维、再生纤维素纤维为代表性品种。

重点开发聚酯、聚酰胺大容量装置的多元、多点在线添加模块化技术，深染、易染高色牢度色母粒、色浆及功能原液着色纤维制备技术等，建立原液着色纤维从颜料 / 染料、色母粒到纤维的一体化品质和基础色检测方法及标准体系，开发高品质、超细旦、高色牢度的原液着色纤维以及原液着色功能纤维等新品种。

(1) Technology for preparing bio-based fibers on a large scale at low costs

The cellulose fiber regenerated with new solvent method, polylactic acid fiber, polymer PTT fiber, and polyamide 56 fiber are the typical products.

Where, for the cellulose fiber regenerated with new solvent method, key breakthrough should be made in the technology for green pulp and pulp-fiber integration, and in the technology for highly efficient large-scale preparation at low energy consumption, and new varieties of functional fibers such as high-quality fiber, anti- fibrillation fiber, and fire-retardant fiber should developed. For polylactic acid fiber, key breakthrough should be made in such technologies as direct spinning and continuous polymerization at high capacity, preparation of lactic acid as non-food resources, and improvement on improved heat resistance with stereo-complex, and such new varieties as high-quality fine denier fiber, heat-insulating fiber, and dope-dyed fiber should be developed.

Meanwhile, it is necessary to develop the technology for spinning, dyeing, finishing and processing bio-based fibers, and push forwards the high-level application of bio-based fiber in such fields as clothes, household textiles, and industrial textiles.

(2) Technology for preparing dope-dyed fibers that are applied in large quantities and in a wide range of fields

Dope-dyed polymer (PET) fiber, polyamide fiber, and regenerated fiber are typical varieties.

It is necessary to intensively develop the technology for adding modules online, in a diversified manner, and in multiple places to the high-capacity device for polyester and polyamide, the technology for preparing deeply dyed and easily-dyed high-color-fastness color master batch, mill base, and functional dope-dyed fiber, establish the method for examining quality and base color and the standard system for dope-dyed fiber that integrates pigment/paints, color master batch, and fiber, and develop new varieties such as high-quality, fine denier, high-color-fastness dope-dyed fiber and dope-dyed functional fiber.

(3) 循环再生纤维的高值化制备技术

聚酯（PET）纤维是代表性品种。

重点开发废旧纺织品高效低成本预处理与分离技术、再生聚酯低能耗连续聚合、熔体高效纯化技术、功能再生聚酯纤维熔体直纺技术、功能再生聚酯纤维柔性化制备技术等，建立高水平聚酯纤维循环再生利用体系，开发出具有高附加值的低熔点再生聚酯纤维、高强工业丝等循环再生纤维新产品。

(4) 生态聚酯纤维的制备技术

钛系催化体系聚酯（PET）纤维是代表性品种。

重点开发高效绿色非重金属聚酯催化剂制备技术、无重金属聚酯纤维大容量连续聚合熔体直纺技术、环保纺丝加工助剂制备技术、生态聚酯纤维纺织染整加工技术等，开发出不含有重金属离子等有害物质、绿色环保、安全的生态聚酯纤维。

3. 创新引领作用

绿色、生态、循环再生纤维的产业化技术正朝着高品质化与高功能化的方向发展，对化纤行业产业化技术的发展具有引领作用。将多元、多点在线添加模块化技术应用于聚酯纤维、聚酰胺纤维和再生纤维素纤维等量大面广纤维的生产，可显著提升其差别化、功能性品种的生产效率与产品品质，大幅降低生产品种切换过程中的物耗和能耗。

绿色、生态、循环再生纤维在实现低成本、规模化制备的同时，更加注重纤维的功能性与舒适性。绿色、生态、循环再生纤维利用纤维细度、截面形态与力学性能的协同调控技术，可赋予纤维柔软的手感，优越的导湿性能和透气性能，显著提升其织物的服用舒适性。此外，绿色纤维重点品种—原液着色纤维制备所采用的多组分、高比例在线添加的强化分散技术，可广泛应用于其他纤维品种的纺前共混改性，实现高功能纤维品种的柔性化高效制备。绿色、生态、循环再生纤维的产业技术发展将推动化纤行业的技术进步，加快行业转型升级。

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(3) Technology for preparing regenerated fiber in a high-value manner

Polymer (PET) fiber is a typical variety.

It is necessary to intensively develop the technology for pre-treating and separating waste and old textiles in a highly efficient and cost-effective way, the technology for continuously polymerizing regenerated polyester at low energy consumption and for efficiently purifying fused mass, the technology for directly spinning the fused mass for functional regenerated polyester fiber, and the technology for softening functional regenerated polyester fiber, establish a high-level system for reusing polyester fiber, and develop new regenerated fiber products such as the regenerated polyester fiber with high additional value and low melting point, and high-strength industrial filament.

(4) Technology for preparing ecological polyester fiber

Titanium catalyst-based polyester (PET) fiber is a typical variety

It is necessary to intensively develop the technology for preparing high-efficiency green non-heavy metal polyester catalyst, the technology for directly spinning the fused mass that is continuously polymerized at high capacity with heavy metal-free polyester fiber, the technology for preparing the agent that helps process environment-friendly filament, and the technology for spinning, dyeing, finishing and processing ecological polyester fiber, and develop the green, environment-friendly, safe ecological polyester fiber that doesn't contain such harmful substances as heavy metal ion.

3. Leading role of innovation

The technology for industrializing green, ecological and regenerated fiber is developing towards high-quality and high-performance, playing a leading role in the development of industrialization technology in chemical fiber industry. If the technology for adding modules online, in a diversified manner, and at many points is applied in the production of the fibers that are used in large quantity and in various fields such as polyester fiber, polyamide fiber, and regenerated fiber, it can remarkably enhance the efficiency of production and the quality of products for differentiated and functional varieties, and largely lower the consumptions of materials and energy during the process of switching products.

While large-scale preparation at low costs is achieved for green, ecological, and regenerated fiber, more attentions should be paid to performance and comfortableness of fiber. If the technology for synergistically regulating the fineness, cross-sectional shape, and mechanical properties is used for green, ecological and regenerated fiber, it will enable the fiber to have a soft feel, good moisture-conductivity and ventilation, remarkably improving the comfortableness of textiles. In addition, the technology of enhanced dispersion for multiple components, high proportion and online addition, applied in preparing dope-dyed fiber, which is a key variety of green fiber, can be widely used for the blended modification before spinning for other fiber varieties, achieving the flexible high-efficient preparation of high-performance fiber varieties. The development in the industrial technology for green, ecological and regenerated fiber will push forwards the technical progress in chemical fiber industry, speeding up industrial transformation and upgrading.

Li Xin's team

China textile academy

安全防护用特种纤维及应用
Safety- and Protection-oriented Special Fibers and Applications

全球有数百万人在特殊危险环境下工作，安全防护用纺织品显得尤为重要，世界各国都在人体防护装备领域不断改进提高。设计高性能的防护材料，关键之一是确定最佳的防护材料，主要是各类特种纤维。国内外的工业化的特种纤维有很多，按防护功能分类，可分为耐高温阻燃纤维、耐辐照防静电纤维、防弹耐切割纤维、以及电磁屏蔽纤维等品种。

1. 耐高温阻燃纤维及纺织品

耐高温阻燃纤维及织物通常是指在较长时间经受高温 (>200°C) 尚能保持其原有的物理机械性能，且在空气中难燃烧的一类高性能纤维及织物，通常在高温下不熔融、离火自熄、高温尺寸稳定性好，常用作消防工作服、电焊工作服、防火手套、防火帘等防护制品。

耐高温阻燃纤维可分为：(1) 芳香族聚酰胺纤维：芳纶 1313(PMIA)、芳纶 1414(PPTA)；(2) 芳香族杂环类纤维: 聚苯并咪唑纤维 (PBI)、聚对苯撑苯并双噁唑纤维 (PBO)、聚酰亚胺纤维 (PI); (3) 芳环杂原子类纤维：聚苯硫醚纤维 (PPS)、聚砜基酰胺纤维 (PSA)；(4) 其他纤维：聚四氟乙烯纤维 (PTFE)、蜜胺纤维 (MF) 等。极限氧指数 (LOI) 可用来表示纤维的阻燃性能，指纤维在氧 - 氮混合气体中维持燃烧所需的最低氧含量的体积分数。极限氧指数越大，说明纤维越难燃。表 1 列举了几种耐高温阻燃纤维的 LOI 值和工作温度上限。

表 1 几种有机耐高温阻燃纤维的 LOl 值和耐热特性

纤维种类	PMIA	PPTA	PBO	PBI	PI	PTFE	PPS	PSA	MF
LOI 值 (%)	32	30	68	41	38	95	40	33	32
工作温度 (°C)	230	190	350	250	280	260	260	200	200

There are millions of people globally who are working under special dangerous conditions. Textiles for safety and protection appear to be particularly important. Throughout the world, constant progresses and advancements have been made in the field of personal protective equipment. The determination of best protective materials is the key to designing high-performance protective materials, which mainly involve a variety of special fibers. There are many industrialized special fibers at home and abroad, which can be classified according to protective functions as such types as high-temperature fire-retardant fibers, irradiation-resistant anti-static-electricity fibers, bulletproof cut-resistant fibers, and electromagnetic shielding fibers.

1. High temperature-enduring fire-retardant fibers and textiles

High temperature-enduring fibers and textiles generally refer to a type of high-performance fibers and textiles that can still maintain original physical and mechanical properties after being exposed to a high temperature (>200℃) for a longer period of time, but are difficult to burn in air. Generally, they are not melted down at a high temperature, self-extinguish any flame immediately after being moved away from fire, keep dimensions stable at a high temperature, and are often used for such protective products as fire-fighting uniforms, welders' uniforms, fire-retardant gloves, and fire-retardant curtains.

High temperature-enduring fire-retardant fibers are classified as: (1) aromatic polyamide fibers: aramid fiber 1313 (PMIA), and aramid fiber 1414 (PPTA); (2) aromatic heterocyclic fiber (PBI), phenylenebenzobisoxazole fiber (PBO), and polyimide fiber (PI); (3) Aromatic heteroatom fibers: polyphenylene sulfide fiber (PPS), and polysulfone amide fiber (PSA); and (4) other fibers: polytetrafluoroethylene fiber (PTFE), and melamine fiber (MF). Limited Oxygen Index ((LOI) can be used to represent the fire-resisting performance of fiber, referring to the volume fraction of the minimum oxygen content necessary for fiber to burn in oxygen-nitrogen mixed gas. The higher Limited Oxygen Index is, the more difficult fiber is to burn. The LOI values and the

Table 1. LOI values and heat-enduring properties of several organic high temperature-enduring fire-retardant fibers

Fiber type	PMIA	PPTA	PBO	PBI	PI	PTFE	PPS	PSA	MF
LOI value(%)	32	30	68	41	38	95	40	33	32
Operating temperature(°C)	230	190	350	250	280	260	260	200	200

间位芳纶是本征阻燃纤维的典型代表，在受火时其织物固化、熔融、成炭从而形成保护层，且燃烧时生烟量小，在安全防护、环保过滤等领域得到了广泛的应用。间位芳纶最早由美国杜邦公司研制成功并实现产业化，商品名为 Nomex，随后日本帝人公司在 1972 年也开始生产商品名为 Conex 的间位芳纶，本世纪初我国实现间位芳纶规模化生产，主要有烟台泰和新材料股份有限公司等公司。

聚酰亚胺纤维是一种新型的耐高温阻燃纤维，是已经工业化的聚合物中耐热性最好的品种之一，自身具有较高的阻燃性能，属于自熄性材料（表 2）。聚酰亚胺纤维织物损毁长度是主流消防服面料的 1/5。聚酰亚胺织物高温碳化，发烟率低，烟密度是 ABD0031 空客标准的 1/200。

表 2. 聚酰亚胺织物的阻燃特性

阻燃性能 (25 次洗涤)		PI 面料	芳纶面料	50%PI +50% 阻燃粘胶	50% 芳纶 +50% 阻燃粘胶
经向	损毁长度 (mm)	10	46	12	60
纬向	损毁长度 (mm)	8	48	13	57

二、耐辐照与防电弧纤维及纺织品

耐辐照纤维是指受高能辐照后不发生降解或交联并能保持一定力学性能的一类高性能纤维。耐辐照性能较好的聚合物纤维主要是聚酰亚胺纤维和芳纶等。电弧则是当金属或者其他导体靠近高压线，距离达到放电距离会产生瞬间弧光，这种弧光主要含紫外线，会产生弧光辐射。聚酰亚胺由于分子主链含有芳杂环结构，赋予其优异的力学、热学、耐辐照、介电及化学稳定性等性能。聚酰亚胺纤维经过 1×10^8 Gy 快电子辐照后，其强度保持率为 90 %，具有良好的耐辐射性能，是最耐辐照和防电弧的结构材料之一，作为高温介质及放射性物质的过滤材料和防弹、防火织物等领域大有用武之地。

三、防弹与耐切割纤维及纺织品

防弹纺织品通过吸收和耗散弹丸动能来达到保护人体或目标的目的，如防弹服、防弹头盔以及防暴车内衬等产品。防弹服通常由高性能纤维编织，目前广泛采用的是对位芳纶和超高分子量聚乙烯（UHMWPE）纤维。除了防弹领域，耐切割纺织品也是这两种高性能纤维的主要应用领域。

对位芳纶具有高强高模、优异的抗冲击性、良好的耐热性和抗腐蚀性，成为防弹和耐切割纺织品的主要纤维材料之一。日本帝人（Teijin）公司开发了用作装甲车内防金属弹片飞散的防弹织物“Twaron T765”，如图 1 所示，左半图是为配备防弹衬里的穿甲弹射入情况，右半图是含 Twaron T765 织物情况。如今国内已建成数套千吨级规模的生产装置并实现产业化，相关产品已逐渐投放市场。

UHMWPE 纤维具有高强高模特性，且密度小，比强度仅次于碳纤维，断裂伸长率达 3.6%，这使其具有较强的耐冲击性和能量吸收能力，是良好的防弹耐切割纤维。荷兰 DSM 公司利用该纤维耐磨、耐切割性能较好等特点，开发了防切割手套。美国 Honeywell 公司发明了一种防弹背心，防护夹层是 Spectra 制成的非织造布与 Kevlar 制成的一种机织物的结合物，可达到极好的防护功能。

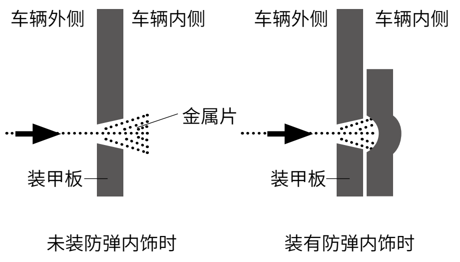

图 1 防金属弹片飞散示意图

upper limits to operational temperatures for several high temperature-enduring fire-retardant fibers are listed in Table 1.

Meta-aramid fiber is typical of intrinsically fire-retardant fibers, and the textiles made of it, if being set on fire, will be solidified, melted down and carbonized so as to form a protective layer. Moreover, it will only emit a small amount of smoke when burning, and is widely used in such fields as safety and protection, environmental protection, and filtration. The US' Dupont successfully developed meta-aramid fiber earliest and achieved industrialization, which was branded as Nomex. After that, Japan's Teijin also started to produce meta-aramid fiber in 1972, which was branded as Conex. At the beginning of this century, the mass-production of meta-aramid fiber was achieved in our country, mainly by such companies as TayHO in Yantai.

As a new type of high temperature-enduring fire-retardant fiber, polyimide is one of the best types to endure heat among already industrialized polymers, inherently having a better quality of resisting fire, and being attributed to self-extinguishing materials (Table 2). The length of burnt area in polyimide textiles is 1/5 of that in major fabrics for fire-fighting clothes. Polyimide textiles are carbonized at a high temperature, low in emission of smoke, with smoke density being 1/200 of that in ABD0031 Airbus Specification.

Table 2. Fire-retardant features of polyimide textiles

Fire-retardant performance (after being washed 25 times)		PI fabrics	Aramid fabrics	50%PI +50% fire-retardant viscose	50% aramid +50% fire-retardant viscose
Warp-wise	Destroyed length (mm)	10	46	12	60
Weft-wise	Destroyed length (mm)	8	48	13	57

2. Irradiation-enduring and electric arc-resistant fibers and textiles

Irradiation-enduring fibers refer to a type of high-performance fibers that are not degraded or cross-linked after being irradiated with high energy and maintain certain mechanical properties. The polymer fibers that have a better performance on irradiation resistance mainly are polyimide fibers and aramid fibers. An electric arc refers to the arc of light that will be instantly produced when metal or any other is so close to a high voltage power line that the distance has reached the one triggering the release of electricity, and this type of arcs mainly include ultraviolet rays, able to cause arc irradiation.

Because its molecular chain includes aromatic heterocyclic structures, polyimide has excellent properties such as stable mechanical, thermal, irradiation-enduring, dielectric and chemical properties. After being irradiated with 1×108 Gy fast electron, polyimide maintains 90 % of its strength, delivering a good performance on irradiation resistance, being one of the most irradiation-enduring electric arc-resistant structural materials, and playing a variety of important roles as the filtration material for high temperature medium and radioactive substance and in such fields as bulletproof and fire-retardant textiles.

3. Bulletproof and cut-resistant fibers and textiles

Through absorbing and dispelling the kinetic energy of projectiles, bulletproof textiles serve the purpose of protecting human bodies or targets, including the products such as bulletproof uniforms, bulletproof helmets and the linings of anti-riot vehicles. Bulletproof uniforms are usually woven with high performance fibers, and are currently made of para-aramid fibers and ultra high molecular weight polyethylene to a wide extent. In addition to bulletproof field, cut-resistant textiles are also the field where these two types of high-performance fibers are mainly applied.

High in both strength and modulus, excellently impact-resistant, giving a good performance on heat insulation and corrosion resistance, para-aramid fiber becomes one of the major fiber materials for bulletproof and cut-resistant textiles. Japan's Teijin has developed “Twaron T765” to serve as the bulletproof textiles in armored vehicles for protection against flying shrapnel, as shown in Fig. 1, where the left half shows that a arm or piecing bullet is shot into the bulletproof lining, while the right half shows the condition of Twaron T765 textile. Nowadays, several sets of 1000-ton production devices have been installed to achieve industrialization, with relevant products gradually put on the market.

四、电磁屏蔽与吸波纤维及纺织品

电磁屏蔽纤维是指电磁波的能量能够被纤维表面反射或吸收而使其传播受阻或减少，对人体起到防护作用的纤维材料。通常情况下，当导电纤维的电导率大于 1 S/m，可作为电磁屏蔽纤维。常用的电磁屏蔽纤维包括金属纤维、金属镀层纤维、碳纤维、聚苯胺纤维等。吸波纤维是指能够吸收或衰减入射电磁波，并将电磁能转变成热能或其它形式的能量而耗散掉的一类纤维，碳化硅纤维、多晶铁纤维有较好的吸波效果。

不锈钢纤维是最早开发出的屏蔽纤维，由美国 Brunswick 公司生产，随后，铝系和铜系金属纤维相继问世，目前已成为应用最多的防电磁辐射纤维。碳纤维具有良好的导电性和力学性能，是优良的电磁波反射材料。为了在宽广的频率范围内获得较好的电磁屏蔽性能，通常在碳纤维表面包覆相关材料，如沉积碳化硅等。例如，德国 BASF 公司研制出一种表面镀 SiC 的碳纤维，在 500 MHz 时的屏蔽效能可达 48dB。碳化硅纤维具有高强度、耐高温、低蠕变、膨胀系数小、耐腐蚀性强和化学稳定性好等特点，同时又具有吸波功能，在吸波纤维制备中运用较多。可将碳化硅纤维作为增强材料，来制作战机、舰艇等，以达到雷达隐身的效果。

结语

安全防护装备领域新产品的开发主要依赖于高性能纤维，而高性能纤维的主要发展方向是对现有品种的高性能化和低成本化。我国安全防护装备潜在的市场空间很大，我国应不断创新生产工艺技术，努力实现高性能纤维的高效化、高性能化、低成本化生产，深入开展应用研究与市场开发研究，通过纤维自身产品性能的提升及市场的调节来提高国内自给率。

东华大学材料学院 张清华 周士绪 李梦洁 巴兆虎 徐国芬

UHMWPE fiber is characterized by high strength, high modulus, and low density, with a specific strength being next to nothing but carbon fiber, and the elongation at break reaching 3.6%. This enables it to be more impact-resistant and more able to absorb energy, becoming a good bulletproof and cut-resistant fiber. Holland's DSM has made good use of the features of this fiber such as resisting wear and tear, and resisting cut, and has developed cut-resistant gloves. The US' Honeywell has invented a type of bulletproof vests, sandwiched with the protective mixture combining the non-woven fabrics made of Spectra and a type of woven textile made of Kevlar, able to deliver extremely good protective performance.

4. Electromagnetic shielding and wave-absorbing fibers and textiles

Electromagnetic shielding fiber refers to the fiber material that has a protective effect on human bodies because the energy of electromagnetic wave can be reflected or absorbed on fiber surface so that such transmission is blocked or reduced. Generally, when the electric conductivity of electricity-conductive fiber is higher than 1 S/m, it can be used as electromagnetic shielding fiber. Common electromagnetic shielding fibers include metal fiber, metal-coated fiber, carbon fiber, and polyaniline fiber. Wave-absorbing fiber refers to a type of fiber that can absorb or attenuate incoming electromagnetic wave and change electromagnetic energy into thermal energy or other forms of energy so as to disperse energy. Silicon carbide fiber and polycrystalline iron fiber have better effect of absorbing wave.

Stainless steel fiber is the earliest developed shielding fiber, manufactured by Brunswic in the US. Afterwards, aluminum- and copper-based metal fibers came out in succession, and have become the anti-electromagnetic radiation fibers that are most used today. Carbon fiber has good electricity-conductive and mechanical performances, and it is a good electromagnetic wave-reflecting material. In order to obtain a good electromagnetic shielding performance with a wider range of frequencies, the surface of carbon fiber is generally covered with relevant materials. The shielding effect at 500 MHz can reach 48dB. While delivering the performance of absorbing wave, silicon carbide fiber has such features as high strength, enduring high temperature, low creep, low expansion coefficient, being highly corrosion-resistant, and stable chemical properties, and is used more in preparing wave-absorbing fibers. Silicon carbide fiber can be used as reinforcing material for making fighter jets and naval ships, so as to achieve the effect of being undetectable to radar.

Conclusion

The development of new products in the field of safety protective equipment mainly relies on high-performance fibers, while the major trend in the development of high-performance fibers is towards adding high performances to existing varieties and lowering costs. Our country has huge market potential for safety protective equipment. Our country should constantly innovate technological processes of production, try to make the production of high-performance fibers highly efficient, highly functional, and highly cost-effective, carry out in-depth study of applications and market research, and improve domestic self-sufficiency through enhancing the performances of fiber products and market regulation.

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民用、军用及航空航天用纤维发展现状与趋势

Current Developments and Trends in the Fibers for Civil and Military Use and for Use in Aviation and Aerospace

纤维，特别是特种纤维及高性能纤维的发展为城市安全和国防安全提供了有力保障。纤维在城市安全及国防安全中的具体应用主要包括：建筑增强、防灾减灾、单兵服备系统、航空航天等。

1. 城市安全及国防安全用纤维种类

城市安全及国防安全用纤维种类繁多，常规纤维包括：天然纤维，如棉纤维、麻纤维等纤维素纤维；有机合成纤维，如维纶、腈纶、聚乙烯纤维、锦纶、丙纶等；无机纤维，如金属纤维、玻璃纤维（特别是耐碱玻璃纤维）、玄武岩纤维、碳纤维等。特种合成纤维包括：芳香族聚酰胺纤维、聚酰亚胺纤维、聚苯硫醚纤维、芳砜纶和聚四氟乙烯纤维、特种阻燃聚丙烯纤维、高韧性阻燃聚乙烯醇纤维、阻燃聚酯纤维、阻燃腈纶、有机杂环类纤维（聚苯并二噁唑、聚苯并噻唑、聚苯并咪唑纤维）等。混杂纤维包括: 钢丝 - 乙纶、钢丝 - 维纶、钢丝 - 丙纶、钢丝 - 尼龙等。

The development of fibers, in particular special fibers and high-performance fibers, has provided powerful assurance for urban safety and national security. Applications of fibers in urban safety and national security mainly include: building enforcement, fire and disaster prevention, personal military equipment, aviation and aerospace etc.

1. Fiber types for urban safety and national security

There are various fibers used for urban safety and national security, with conventional fibers including: natural fibers such as cellulose fibers including cotton fibers and bast fibers, organic synthetic fibers such as polypropylene fibers, vinylon, acrylic fibers, polyethylene fibers, polyamide fibers, polypropylene fibers, and nylon, and inorganic fibers such as metal fibers, glass fibers (especially, alkali-resistant glass fibers), basalt fibers, and carbon fibers. Special synthetic fibers include: aromatic polyamide fibers, polyimide fibers, polyphenylene sulfide fibers, polysulfonamide fibers and polytetrafluoroethylene fibers, special fire-retardant polypropylene fibers, high-tenacity fire-retardant polyvinyl alcohol fibers, fire-retardant polyester fibers, fire-retardant acrylic fibers, and organic heterocyclic fibers (polybenzazole, polybenzothiazole, and polybenzoimidazole fibers). Hybrid fibers include: steel wire- polyethylene fibers, steel wire-vinylon, steel wire- polypropylene fibers, and steel-wire nylon.

2. 发展现状

2.1 建筑增强及防灾、减灾用纤维

轻质高强纤维增强混凝土及预应力混凝土不仅可减少钢筋用量，减轻混凝土自重，改善钢筋混凝土结构的抗裂性能，并可大大增强其抗震、防灾、减灾性能。

纤维用于建筑增强最早于1965年由Goldfein提出，并将聚丙烯纤维用于美军工兵部队的防爆结构。60年代末，美国、欧洲开始将聚丙烯纤维混凝土用于水泥制品和建筑业。1971年英国制定了纤维增强混凝土用于管道、管件的国家标准。80年代以来，美国、欧洲研制出高强、高弹模的改性纤维用于增强混凝土。纤维增强混凝土的用量已占混凝土总量的10%以上，应用较多的是丙纶、维纶、锦纶以及高强高模聚乙烯纤维等。

中国建筑材料科学研究院和北京建筑材料研究所最早于上世纪80年代进行了丙纶和维纶混凝土的研究，近年来，国内相继开发了丙纶、高强高模聚乙烯纤维、高韧性维纶、芳纶、碳纤维增强混凝土。其中以碳纤维增强混凝土性能最优，具有其它纤维增强型混凝土所不具备的优良机械性能、防水渗透性能、耐自然温差性能，在强碱环境下具有稳定的化学性能、持久的机械强度和尺寸的稳定性。

2. Present condition of development

2.1 Fibers for building enforcement and disaster and fire prevention

Lightweight high-strength fiber-enhanced concrete and pre-stressed concrete cannot only reduce the usage of reinforcing bars, but also shed the dead weight of concrete, improving the performance of crack resistance by reinforced concrete structure, and possibly enhancing the performances of seismic resistance, and fire and disaster prevention.

Goldfein proposed earliest the use of fibers in building enforcement in 1965, and polypropylene fibers were used in the explosion-proof structure for American troops. In late 1960s, polypropylene fiber-reinforced concrete began to be used in cement products and building industry in the United States and in Europe. In 1971, a national specification for the use of fiber-reinforced concrete in pipelines and tubing was formulated in the UK. Since 1980s, the modified fibers with high strength and high elastic modulus have been developed in the US and in Europe for use in reinforced concrete. The usage of fiber-reinforced concrete already accounts for over 10% of the total of concrete, and the usages of polypropylene, vinylon, nylon and high-strength high-modulus polyethylene are relatively high.

China Building Materials Academy and Beijing Building Materials Institute carried out the research into polypropylene fiber- and vinylon-reinforced concrete as early as in1980s. For recent years, polypropylene fiber-, high-strength high-modulus polyethylene fiber-, high-tenacity vinylon-, aramid fiber-, and carbon fiber-reinforced concrete have been domestically developed in succession. Among them, carbon fiber-reinforced concrete has the best performance, delivering the good mechanical performances, the performance of anti-water seepage, and the performance of enduring temperature difference, which other fiber-reinforced concrete cannot give, and featuring stable chemical performances, lasting mechanical strength and stable dimensions in strong alkali environment.

Today, fiber-reinforced concrete has drawn wide attentions from at home and abroad. In the US, UK, Japan, Western Europe etc, a huge success has been made in using fiber-reinforced concrete for the covering layer on bridge surface and road surface (highway and airfield runway), as well as in mining and tunneling projects, and for the covering of side slopes, fire-prevention facilities, concrete patching, and industrial flooring. Japan's Disaster Prevention Research Institute has successfully developed polypropylene-reinforced concrete, and the model of bridge pier made of it can resist 1.5 times more severe earthquakes than the Kobe earthquake. Special polypropylene fiber-reinforced concrete is applied in the crossbeam of the extremely large transformation floor for Sichuan's World Trade Center, successfully solving the problems of cracking and low tenacity during the construction of high-grade bulky concrete. Special polypropylene fibers are added to C50 high-strength concrete in the cross section of the crossbeam on the transformation floor in the project of Chongqing's Jinshayuan Building, so as to largely improve the performance of resisting cracks for high-strength concrete. Polypropylene fiber-reinforced concrete able to resist cracks and prevent seepage is used in the underlying part and basement of National Grand Theatre, and there was no blockage during the entire process of casting. Its strength and anti-seepage level have

如今，纤维混凝土增强受到国内外广泛重视，在美国、英国、日本和西欧等地，纤维混凝土在桥面和路面（公路和机场跑道）的罩面层，采矿和隧道工程、边坡的固定、防火设施、混凝土修补、工业地面等方面的应用均获得了巨大成功。日本防灾科学研究所成功研制出聚丙烯纤维混凝土，由其建造的桥墩模型能够抵抗阪神大地震 1.5 倍以上的震动。重庆世界贸易中心在特大型转换层大梁中应用特种聚丙烯纤维增强混凝土，成功解决了高标号大体积混凝土施工中的抗裂和提高韧性等问题。重庆金厦苑大厦工程转换层大梁截面采用在 C50 高强混凝土中掺加特种聚丙烯纤维，以提高高强混凝土的抗裂性能。国家大剧院基础底板和地下室防水采用防裂抗渗聚丙烯纤维混凝土，整个浇注过程中未发生堵塞，强度和抗渗等级均满足设计要求，至今未出现可见裂缝。湖南月湖桥为预应力聚丙烯纤维钢筋混凝土连续梁桥，达到动、静态检测标准，符合设计要求。平顶山市平东线姚孟段铺设了 200m 的聚丙烯纤维混凝土路面，至今无明显裂缝、断面、错台现象。

纤维亦可应用于发泡水泥保温材料的增强，赋予保温材料良好的强度、韧性、保温和阻燃等功效。

纤维增强树脂基复合材料筋材应用到建筑混凝土梁、柱及门窗结构，实践证明，在对于抗震性能、耐久性与耐腐蚀性能有特殊要求的梁、柱、屋架等各种建筑承载结构加固补强方面，纤维增强树脂基复合材料以及其智能复合材料具有更为安全的性能优势和简便的施工优势。

纤维对城市防灾、减灾领域的作用体现在建筑结构抗震加固、临近建筑的山体锚固、城市防洪、建筑材料阻燃、工程抢险掩体以及防空工程等技术领域。纤维在给防灾与减灾领域用复合材料带来减重、增强、增韧、抗震、阻燃、保温等性能效益的同时，提供了广阔灵活的可设计性。例如，纤维使得其增强水泥基复合材料的重量大大降低，且韧性指标提升多倍，显著增强建筑结构抵抗瞬间冲击爆裂能力，避免钢筋直接暴露于火灾中，延缓建筑结构的损伤，有效减少次生灾害。

表 1 混凝土常用合成纤维的性能

纤维种类	抗拉强度	弹性模量	极限延伸率	比重	耐碱性	吸湿率	耐光性
聚丙烯单丝	285-570	3-9	15-25	0.91	好	0	不好
聚丙烯裂膜	450-650	8-10	8-10	0.91	好	0	不好
聚丙烯腈纤维	250-440	3-8	12-20	1.17	尚好	2.0	好
对位芳纶	1500-2000	27-40	3-5	1.43	尚好	2.0	尚好
高强高模量碳纤维	1750-2250	280-500	0.1-0.2	1.7-2.0	好	0	好

2.2 国防安全用纤维

2.2.1 单兵防护系

一套典型的单兵防护系统包括头盔、作战套服、携行具、防弹背心、作战靴等五个部分，可用于装备部队、武警等，在全域作战、立体攻防情况下为单兵提供战斗生存保障。系统基本的防护要求涉及伪装、阻燃、保暖、防弹、耐磨、透气、吸湿、散热、速干、拒水、保温、防水等，更高的防护要求还包括对化学、生物、放射性尘埃的防护。美军从上世纪 80 年代就启动了单兵综合系统的一体化建设，我国起步较晚，但近年来已获得高度重视。单兵防护系统的整体特点是根据任务不同，可逐层叠加，以满足全域作战要求。在设计时应考虑穿戴方便快捷、贴身稳固，便于肢体运动、具备多样化随身物品装载手段，易于快速取放等。单兵防护系统开发的关键是结构设计和材料性能，特种纤维材料为性能设计提供了可能性。

纤维品种主要有：芳纶纤维、阻燃粘胶、阻燃尼龙、吸湿排汗涤纶、抗菌整理聚酯、氨纶、腈氯纶、活性碳纤维等。

all met design requirements, and there has been no visible crack so far. The continuous girder of Hunan's Yuehu Bridge is made of pre-stressed polypropylene fiber-reinforce concrete, complying with static and dynamic testing criteria, and satisfying design requirements. Polypropylene fiber-reinforced concrete is used for the road surface that is 200 meters in length in Yaomeng section of Pingdong line in Pingdingshan City, where this is no obvious fracture, gap or faulting of slab ends so far.

Fibers can also be used to reinforce the heat insulation materials for foam cement, giving heat insulation materials good strength, tenacity, and the performances of heat insulation and fire resistance.

Reinforcement with fiber-reinforced resin-based composite materials is applied in concrete beams of buildings, pillars, doors and window assemblies. Practice has proven that, with respect to strengthening and reinforcing various load-bearing architectural structures such as beams, pillars and roof trusses on which special demands are placed by the performances of resisting earthquake, enduring wear and tear, and resisting corrosion, fiber-reinforced resin-based composite materials and their intelligent composite materials have the advantage of delivering more secure performances and the advantage of easy construction.

The effects of fibers on the field of disaster prevention and alleviation are reflected in such technical fields as strengthening architectural structure against earthquakes, anchoring mountain slopes for buildings in close proximity, urban flood defense, making building materials being fire-retardant, sheltering from engineering emergencies, and air defense works. While providing the benefit of reducing weight, increasing strength, improving tenacity, resisting earthquakes, preventing fire, and insulating heat for the composite materials used in the field of disaster prevention and alleviation, fibers offer many possibility for flexible designs. For example, fibers enable their reinforced cement-based composite materials to lose weight significantly, and increase tenacities several times, obviously enhancing the ability of architectural structures to resist instant impact and burst, preventing reinforcing bars from being directly exposed to fire, slowing down the damage to architectural structures, and effectively reducing secondary disasters.

Table 1. Properties of common synthetic fibers for concrete

Fiber type	Tensile strength /MPa	Modulus of elasticity /GPa	Extensibility limit /%	Specific gravity /(g/cm3)	Resistance to alkila	/% Moisture absorption	Light resistance
Polypropylene monofilament	285-570	3-9	15-25	0.91	good	0	poor
Polypropylene split film	450-650	8-10	8-10	0.91	good	0	poor
Acrylic fiber	250-440	3-8	12-20	1.17	so so	2.0	good
Para-aramid fiber	1500-2000	27-40	3-5	1.43	so so	2.0	so so
High-strength high-modulus carbon fiber	1750-2250	280-500	0.1-0.2	1.7-2.0	good	0	good

2.2 Fibers for national defense and security

2.2.1 Personal protective system

A set of typical personal protective system includes five parts, helmet, combat uniform, portable tools, bulletproof vest, and combat boots, able to be used to equip troops and armed policemen, providing life-saving protection during war for individual troops in the case of combats across entire areas, and attacks and defense in a three-dimensional way. The basic protective requirements of the system involve camouflage, fire resistance, heat insulation, resistance to bullets, enduring wear and tear, ventilation, moisture absorption, heat radiation, fast drying, water resistance, heat preservation, and being waterproof. Higher protective requirements also include the protection against chemical, biological and radioactive particles. American troops have started the construction of integrated personal comprehensive system since 1980s, which started relatively late in our country, but has received great attentions in recent years. The characteristics of the personal protective system as a whole lie in that layers can be added one by one depending on different tasks so as to meet the requirements on the combats across whole areas. At the time of designing, attentions should be paid to being easy to wear, being tight-fitting and secure, being suitable for the movement of arms and legs, and providing diversified means for carrying personal belongings, and being easy to take or deposit. The key to the development of personal protective system is structural design and performance of materials. Special fiber materials provide possibilities for designing performances.

2.2.2 航空与航天领域

作为国家战略发展的关键新材料，高性能纤维及复合材料增强用特种纺织品在航空航天、国防安全等高技术领域的应用和需求与日俱增。军用和民用航空领域高性能纤维复合材料的应用已经从三级结构扩展到主、次承力结构件，例如直升机旋翼系统、方向舵、着陆架等；战斗机发动机前锥套、雷达罩、电磁发射窗等透波部件以及垂直尾翼、方向舵、着陆装置、机翼箱等；A 380 客机机身、消音板、座舱、高温管道、GLARE 地板，多型号航空发动机风扇机匣包容环、喷管燃烧室、火焰筒、内衬、隔热屏、混合器、静子和转子叶片、喷管调节片、密封片等热端部件和涡轮导向器绝缘板等。高性能纤维及其复合材料更容易适应导弹、运载火箭、卫星和航天飞机等苛刻运行环境的需要，已成功应用于导弹天线罩、天线窗、承力筒、相机镜筒、卫星束缚展开系统等。基于纤维材料，美国航空航天局正致力于研发用于航天器再循环水处理系统的过滤装置，宇航服生命维持系统以及宇航服反射绝缘层和外防火层等。

通常，应用于航空航天、国防安全领域的纤维要求具有低密度、高比强、高比模量、耐高温、抗化学腐蚀、低电阻、高热导、低热膨胀和耐化学辐射等特性。关注的纤维种类有主要包括：玻璃纤维、T300 级以上、M 系列、MJ 系列聚丙烯腈基碳纤维、芳香族聚酰胺纤维（芳纶III）、聚芳酯（Vectran）纤维、耐高温沥青基碳纤维及粘胶基碳纤维、硼纤维、碳化硅纤维、石英纤维、氮化硼纤维、氧化锆纤维、氧化铝纤维、莫来石纤维、聚酰亚胺（PI）纤维、聚苯硫醚（PPS）纤维、聚对苯撑苯并双噁唑（PBO）纤维、超高分子量聚乙烯（UHMWPE）纤维等。

航空航天用特种织物具有高维自由度的可设计性，通过改变织物内部结构，可以在很宽的范围内“量体设计”材料的力学性能和物理性能以满足特殊环境下的使用要求。目前，包括三维机织物、三维编织物、三维针织物、正交非织造织物、针刺和 z-pinning 织物等在内的仿形三维织物被认为是提高复合材料强度、抗烧蚀、抗热震和抗蠕变等性能最为有效的方法，同时是实现航空航天飞行器结构一体化设计制造的技术关键，已成为新一代飞行器研制的核心技术和重点发展领域。

The varieties of fibers mainly are: aramid fibers, fire-retardant viscose, fire-retardant nylon, moisture-absorbing sweat-wicking polyester, polyester with antibacterial finish, polyurethane fibers, modacrylic fibers and active carbon fibers.

2.2.2 In the field of aviation and aerospace

As the key new materials for national strategic development, high-performance fibers and the special textiles for reinforcing composite materials are increasingly applied and demanded in high-tech fields such as aviation, aerospace, and national defense and security. The applications of high-performance fiber composite materials in the fields of civil and military aviation have been extended from in tertiary structures to primary and secondary load-bearing structural components, for example, in the rotor wing system, rudders, and landing pads for helicopters; in the front engine taper sleeves, radar hoods, wave-transmitting components such as electromagnetic launch windows and vertical empennages, rudders, landing pads, and wing boxes for fighter jets; in the fuselages, silencers, cockpits, high-temperature pipelines, GLARE floorings, various air engine fan casing containment rings, nozzle combustion chambers, flame tubes, linings, heat screens, mixers, stator and rotor blades, nozzle adjusting plates, heat radiation components such as gasket rings, and turbine guider insulation boards for A380 aircrafts. High-performance fibers and their composite materials are easier to adapt to the requirements in the strict operational environment for missiles, carrier rockets, satellites and space shuttles, and they have already been successfully applied in missile-borne radomes, antenna windows, loaded cylinders, camera lens holders, and satellite restriction releasing systems. Based on fiber materials, NASA is engaging in the development of filtration device for recycled water treatment system in spacecrafts, life-maintaining system in spacesuits, and reflective insulation layer and fire-retardant layer in spacesuits.

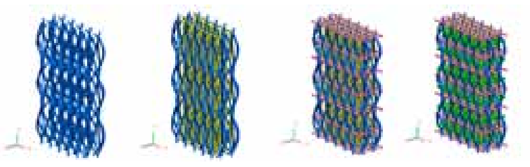

图 1 三维编织物结构示意图

Fig.1. Illustration of the structure of three-dimensional textiles

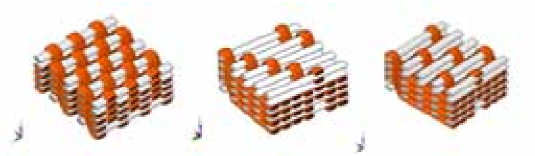

图 2 层层联锁三维机织物结构示意图

Fig.2. Illustration of the structure of the three-dimensional textiles with interlocked layers

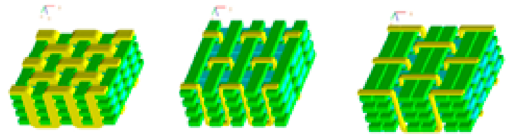

图 3 三维正交织物结构示意图

Fig.3. Illustration of perpendicular type three-dimensional textiles

3. 结语

城市安全及国防安全用纤维品种虽然种类繁多，但真正实际应用的纤维品种有限，然而，国家的城镇化建设的突飞猛进及国防建设的飞速发展，对纤维提出了更高的要求：

1）纤维要满足高强度、高模量，轻量化、多功能化、智能化及低成本的发展需要。对于特殊要求的领域如居民建筑、作战服、航空航天等还应满足阻燃、燃烧低毒性、透波性、吸波性、电磁性、隔音、保温等要求；

2）建筑增强纤维通过表面构筑技术增加纤维与混凝土的相容性，不出现界面剥离问题。

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In general, the fibers applied in the fields of aviation, aerospace, national defense and security are required to have such qualities as of being low in density, high in specific strength, and high in specific modulus, enduring high temperature, resisting chemical corrosion, being low in electric resistance, high in thermal conductance, and low in thermal expansion, and enduring chemical radiation. The varieties of fibers in the spotlight mainly include: glass fibers, polyacrylonitrile-based carbon fibers graded higher than T300 in M and MJ series, aromatic polyamide fibers (aramid fibers Ⅲ), polyarylester (Vectran) fibers, high-temperature asphalt-based carbon fibers and rayon-based carbon fibers, boron fibers, silicon carbide fibers, quartz fibers, boron nitride fibers, zirconia fibers, alumina fibers, mullite fibers, amanium (PI) fibers, polyphenylene sulfide (PPS) fibers, polybenzazole (PBO) fibers, and ultrahigh molecular weight polyethylene (UHMWPE) fibers.

The special textiles for aviation and aerospace have such a quality that the degrees of their multidimensional freedom can be designed. Through the changes in the inner structures of textiles, the mechanical and physical properties of materials can be "designed according to measurements" in a very wide scope so as to meet the usage requirements in special environment. At present, the emulated three-dimensional textiles including three-dimensional machine-woven textiles, three-dimensional weavings, three-dimensional knitting, perpendicular type non-woven textiles, needle-punched and z-pinning textiles are regarded as the most effective methods for improving such performances as of increasing strength, resisting ablation, and resisting thermal shock and creep deformation. Meanwhile, they represent the key technology for designing and manufacturing integrated structures of aerospace vehicles, becoming the core technology and key area in the development of new generation of aircrafts.

3. Conclusion

Although there are a great variety of fibers for urban safety and national security, the varieties of fibers actually applied in reality are very limited. However, the rapid advancement in nationwide urban construction and the fast development in defense construction have placed more demands on fibers:

1) Fibers need to satisfy the requirement of development that they should be high in strength, high in modulus, and lightweight, serve multiple purposes, have intelligent features, and be low in costs. In the fields such as residential buildings, combat clothes, and aviation and aerospace where there are special requirements, the requirements concerning fire resistance, lox toxicity when burning, wave conductivity, wave absorption, electromagnetism, sound insulation, and heat insulation.

2) With regard to the fibers for reinforcing buildings, the compatibility between fibers and concrete is improved through surface-building technologies, without the problem of separation from interface.

by Cheng Bowen, Chen Li, Sun Ying, Ren Yuanlin, and Zhao Xiaoming

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纤维新材料的军事应用与发展
Military Application and Development of New Fiber Materials

随着科学技术的迅速发展，新型纤维材料不断涌现和被采用，新纤维材料在新产品开发与应用中的作用日益重要。新型纤维复合材料及特种加工技术对新型武器装备的研制和生产，起到举足轻重的作用，是现代工业不可缺少的重要组成。

1. 国内外纤维新材料的军事应用发展

1.1 美国纤维材料军事应用的发展

2015年3月18日，奥巴马亲自宣布“革命性纤维与织物制造创新机构”开启竞标。2016年4月1日，美国国防部长阿什顿 • 卡特宣布成立革命性纤维与织物制造创新机构 (RFT-IMI)，这是美国制造创新网络中第八家制造创新机构，该机构由美国国防部牵头组建，获得由联邦政府、地方政府、大学和企业等超过3亿美元的投入资金。RFT-IMI 由麻省理工学院 (MIT) 负责领导，并接受美国国防部监管。

纤维科学的新进展已经创造出了具备非凡属性的纤维。这些新属性已经使纤维与织物应用空间发生了变革——因此使用了“革命性”这个词。革命性纤维与织物具有与众不同的属性，不可思议的轻质、防火性，非凡的强度以及包含纤维材料的电子传感器等。RFT 覆盖了一系列称作“技术纺织品”的纤维系统，由特种面料、工业面料、电子纺织品、智能面料以及其它先进纺织品组成。图1是美军士兵系统的装备，高性能纤维及复合材料应用突出。

革命性纤维与织物的国防需求十分广泛。主要包括四大类：(1) 个人挑战与货物空投系统；(2) 软墙 / 刚性墙掩体 / 帐篷和营地系统；(3) 士兵电源与数据集成系统；(4) 士兵制服。具体包括：士兵服装 (可穿戴电子纺织品电源和数据传输总线)，微小气候管理以及单兵装备，掩体 / 帐篷，降落伞，弹药与爆炸防护，化学、生物、辐射与核 (CBRN) 防护，阻燃阻热、环境保护、安全浮游装置、反重力外套等。

With the rapid development in science and technologies, new fiber materials are constantly emerging and applied, playing an increasingly important role in the development and application of new products. New types of composite fiber materials and special processing technologies carry a big weight in the development and production of new weapons and equipment, being an indispensable important part of modern industries.

1. Development in military application of new fiber materials at home and abroad

1.1 Development in the military application of fiber materials in the United States

On March 18, 2015, Obama personally announced the launch of the competition for “Revolutionary Fibers and Textiles-Institute for Manufacturing Innovation”. On April 1, 2016, Ashton Carter, United States Secretary of Defense, announced the establishment of Revolutionary Fibers and Textiles-Institute for Manufacturing Innovation (RFT-IMI), which is the eighth manufacturing innovation institute in the United States’ network of manufacturing innovation. United States Department of Defense took the lead in organizing the establishment of this institute, which received an investment of over 300 million US dollars from federal governments, local governments, universities, enterprises, etc. RFT-IMI is under the leadership of Massachusetts Institute of Technology, and supervised by US Department of Defense.

New advancement in fiber science has led to the fibers with unique qualities.

1.2 我国高度重视纤维新材料的发展

材料是工业的基础。大力推动新材料产业的发展对做强“中国制造”具有重要意义。2016 年 12 月 23 日，国务院成立了“国家新材料产业发展领导小组”，小组决定国家重大工程“重点新材料研发及应用”已于 2017 年启动并发布指南。

基础材料产业是实体经济不可或缺的发展基础，我国基础材料产量面临总体产能过剩、产品结构不合理、高端应用领域尚不能完全实现自给等三大突出问题，迫切需要发展高性能、差别化、功能化的先进基础材料，推动基础材料产业的转型升级和可持续发展。先进基础材料是指具有优异性能、量大面广且“一材多用”的新材料，其发展重点为：一是先进钢铁材料；二是先进有色金属材料；三是先进石化材料；四是先进建筑材料；五是先进轻工材料；六是先进纺织材料。这些材料中的高端材料，对国民经济、国防军工建设起着基础支撑和保障作用。

对于高端装备用特种合金、高性能分离膜材料以及高性能纤维及复合材料等我国所需的关键工程战略材料要转移高端、加大国产化比重，我国前沿材料须抢占战略制高点。但是目前而言，在发挥前沿新材料引领产业发展方面，我国的自主创新能力严重不足，迫切需要在 3D 打印材料、超导材料、智能仿生与超材料、石墨烯等新材料前沿方向加大创新力度，加快布局自主知识产权，抢占发展先机和战略制高点。

These new qualities have resulted in changes to applications of fibers and textile. Therefore, the term “revolutionary” is used. Revolutionary fibers and textiles have unique qualities, being incredibly light and fire-retardant, possessing extraordinary strength, and including the sensors specific to fiber materials. RFT covers a series of fiber systems called “technical textiles“, consisting of special fabrics, industrial fabrics, electronic textiles, intelligent fabrics, and other sophisticated textiles. Fig. 1 shows the equipment in the system for American troops, highlighting the application of high-performance fiber and composite fabrics.

National defense makes an enormous demand on revolutionary fibers and textiles. It includes four major categories, individual challenge and cargo airdrop system, softly/rigidly walled shelter/tent and camp system, troop-oriented power supply and data collection system, and troops’ uniforms. Specifically, it includes: troops’ clothes (wearable electronic textiles power supply and dada transmission bus), micro-climatic regulation and individual equipment, shelter/tent, parachute, ammunition and explosion protection, chemical, biological, radiological and nuclear (CBRN) defense, fire retardation and heat insulation, safety flotation devices, anti-gravity garments etc.

1.2 Importance attached to development of new fiber materials in China

Materials are the cornerstones of industries. It has great significance for boosting “made in China” to intensively advance the development of new material industries. On December 23, 2016, State Council set up a “team to lead the development of new material industries in the country”, and based on the decision made by this team, the “R&D and application of important new materials” in major projects was launched in 2017 and guidance was issued.

Basic material industries are foundations indispensable for the development of the real economy, and the production of basic materials in our country faces the three outstanding problems, overall overcapacity, unreasonable product structure, and failure to totally achieve self-sufficiency in the field of high-end applications. It is urgently necessary to develop high-performance basic materials that feature difference, functionality and sophistication, and to facilitate the transformation, upgrading, and sustainable development of basic material industries. Sophisticated basic materials refer to the new materials that give excellent performance, accommodate huge demands from various users, and “serve multiple purposes”, and emphasis should be placed on the development of: firstly, sophisticated steel and iron materials, secondly, sophisticated non-ferrous materials, thirdly, sophisticated petrochemical materials, fourthly, sophisticated building materials, fifthly, sophisticated light industry-oriented materials, and sixthly, sophisticated textile materials. The high-end ones among these materials have the effect of supporting foundations and providing protection on national economy, defense and military construction.

As to the special alloy, high-performance separation membrane materials as well as high-performance fibers and composite materials, which are used for high-end equipment, it is necessary to move up to the high end of the industry chain for the materials needed in our country’s key strategic projects, and increase the proportions of domestic products, and our country has to take the strategic dominant position in cutting-edge materials. At present, however, in terms of the role of cutting-edge new materials in leading

1.3 纤维材料在军工国防中的应用

碳纤维、芳纶、超高分子量聚乙烯纤维、生物基聚酰胺纤维等高性能纤维在军工国防、航空航海 、体育器材、医疗卫生及建筑纺织等军用、民用行业具有重要的应用价值。这些高性能纤维及其复合材料应用于战略导弹发射设备、航空航天器、人造卫星、战斗机、单兵防护等方面不仅能提高各项器材的防御性能，还能提高单兵作战效率。

为了提高战斗效率，减少战斗人员体能消耗，降低高昂的运输成本要加强研究便于执行多样化任务、轻质的地面战斗车辆和战斗防护服。如比重小、强度高的高强聚酰胺纤维、用于帐篷支架、背架等的碳纤维增强复合材料，可制造轻便防弹衣，防弹插板等的高强高模纤维，可减小单兵背囊、帐篷支架、枪托的负重。

复合纤维材料是减重纤维研究的重要方向。传统的金属材料疲劳性能较差，而纤维增强树脂基复合材料单向力学性能虽高，但层合过后性能降低很多，并且呈脆性断裂。纤维金属层板则是打破两者的界限，采用合适的工艺将二者结合起来，使它们相互取长补短，相得益彰。金属纤维层状材料被认为是用于下一代飞机的先进材料，不仅重量轻，而且还具有较好的力学性能。目前 DLR 在机身壳体部件自动化铺放方面已取得了部分成果，未来将致力于机身自动化生产线的研究，并用该生产线生产出首架机身。

另外，减重材料应用在车辆中可减轻车身重量 (减重 100-200kg)，即可减少燃料消耗，降低尾气排放，减少组装工序，降低劳动成本，实现现代化组装过程，提高运行效果，减小运动阻尼，提高发动机转速等。同样还可广泛应用于后勤装备，如帐篷支架、野炊箱组（盖板、油罐、挂件等）、冷藏箱（箱体、隔板等）、医疗方仓（仓体、担架）等。总之，减重材料可根据其性能的不同应用于现代化建设中的方方面面，百利而无一害。

我国纤维材料经过发展，建立了较完整的工业化生产体系，碳纤维、芳纶、聚酰亚胺等高性能纤维实现了国产化，常规纤维的差别化、功能化也取得了长足进展，这些带动了产业用纺织品发展，实现了纤维的跨行业对接，提升了防护服装的技术水平，在国防等关键领域得到了一定应用，为做强我国国防纤维材料奠定了基础。

1.4 我国前沿性纤维材料发展思考

我国高性能纤维还存在价格高昂、性能不稳定；低端多、高品质少；厂家投产多，销售比例低；投入多，盈利少；自己做的多，联合少；自身研究多，下道服务少；小试应用多，大批订单少；民用多，国防应用少；研究多，成果转化少；报奖多，得奖少；科研小项目多，大项目少等众多问题。

我国的高性能纤维材料中，民用多于国防应用，需借鉴国外“军民融合”的成功经验，制定适宜我国国情的发展战略，引领新材料的发展方向，使高性能纤维进入快速发展阶段，解决上述不利问题，以应用需求牵引纤维开发，创建产学研用结合的研发系统，注重应用开发和应用服务，上下产业链联合，实现可持续发展，建立系统的标准化技术体系。

industrial development, there is a serious lack of independent innovation capacity in our country, and it is urgently necessary to intensify innovation, speed up the enforcement of intellectual property rights, and attain strategic dominant positions in the front line of new materials such as 3D printing materials, superconducting materials, intelligent bionic materials and metamaterial, and graphene.

1.3 Application of fiber materials in military industry and national defense

The high-performance fibers such as carbon fibers, aramid fibers, ultra high molecular weight polyethylene fibers, and bio-based polyamide fibers are of important value to the applications in military and civil industries such as military defense, aviation and navigation, sport equipment, health care, buildings and textiles. If applied in such fields as strategic missile-launching equipment, aerospace vehicles, man-made satellites, fighter planes and individual protection, these high-performance fibers and their composite materials can not only enhance the protective features of every piece of equipment, but also increase the efficiency of individual combat.

In order to enhance the effectiveness of fight, lower the physical energy consumption by combat crew, and reduce the expensive cost of transportation, the research should be intensified of the ground combat vehicles and protective uniforms that are suitable to perform diversified tasks and light in weight. For example, the high-strength nylon fibers that are low in specific gravity but high in strength, the carbon fiber-enhanced composite materials that are used for tent poles and back frames, and the high-strength modulus fibers that can make up light armors and bulletproof plates, can reduce the weights of individual backpacks, of tent poles, and of gunstocks.

Composite materials represent the important direction for the study of weight-reducing fibers. Conventional metallic materials have a poor fatigue performance, but although fiber-enhanced resin-based composite materials are high in unidirectional mechanical properties, their performances will decrease seriously after lamination, and brittle ruptures may occur. Fiber metal laminates break the boundary between them, combining them with suitable technologies, so that they complement each other and bring out the best in each other. Metal-fiber laminated materials are regarded as the sophisticated materials for next generation of airplanes, not only being lightweight, but also delivering better mechanical performances. At present, DLR has made some achievements in automatically placing the components of fuselage shells, and will be dedicated in the future to the research into an automatic production line of fuselages, and use this production line to make the first fuselage.

In addition, if applied in vehicles, weight-reducing materials can reduce the weights of vehicles (by 100-200kg), while lowering fuel consumption, cutting emission, streamlining assembly processes, slashing labor costs, achieving modernized assembly processes, enhancing operational effects, diminishing the effect of damping on movement, and increasing engine speed. Likewise, they can also be used in logistical equipment, such as tent poles, picnic tools sets (covering plates, oil tanks and pendent pieces), refrigerators (walls and partition plates), and mobile medical cubicles (walls and stretchers). All in all, depending on the differences in their performances, weight-reducing materials can be used in different areas of modern construction, providing immense benefits without any harm.

A relatively complete industrialized production system has been established for fiber materials in our country after going through the processes of development. It has been achieved that high-performance fibers such as carbon fiber, aramid fibers, and polyimide are made domestically. Great achievements have also been made in making conventional fibers have different qualities and more functions. This has led to the development of industrial textiles. Connection to fibers across different sectors has been achieved. The technical level of protective clothes has been improved. These materials have been applied to a certain degree in key fields such as national defense, laying a foundation for strengthening the position of the fiber materials for our country's national defense.

1.4 Thoughts about the development of cutting-edge fiber materials in our country

There are still many problems about the high-performance fibers in our country, such as, high prices,

2. 国内外军民融合发展

为保证国家的军事能力，促进军事工业的持续进步，世界各国多采取了将国防和军队现代化建设深深融入经济社会发展体系之中，在更广范围、更高层次、更深程度上把国防和军队现代化建设与经济社会发展结合起来，也就是广义上的军民融合模式。

unstable performances, too many low-end products, few high-quality products, excessive outputs, decreased sales, more inputs, less profits, more individual productions, lack of cooperation, self-centered researches, isolation from next links, more small-scale applications, few large orders, more civil applications, few applications in national defense, more studies, less achievements, more applications for awards, less winners, too many small scientific projects, and less large projects.

Among the high-performance fibers in our country, those for civil use are more than for the use of national defense. It is necessary to draw on the successful foreign experience of “civil-military integration”, to formulate a development strategy suitable for the conditions of our country, to lead the way of developing new materials, to enable high-performance fibers to enter fast growing stage, to solve the above-mentioned knotty problems, to use the demands for applications to lead the development of fibers, to create a system of research and development that combines production, learning, research and application, to attach importance to the development of applications and to applied services, to combine upper and lower industrial chains, to achieve sustainable development, and to establish a holistic standardized technical system.

2. Development in civil-military integration at home and abroad

In order to ensure military capacity, and facilitate continuous progress in military industry, all the countries in the world have integrated the modernized construction of national defense and armed forces deeply into the system for the development of economic societies, combining the modernized construction of national defense and armed forces with the development of economic societies in a wider scope, at a higher level, and to a larger extent, that also is, the model of civil-military integration in a broad sense.

2.1 Revelation from the foreign experience of civil-military integration

At present, the model of civil-military integration that is adopted in foreign countries mainly refers to the model of “civil-military integration” in the United States, the model of “the military disguised as the civilian” in Japan, the model of “the military coming before the civilian” in Russia, and the model of “the civilian leading the military” in Israel. The “civil-military integration” strategy has produced certain effects in these countries, and comes somewhat as an empirical revelation for the development in our country’s civil-military integration.

Without its complete standardized system, US army cannot be today’s most modernized and information-enabled army in the world. Many aspects of the practice of developing military standardization in the US are worth our drawing on: (1) using laws and regulations to facilitate the improvement on the level of standardized military management; (2) using strict quality requirements to control the increase in the standardized quantities for military use; (3) using non-governmental standards to facilitate the integration of civil and military standards; (4) Changes in the system of non-governmental standards playing a leading role in promoting the military application of civil standards; (5) using the popularity of standards to lead the development of the scientific industry for national defense in the world.

2.1 国外军民融合经验启示

目前，国外采取的军民融合模式主要有美国“军民一体化”模式、日本“以民掩军”模式、俄罗斯“先军后民”模式、以色列“以民带军”模式，这些国家的军民融合战略都取得了一定的成效，并且为我国发展军民融合起到一定的经验启示。

美军作为当今世界最为现代化、信息化的军队与其完备的标准化体系是密不可分的，美国军用标准化的发展做法有很多方面是值得我军借鉴的：(1) 以法规制度促进军用标准化管理水平的提高；(2) 以严格的质量要求控制军用标准数量的增长；(3) 以非政府标准促进军民标准一体化的实现；(4) 以民间标准制修订为主导提升民用标准的军用化程度；(5) 以标准的输出主导世界国防科技产业的发展。

2.2 我国军民融合发展

我国在“十三五”规划明确提出，“实施军民融合发展战略，形成全要素、多领域、高效益的军民深度融合发展格局”，真正意义上将军民融合发展上升为国家战略。我国军民融合发展战略在新材料领域提出，军民两用新材料是技术创新的先导、基础和支撑，新材料的使用改变着人类的生活习惯与生活方式，同时也为军工国防建设发挥重要作用。新建筑材料为人类创造了更加美观而舒适的居住条件；新交通运输材料使得火车与飞机更加快捷；生物材料为人类提供了新的医疗手段；新的合成纤维使人类突破自然纤维单一获取途径，得到更加丰富多彩的纺织品和服装；信息材料的发展，丰富了人类的通信手段，改变着人们的交流方式。新材料还为人类的航空航天事业提供了前提条件，为人类实现拓展生存空间提供可能的机会。

利用我国已有军工新材料产业发展的技术优势，优化配置军民科技力量和产业资源，推进国防科技成果加速向经济建设转化，促进军民新材料技术在基础研究、应用开发、生产采购等环节有机衔接，加快军民共用新材料产业化、规模化发展。鼓励优势新材料企业积极参与军工新材料配套，提高企业综合实力，实现寓军于民。建立军民人才交流与技术成果信息共享机制，积极探索军民融合的市场化途径，推动军民共用材料技术的双向转移和辐射。

3. 未来军民两用纤维发展趋势

科技创新和绿色发展已成为我国经济发展的新动力，先进基础材料、关键战略材料、前沿新材料则是国家战略性新兴产业发展的重要基础。加快培育和发展纤维新材料，对促进化纤工业转型升级、提升行业核心竞争力具有重要的战略意义。我国在军民两用纤维的主要发展趋势为高效化、高性价比、绿色化、轻质化、系统化、标准化，这些趋势将引领纤维的研发和应用。

我国纤维新材料的军民融合，应该制定并完善军民两用化纤标准体系以助推化纤应用，国防应用助推高性能纤维发展壮大，民用新纤维研发助推国防建设，军民融合发展助推化纤强国建设，使我国纤维新材料的研发得到创新性、前沿性，综合性发展。

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2.2 Development in our country’s civil-military integration

It is clearly stated in the “thirteenth-five year” plan for our country that “the strategy for developing towards civil-military integration should be implemented, and a landscape including all the elements, involving many fields, providing great benefits, and featuring the development in civil-military integration should be shaped”, promoting the development in civil-military integration as a national strategy in a real sense. In the strategy on the field of new materials to develop towards civil-military integration for our country, it is stated that new materials for both civil and military use are leading, maintaining and supporting technological innovations, and the use of new materials is changing the habit of human beings and their way of living, while also exerting important effects on the construction of military defense. New building materials have created more beautiful and comfortable living conditions for human beings. New communications and transportation materials have enabled trains and airplanes to move faster. Biological materials have provided new medical methods for human beings. New composite fibers have enabled human beings to open more ways than the only one of obtaining natural fibers, and enjoy more enriched colorful textiles and clothes. The development of information materials has enriched the means of communication for human beings, changing the way people communicate. New materials have also provided the precondition for the cause of aviation and space industry for human beings, offering possible opportunities for mankind to explore living space.

It is necessary to make good use of the existing technical advantages in the development of new materials industry for military purpose, optimize the distribution of civil and military scientific forces and industrial resources, advance the accelerated translation of the scientific achievements in national defense into economic construction, facilitate the organic connection between the civil and military technologies for new materials and the processes such as basic research, applications development, production and purchase, speed up the development in the processes of industrializing and producing in large scale the new materials for both civil and military use, encourage leading new materials enterprises to actively participate in what can make new military materials a complete industry chain, increase enterprises’ general strength, achieve civil-military integration, establish the mechanism for transferring civil and military talent and sharing the information on technological achievements, actively explore ways for market-oriented civil-military integration, and push forwards the two-way transfer and spread of the technologies for the materials for both civil and military use.

3.Future trends in development of fibers for both civil and military use

Scientific innovation and green development have already become the driving force for the economic development in our country. Sophisticated basic materials, key strategic materials, and cutting-edge new materials are the important cornerstones for the development of the emerging industries in national strategy. It is of important strategic significance for facilitating the transformation and upgrading of chemical fiber industry and improving the core competitiveness of the industry to speed up the making and development of new fiber materials. The major trends in the development of the fibers for both civil and military use in our country are toward high efficiency, high performance-price ratio, being green, being lightweight, being systematic, and being standardized, and these trends will lead the research, development and application of fibers.

In terms of civil-military integration for new fiber materials in our country, it is necessary to formulate and perfect a standard system of the fibers for both civil and military use so as to boost the application of chemical fibers, while the applications in national defense will promote the development and growth of high-performance fibers, the research and development of new fibers for civil use will facilitate the construction of national defense, and the development in civil-military integration will help build a powerful country in respect of chemical fibers, so that progress will be made in an innovative, cutting-edge and comprehensive manner in the research and development of new fiber materials in our country.

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高性能性纤维与复合材料
High-performance fibers and composite materials

高性能纤维包括碳纤维、对位芳纶、间位芳纶、高强高模聚乙烯纤维、聚酰亚胺纤维、玄武岩纤维、碳化硅纤维、氧化铝纤维、硅硼氮系纤维，PBO，M5等，过去几十年来是世界各国武器装备研发生产不可或缺的国家战略物资，是国家实力象征之一。更是未来低碳及先进制造业轻量化、抗腐蚀等科技进步的共性核心技术，是国家制造业和低碳经济的核心竞争力之一。

High-performance fibers include carbon fibers, para-aramid fibers, meta-aramid fibers, high-strength high-modulus polyethylene fibers, polyimide fibers, basalt fibers, silicon carbide fibers, alumina fibers, silicon boron nitride fibers, PBO, and M5. In the past decades, they had been national strategic materials indispensable to the research, development and production of weapons and equipment for all the countries across the world, becoming one of the symbols for national strength, what's more, being the common core technology for the scientific advancement in weight reduction and corrosion resistance for the low-carbon and sophisticated manufacturing industry in the future, and being one of the core competitive weapons for national manufacturing industry and low-carbon economy.

一、发展高性能纤维及其复合材料的重要意义

高性能纤维及其复合材料是重要战略物资，新一轮新型武器装备研发，对高性能纤维及其复合材料提出新的要求，高性能化与结构功能一体化是高性能纤维与复合材料的重要发展趋势。高性能纤维及其复合材料，因其强度高、比重小，是新型武器装备研发，发展不可或缺的战略物资，几十年来轻质高强的碳纤维复合材料一直是国家安全、航空航天与海洋开发等不可或缺战略物资，是先进国家实力象征之一。随着中国的强大，新一轮武器装备竞赛序幕已经拉开，对高性能纤维及其复合材料提出新的要求，美国、中国、日本欧洲、俄罗斯等均设立超高性能纤维，结构功能一体化纤维等专项，进行攻关，包括超高强度纤维、高模量纤维、高导热纤维、抗高温氧化高强度纤维、高导电高强度纤维、高温透波高强纤维、高温吸波高强纤维，特别是纤维学科与纳米、化学、凝聚态物理、电磁波、仿生结构等多学科交叉的研发团队，有望为高性能纤维及其复合材料的制备带来全新的理论和技术突破。

二、碳纤维复合材料是制造业轻量化核心

碳纤维复合材料不再只是国防战略物资，轻量化碳纤维复合材料技术更是低碳经济和先进制造业的核心竞争力; 轻量化技术可以提升交通运输工具能源利用率，减少排放，提高科技水平;轻量化技术可以减少运动部件惯量，提高运动速度，提高精度，减少噪音，减少能耗，提高机械设备科技水平；高性能纤维及其复合材料具有良好抗腐蚀性，可以提高海洋、化工、石油、建筑等领域建筑与装备的抗腐蚀性，延长寿命，提高竞争力。

高性能纤维及其复合材料，特别是碳纤维复合材料，经过 50 多年发展，技术不断进步，产业不断成熟，正在发展成为低碳经济和制造业轻量化核心技术，为此，近十年来，发达国家正在调整发展战略，把发展碳纤维复合材料作为制造业振兴、提升国家制造业核心竞争力的重要途径。

几十年来，日本、美国、欧洲等发达国家一直在引领全球航空航天等高端领域碳纤维复合材料制造与应用的发展。2014 年德国宝马联合 SGL、BASF 等产业链企业攻克碳纤维在汽车应用技术，并建立完整供应链体系，率先实现碳纤维在量产车型应用，开启了碳纤维复合材料在制造业大规模应用的序幕。轻量化碳纤维复合材料将为大型客机、轨道交通、节能和新能源汽车等交通运输工具减重、减排、将耗和提高续航里程，提供技术支撑；机械运动部件的减重减小惯量，将提高精度、提高运动速度，减少能耗，降低噪音，提高机械科技水平；碳纤维复合材料的抗腐蚀性将为海洋工程、化工装备、建筑提供轻质高强抗腐蚀材料，提高装备寿命。美国、日本、法国、意大利、英国、中国、韩国等国家立即意识到一场制造业轻量化技术革命即将来临，纷纷把轻量化碳纤维复合材料在制造业中的大规模应用，作为制造业振兴的核心竞争力，列入国家战略发展计划，迎来了工业用碳纤维的快速发展。

One. The great significance of developing high-performance fibers and their composite materials

High-performance fibers and their composite materials are important strategic materials. A new round of research and development of new weapons and equipment has new requirements for high-performance fibers and their composite materials. The important trend in the development of high-performance fibers and their composite materials is towards the integration of high-performance and structural functions.

Thanks to their high strength and low specific gravity, high-performance fibers and their composite materials are indispensable strategic materials for the research, development and upgrading of new weapons and equipment. Over decades, lightweight high-strength carbon fiber composite materials have always been the indispensable strategic materials for national security, aviation and aerospace, and ocean development, being one of the symbols for national strength. As China becomes stronger, the curtain has been lifted on the new round of competition for weapons and equipment, which has new requirements for high-performance fibers and their composite materials. Special projects such as for ultra-high-performance fibers and structurally and functionally integrated fibers have been set up in the US, China, Japan, Europe, and Russia, to tackle the key problems with ultra-high-strength fibers, high-modulus fibers, high-heat-conductivity fibers, high temperature oxidation-resisting high-strength fibers, high-electricity-conductivity high-strength fibers, high-temperature wave-conductive high-strength fibers, high-temperature wave-absorbing and high-strength fibers. Especially, the interdisciplinary research and development team involving the subject of fiber, nanometer, chemistry, physics of condensed matter, electromagnetic wave, bionic constructions is expected to put forward brand new theories and make breakthrough in preparing high-performance fibers and materials.

Two. Carbon fiber composite materials are at the core of the manufacturing industry going lightweight

Carbon fiber composite materials are more than the strategic materials for national defense, and the technology for lightweight carbon fiber composite materials even is the core competitive power for low-carbon economy and advanced manufacturing industry. Lightweight technology can improve the utilization of resources for communication tools, reduce emission, and enhance scientific level. Lightweight technology can soften the effect of inertia on moving components, increase the speed of movement, improve accuracy, reduce noise, lower energy consumption, and enhance the scientific level of mechanical equipment. High-performance fibers and their composite materials are good at resisting corrosion, able to improve the performance of resisting corrosion for the buildings and equipment in the fields such as ocean, chemical industry, oil, and architecture, extend service life, and increase competitiveness.

High-performance fibers and their composite materials, in particular carbon fiber composite materials, have seen their technologies constantly advancing after over 50 years of development, and their industries becoming more mature, developing towards being the core technology for low-carbon economy and lightweight-oriented manufacturing industry. Therefore, over recent decades, developed countries are adjusting their development strategies, regarding the development of carbon fiber composite materials as an important way for reviving manufacturing industry and enhancing the core competitiveness of national manufacturing industry.

Over decades, such developed countries as Japan, the US, and Europe have always led the development in the manufacturing and application of carbon fiber composite materials in global high-end fields such as aviation and aerospace. In 2014, German's BMW joined hand with industry chain enterprises such as SGL and BASF to make breakthrough in the technology for applying carbon fibers in automobiles, establish a complete system of supply chain, take the lead in achieving the application of carbon fibers in mass-produced automobile models, and lift the curtain on the large-scale application of carbon fiber composite materials in manufacturing industry. Lightweight carbon fiber composite materials will provide technical support for communication tools such as large airliners, railway transportation, and energy-saving and new energy automobiles to reduce weight, cut emission, lower consumption, and increase mileage. Reducing

三、全球碳纤维复合材料的应用情况

全球工业用碳纤维复合材料技术不断进步，产业发展迅猛；高性能纤维制造技术进步，规模扩大，成本降低；复合材料成型与装备技术不断进步，涌现一批快速成型新技术及其自动化量产装备，为高性能纤维及其复合材料在制造业大规模应用奠定基础。

高性能纤维，特别是碳纤维、芳纶、高强聚乙烯纤维等，产业链技术不断进步，规模不断扩大，成本不断降低，为在制造业规模应用，奠定了经济可行性基础。碳纤维复合材料成型技术不断进步，低成本化自动化量产技术与装备不断涌现，生产节拍可以高达 1-3 分钟 / 件，而且还有很大进步潜力，为制造业规模应用，奠定了技术可行性基础。制造业各行业纷纷尝试应用碳纤维复合材料，不断积累应用经验、不断积累数据库、不断提升结构设计与验证能力，为各行业规模应用，奠定了需求与市场基础。形成了航空航天高端碳纤维复合材料和量大面广的工业用碳纤维复合材料并行发展的良好基础，2016 年全球碳纤维复合材料产值 200 多亿美元，预计到 2020 年将达到 357 亿美元规模（预计 2020 年铝合金 1260 亿美元，涤纶 364 亿美元）。

the weight and inertia of moving mechanical components will improve accuracy, increase movement speed, lower energy consumption, reduce noise, and enhance mechanical and scientific levels. The performance of resisting corrosion delivered by carbon fiber composite materials will provide lightweight high-performance corrosion-resistant materials for ocean projects, chemical equipment and buildings, increasing the service life of equipment. There is an immediate awareness that a lightweight-enabled technical revolution will come in manufacturing industry, in such countries as the US, Japan, France, Italy, UK, China and South Korea, who have one after another regarded the large-scale application of lightweight carbon fiber composite materials in manufacturing industry as the core competitiveness to revive manufacturing industry, and list it into the plan for national strategic development, welcoming the rapid development in carbon fibers for industrial use.

Three. About global applications of carbon fiber composite materials

The technology of carbon fiber composite materials for global industrial use has been continuously progressed, and their industries have developed rapidly. The manufacturing of high-performance fibers has seen technical advancement, scale increase, and cost reduction. Progress has been made constantly in the technology for shaping and equipping composite materials, and a batch of new technologies for fast shaping and their automatic mass-production equipment have emerged, laying foundations for the large-scale application of high-performance fibers and their composite materials in manufacturing industry.

For high-performance fibers, in particular, carbon fibers, aramid fibers, and high-performance polyethylene fibers, the technology for industry chain has advanced continuously, the scale has been increased constantly, and costs have been reduced all the time, laying an economically feasible foundation for large-scale application in manufacturing industry. Progress has been made continuously in the technology for shaping carbon fiber composite materials. Low-cost automatic mass-production technologies and equipment have emerged constantly. The speed of production can be as fast as one piece/1-3 minutes, and there is still great potential for improvement, laying a technically feasible foundation for large-scale application in manufacturing industry. All the sectors in manufacturing industry have one after another attempted to apply carbon fiber composite materials, continuously accumulating the experience with application, constantly building up database, always improving structural design and the ability for verification, and laying the foundation for the demands and market for the scale applications in all the industries. A good foundation has been built for aviation- and aerospace-oriented high-end carbon fiber composite materials to develop in parallel with the carbon fiber composite materials for industrial use that are high in quantity and wide in applications. In 2016, the value of global output of carbon fiber composite materials is over 20 billion US dollars, and it is predicted that it will be scaled to 35.7 billion US dollars by 2020 (aluminum alloy is predicted to be 126 billion US dollars, polyester 36.4 billion US dollars by 2020)

四、高性能纤维及其复合材料的发展模式

高性能纤维及其复合材料的发展模式发生重大转变，如何应用高性能纤维及其复合材料，如何降低成本，扩大应用领域，是未来高性能纤维及其复合材料发展的关键。

如何在制造业中大规模应用高性能纤维及其复合材料—应用技术及其标准建设是关键。过去几十年来，高性能纤维及其复合材料发展的关键是如何制造出高性能碳纤维，提高武器装备的性能。近 10 年来，随着碳纤维复合材料在制造业规模应用，如何应用碳纤维成为关键核心问题。

1、高性能纤维产业与制造业融合

高性能纤维产业与制造业各行业紧密融合，研究应用技术体系，培育学科交叉人才，是制造业大规模应用的关键之一。不懂汽车的碳纤维技术人员，无法设计出汽车零部件；而不熟悉碳纤维的汽车工程师，在民用标准的情况下，无法下决心签字使用碳纤维复合材料零部件。因此应该建立高性能纤维产业与飞机、汽车、高铁、轮船、机器人、家电、建筑、海洋、化工等领域的深度融合机制，培育一批学科交叉人才队伍。

2、建立高性能纤维复合材料应用标准

结构设计与验证新技术及其应用标准是推动高性能纤维及其复合材料替代金属材料，大规模应用的关键之一。由于复合材料的各向异性，数据库和设计方法与各向同性的金属完全不同，而现有的制造业设计均基于各向同性的金属材料数据库和设计准则。应该花大力气建立复合材料数据库、设计与验证方法，及其在制造业各领域应用标准。才能推动制造业各领域大规模应用轻量化复合材料，提高制造业的科技水平，提高制造业的国际竞争力。

3、复合材料自动化量产新技术

复合材料自动化量产新技术与装备是制造业大规模应用的关键之一。现有复合材料成型技术均源于航空航天，但成型周期长，设备投资大，成本高，无法满足制造业快节拍的生产需要。因此要研发快速成型技术及其自动化量产技术及其装备。包括快速固化高压 RTM 技术与装备，低粘度快速浸润 RTM 技术与装备，快速固化预浸料及其模压成型技术与装备，湿法模压技术与装备，自动化铺放成型技术与装备，自动化缠绕与低成本专用铺放设备，拉挤型材与自动化连接技术与装备，激光辅助连接技术与装备，打孔修边加工技术与装备等

Four. Model of development in high-performance fibers and their composite materials

Important changes have happened to the model of development in high-performance fibers and their composite materials. The key to the future development in high-performance fibers and their composite materials lies in how to apply high-performance fibers and their composite materials, how to reduce costs and increase applied fields.

How to apply high-performance fibers and their composite materials on a large scale in manufacturing industry, the key lies in applied technologies and the construction of their standards. In past decades, the key to the development of high-performance fibers and their composite materials is how to manufacture high-performance fibers and enhance the performances of weapons and equipment. Over recent decades, with the scale application of carbon fiber composite materials in manufacturing industry, how to apply carbon fibers becomes a key central issue.

1. Integration between high-performance fibers industry and manufacturing industry

The key to the large-scale application in manufacturing industry lies in the close integration between the high-performance fibers industry and all the sectors in manufacturing industry, the research and application of a technical system, and the cultivation of interdisciplinary talent. Without knowledge of automobiles, carbon fiber technicians cannot design automotive components. Without knowledge of carbon fibers, automotive engineers cannot decide whether or not to sign up to the use of the components made of carbon fiber composite materials in the case of civil specification. Therefore, a mechanism should be established for in-depth integration of high-performance fibers industry with such fields as airplanes, automobiles, high-speed trains, ships, robots, household appliances, architecture, ocean, and chemical industry, and a team of interdisciplinary talent should be cultivated.

2. Specification available for applications of high-performance fiber materials

Structural design, verified new technology and applied specification are the key to the progress in substituting and applying on a large scale high-performance fibers and their composite materials for metal materials. Because of the anisotropies of composite materials, database and design method are totally different from isotropic metal. However, all the existing designs in manufacturing industry are based on the database and design rules that are specific to isotropic metal materials. Great efforts should be made to establish the database, and design and verification methods for composite materials, as well as the specifications for their applications in various industries, so as to push forwards the large-scale application of lightweight composite materials in all sectors of manufacturing industry, enhance the scientific level of manufacturing industry, and improve the international competitiveness of manufacturing industry.

3.New technology for automatic mass-production of composite materials

New technology and equipment for automatic mass-production of composite materials is the key to the large-scale application in manufacturing industry. Existing technologies for shaping composite materials are all originated from

（1）高性能纤维低成本制造新技术

高性能纤维低成本制造新技术是制造业大规模应用的关键技术之一。最近十年来，高性能纤维低成本制造新技术不断涌现。

1）美国开发的腈纶工程为基础的大丝束碳纤维制造与应用技术体系，为碳纤维复合材料的低成本奠定了基础；

2）中国开发的干喷湿法制造 T800 级高性能纤维，提高纺丝速度，可望大幅度降低 T800 级碳纤维制造成本；以不受石油市场价格影响的煤化工（如运输困难，很多地方的煤价格与石油价格紧密相关，但有些地方关联性很小）制造丙烯腈，稳定丙烯腈价格，建立煤化工 PAN 原丝联产腈纶大型生产基地，同时以煤发电，建立大型碳纤维氧化碳化基地，将形成原料与能源优势，形成具有国际竞争力的碳纤维大型生产基地；

3）研发提高 PAN 纺丝单线产能新技术（现有生产线扩容），降低碳纤维原丝成本；

4）研发提高氧化碳化效率、单线产能新技术及其氧化碳化生产线国产化，降低设备折旧成本；

5）研发油剂作用机理及其在氧化碳化过程油膜结构演变规律，实现油剂国产化，降低碳纤维成本；

6）微波、等离子体、超临界等新技术在高性能纤维制造过程的应用，提高能源利用率，减低成本；

7）中间相与各项同性煤焦油沥青基碳纤维，大规模生产技术，不同模量序列化产品；

8）改性 PAN 原丝制备新技术（提高氧化效率，提高碳得率，功能型碳纤维增加附加值）；

9）开发高模量低成本工业用碳纤维（如强度 3.0 左右，模量 400 左右），提高增强效率。

aviation and aerospace. However, the process of shaping takes a long period of time to end every cycle, and the equipment comes with large investment and at high costs, unable to meet the needs of the fast production in manufacturing industry. Therefore, it is necessary to research and develop fast shaping technology, as well as its automatic mass-production technique and equipment, including fast solidifying high-pressure RTM technology and equipment, low-viscosity fast socking RTM technology and equipment, fast solidifying pre-socking and mould-pressed shaping technology and equipment, wet mould-pressing technology and equipment, automatic placement shaping technology and equipment, automatic wrapping and low-cost special placing equipment, extruded profiled materials and automatic connecting technology and equipment, laser auxiliary connecting technology and equipment, and drilling, trimming and processing technology and equipment.

(1) New technology for manufacturing high-performance fibers at low cost

New technology for manufacturing high-performance fibers at low cost is one of the key technologies for the large-scale application in manufacturing industry. For recent decade, new technologies for manufacturing high-performance fibers have emerged constantly.

1) The acrylic fiber project-based system for manufacturing and applying large-tow carbon fibers that is developed in the US has laid a foundation for the low costs of carbon fiber composite materials.

2) The dry and wet method developed in China for manufacturing T800-grade high-performance fibers can increase spinning speed, and is expected to largely lower the costs for manufacturing T800-grade carbon fibers. The coal chemical industry (in many places, if there is difficulty in transportation, coal price will be closely related to oil price, while in some places, they are less related) that is not affected by the price in oil market is used to manufacture acrylonitrile, so as to stabilize the price of acrylonitrile, establish the base for the large-scale production of PAN proto-filament and acrylonitrile in coal chemical industry. Meanwhile, coal is used to generate electricity, and a large base is established for oxidizing and carbonizing carbon fibers, bringing the advantages in raw materials and energy, and forming an internationally competitive large base for the production of carbon fibers.

3)To research and develop new technology for increasing the capacity of single PAN spinning production line (expansion of existing production line), and lower the cost of proto-filament for carbon fibers.

4)To research, develop and increase the efficiency of oxidation and carbonization, make the new technology for the capacity of single production line and the production line for oxidation and carbonization available domestically, and lower the depreciation cost of equipment.

5)To research and develop the mechanism for the effect of oiling agent and the pattern in the evolution of oil film structure during oxidation and carbonization, make oiling agent being produced domestically, and lower the cost of carbon fibers.

6)To apply new technologies such as microwave, plasma, and above-critical technique in the manufacturing of high-performance fibers, increase the utilization of energy, and lower costs.

7)Intermediate phase and isotropic coal tar pitch-based carbon fibers, mass-production technology, and serialized products with different modulus.

8)New technology for preparing modified PAN filament (improving the efficiency of oxidation, increasing carbon yield, and enhancing the additional value of functional carbon fibers).

9)To develop the carbon fiber that is high in modulus but low in cost for industrial use (e.g. at a strength of 3.0 or so, and at a modulus of 400 or so), and increase the efficiency of reinforcement.

(2). Recycling and reuse of carbon fiber composite materials

The recovery and re-making of carbon fiber composite materials cannot only solve environmental issues, but more importantly also lower the costs of carbon fibers through remaking. The recycling and reuse of carbon fibers should be in the light of China's actual conditions and the new trends in the development of carbon fiber industry. Carbon fibers are the waste with high additional values, and should be recycled with new methods, and are not supposed to be treated as ordinary waste that only addresses the problem

（2）碳纤维复合材料的回收再利用

碳纤维复合材料的回收再制造，不仅可以解决环境问题，更重要的是通过再制造降低碳纤维成本。碳纤维回收再利用应该结合中国国情和碳纤维产业新发展趋势：碳纤维是高附加值废料，应该用新方法循环使用，不应该作为一般废料只是解决污染问题。充分利用碳纤维废料的高附加值，可以助力制造业大规模碳纤维。如果能让碳纤维以预成型体的形式再利用一次，碳纤维成本就降低一半，并减少了预成型体织物制造成本。现阶段，中国碳纤维车间废料达3700 吨，应该研发可以充分利用碳纤维车间废料高附加值的技术途径，希望以后碳纤维零部件生产线，能配置一套小型回收装备，将车间废料回收使用。

五、性能纤维及其复合材料发展趋势

中国政府高度关注高性能纤维及其复合材料发展，中国具有巨大的市场空间，具备碳纤维复合材料后发优势，有望成为高性能纤维复合材料的大国和强国。

国家高度重视碳纤维复合材料产业。近两年，国家相关部委密集出台政策，大力支持碳纤维复合材料发展。《国家创新驱动发展战略纲要》、《“十三五”国家科技创新规划》、《“十三五”国家战略性新兴产业发展规划》、《中国制造 2025》、《国家新材料发展计划》等纷纷将发展碳纤维复合材料列为重点任务和重点支持领域。

轻量化碳纤维复合材料是中国制造 2025 的核心技术之一，10 大重点发展领域，8 大领域迫切需求轻量化碳纤维复合材料，包括航空航天装备，先进轨道交通装备，新能源汽车，电力装备，海洋工程装备、高技术船舶，高档数控机床、机器人，农机装备，高性能医疗器械。中国是制造业大国，高铁、汽车、造船等众多产业全球第一，具有巨大的碳纤维复合材料应用市场空间，有望引领碳纤维复合材料在制造业应用。

我国初步形成碳纤维复合材料产业，具备一定的基础。经过几十年几代人的努力，初步形成T300、T700 级、T800 及碳纤维的批量生产能力，但以军工应用的小丝束为主，迫切需要发展工业用低成本大丝束碳纤维。中国经过几十年武器装备的研发生产，已经具备较强的碳纤维复合材料应用能力，每年使用碳纤维约 2 万吨，占全球 25%，但迫切需要建立碳纤维复合材料在民用航空、汽车、轨道交通、新能源、高压容器、海洋与化工、机械制造、建筑工程等领域的应用技术体系和供应链体系。

总之，中国具备高性能纤维及其复合材料的后发优势，有望成为高性能纤维及其复合材料强国和大国。

东华大学 余木火团队

of pollution. If the high additional value of wasted carbon fibers can be fully used, it can power the large-scale production of carbon fibers in manufacturing industry. If carbon fibers can be reused for one more time in pre-shaped forms, the costs of carbon fibers will decrease by half, and the costs for manufacturing pre-shaped textiles will be lowered. At present stage, the waste from China's workshops has reached 3700 metric tons, and the technology and methods should be developed for making good use of the high additional values of the waste from carbon fiber workshops. It is hoped that the production line for carbon fiber components can be equipped later on with a small recovery device, which will retrieve and recycle the waste from workshops.

Five. Trends in the development of high-performance fibers and their composite materials

China's government has attached importance to the development of high-performance fibers and their composite materials. China has a huge market, having the advantage of being a leader later in carbon fiber composite materials, and is expected to become a strong and power country for high-performance fiber composite materials.

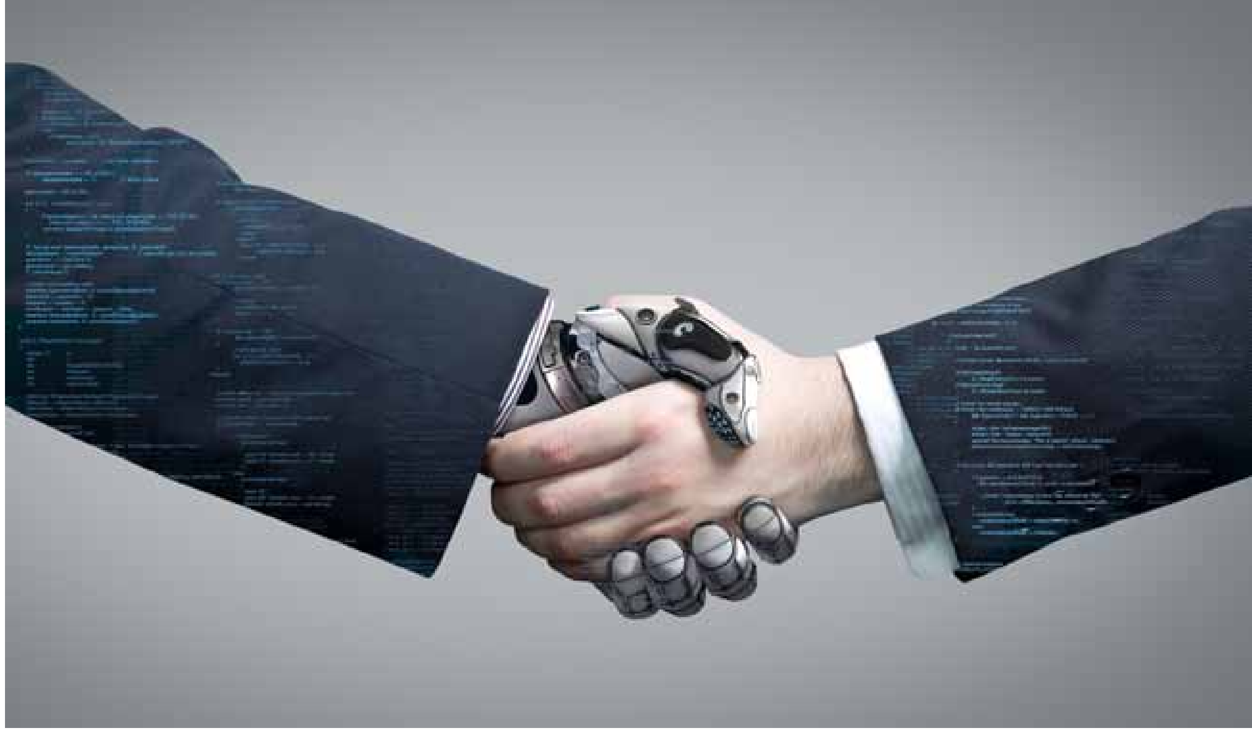
Attentions have been paid to the industry of carbon fiber composite materials in the country. For recent two years, the relevant ministries and commissions have intensively introduced policies, vigorously supporting the development of carbon fiber composite materials. The development of carbon fiber composite materials has been successively listed as key mission and preferentially-supported field in the "Outlines of State Strategy to Drive and Develop Innovations", "New State Plan for Scientific Innovations in the 'Thirteenth Five Years' ", "State Plan to Develop Strategic Emerging Industries in the 'Thirteenth Five Years'", "Made in China 2025", and "State Plan to Develop New Materials."

Lightweight carbon composite materials are one of the core technologies for Made-in-China 2025. 10 major preferentially developed fields, and 8 key fields are in urgent need of lightweight carbon fiber composite materials, including aviation and aerospace equipment, advanced railway communication equipment, new energy-enabled automobiles, electrical equipment, ocean engineering equipment, high-tech ships, high-end digitally controlled machine, robots, agricultural mechanical equipment, and high-performance medical equipment. China is a super country in manufacturing industry, ranking first globally in many industries such as high-speed railway, automobiles, and shipbuilding, and having a huge market for the application of carbon fiber composite materials, and is expected to take the lead in the application of carbon fiber composite materials in manufacturing industry.

The industry of carbon fiber composite materials has been initially established in our country, with certain foundations. After decades of efforts made by several generations of people, the initial capacity for mass-production of T300-grade, T700-grade, and T800-grade carbon fibers has been built, but is dominated by small tow for military use, and it is urgently necessary to develop large-two carbon fibers for industrial use at low costs. After decades of researching, developing, and producing weapons and equipment, China has already possessed a stronger capacity to apply carbon fiber composite material, with an annual usage of carbon fibers at 20,000 metric tons, accounting for 25% of global usage. However, it is urgently necessary to establish the system of applied technologies and the system of supply chains for carbon fiber composite materials in such fields as civil aviation, automobiles, railway communication, new energy, high-pressure containers, marine and chemical industry, mechanical manufacturing, and architectural engineering.

All in all, China has the advantages of taking the lead later in high-performance fibers and their composite materials, expected to become a strong and a powerful country in respect of high-performance fibers and their materials.

Yu Muhuo's team
Donghua University



智能纤维：编织智慧社会
Intelligent fibers: Connected Smart Society

人类社会的发展与纤维息息相关，从天然纤维于原始社会，到化学纤维于工业社会。现在以物联网、人工智能为代表的革新技术正在推动社会进入智慧社会，由此纤维的发展也正在跨入一个新时代——智能纤维。智能纤维是指能够感知（外部或内部环境的变化）、信息处理并做出响应的纤维。其本质上是物联网和人工智能在纺织业的一个应用延伸，使传统的纤维拥有生命和智能。

一、国内外支撑计划

早在 2005 年，法国在北部里尔的全国第二发达技术纺织品生产集聚区，建设了纤维新材料与产业用纺织品技术创新基地 Up-tex，致力于智能纤维面料、生态科技纤维面料等方面的创新和生产。德国从 2013 年起就提出了名为“未来纺织”的国家级战略项目 (future TEX)，立志将纺织业打造成为基于新材料、节能环保、智能产品等的创新基地，目标让新型纺织、纤维作为工业 4.0 的急先锋，成为德国最有创新活力的行业之一。欧盟于 2014 年发布“HORIZON 2020”计划，对纤维产品高质化、专业化及其技术创新机制等方面进行全面布局，核心为高性能、多功能和智能化纤维。美国于 2016 年成立革命性纤维与织物制造国家创新机构 (RFI-IMI)，致力于开发多材料多结构多功能的智能纤维及织物，并且加强纤维材料的军用转民用，促进纺织纤维与多学科、多领域的交汇融合。中国于 2016 年由以院士为主体的跨界专家组提出了“大纤维”概念，是指基于材料、信息、机械、生物、能源等学科领域的技术突破与交叉融合，以“智能、超性能、绿色”为特征，具有多功能、多结构、多材料特性，能够对传统产业集群起到高渗透性、颠覆性、革命性提升效果的新一代纤维。

The development of human society has been closely related to fibers, from the natural fibers in primitive society, to the chemical fibers in industrial society. Nowadays, revolutionary technologies represented by Internet of things and artificial intelligence is driving society into a smart era. As a result, the development of fibers is also entering a new era, i.e. intelligent fibers. Intelligent fibers refer to the fibers that can sense (the changes in external or internal environment), process information and make response. Essentially, this is the extended application of Internet of things and artificial intelligence in textile industry, giving life and intelligence to conventional fibers.

One. Support programs at home and abroad

As early as in 2005, Up-tex, the base for technological innovations in new fiber materials and industrial textiles, was established in the nationally second developed technical textiles production cluster in Northern Lille of France, dedicated to the innovation and production in such aspects as intelligent fiber fabrics, and ecological and scientific fiber fabrics. Since 2013, a national strategic project called “future textiles” (future TEX) has been proposed in German, intended to transform the textile industry into an innovation base relying on new materials, energy preservation, and smart products, aiming to let new textiles and fibers lead Industry 4.0 and become one of the most innovative industries in German. Europe Union published the “HORIZON 2020” Plan in 2014, making overall arrangement for fiber products to develop towards high qualities and professional applications, and for the mechanism

二、智能纤维的设计

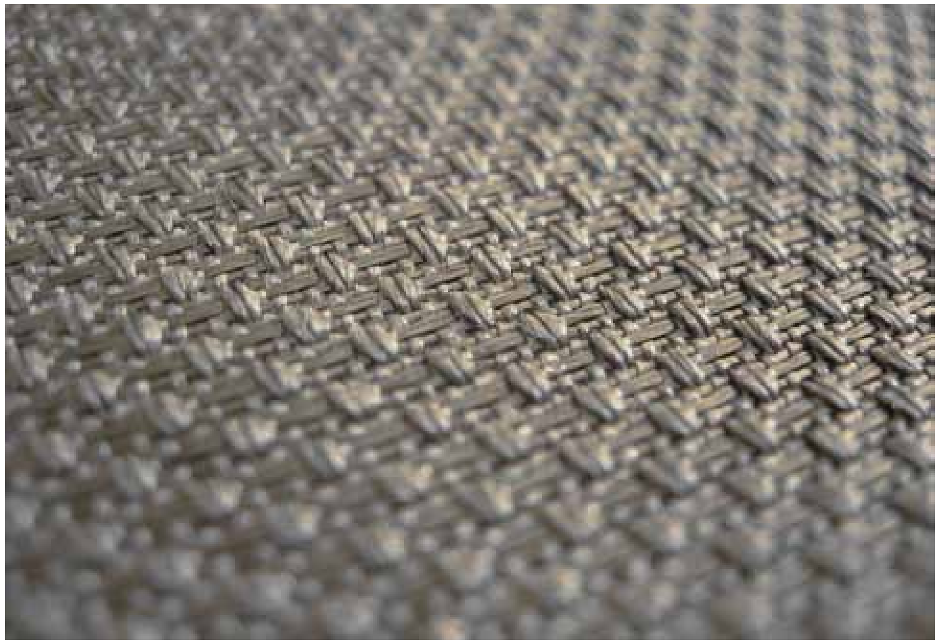
1）从材料角度出发。多组分是构筑智能纤维的有效途径。以碳纳米管、石墨烯为代表的新兴材料具有特殊物性和优异性能，成为智能纤维的主体材料。石墨烯是由碳原子以蜂窝状链接起来的二维片状纳米材料，具有迄今为止最高的拉伸强度和杨氏模量，同时还有最快的载流子迁移率以及最快的传热速率，具有极大的应用潜力。石墨烯纤维是 2011 年才开始发展的一种新型纤维。石墨烯纤维遗传了石墨烯的诸多优异性能。碳纳米管主要由呈六边形排列的碳原子构成数层到数十层的同轴圆管，是一种一维纳米材料，具有优良的力学、电学和化学性能，碳纳米管纤维继承了碳纳米管的诸多优异性能。

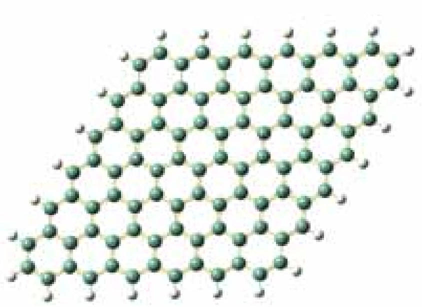
2）从结构角度出发。多结构是构筑智能纤维的另一有效途径。不同的纤维截面形貌使得纤维具有额外特殊性能，例如将纤维制作成三角形，五边形，八边形时，可以将照射到纤维表面的光最大程度地散射出去，使织物看上去不会耀眼，且颜色更加鲜艳。同时中空结构、梯度结构、皮芯结构等结构将使得纤维更凸显出其智能化。

三、智能纤维的雏形

1）导电纤维。本研究团队以湿法纺丝方法连续制备得到石墨烯纤维，其导电率达到 10^4 S/m。另外，东华大学朱美芳团队通过表面工程化方法在聚苯硫醚织物上涂覆石墨烯，获得导电织物，其导电率可在 10^{-2} ～ 10^1 S/m 区间调节，并且导电织物具有良好柔性，即使在弯折条件下导电性能仍然不受影响。这些导电纤维与织物在电子纺织品和可穿戴设备上具有广阔的应用前景。

2）发电纤维。复旦大学彭慧胜团队制备了一种碳纳米管 / 二氧化钛复合纤维，并且以此构建了太阳能电池纤维，其转化率为 2.73%。后来该团队又制备了一种石墨烯 / 铂纳米颗粒复合纤维，并且以此构建了太阳能电池纤维，其转化率高达 8.45%，接近 12% 这个可实用化的转化率，为太阳能发电服提供了可能。





of their technological innovations, with high-performance and multi-functional intelligent fibers as the core. Revolutionary Fiber and Textiles Institute for Manufacturing Innovation (RFT IMI) was established in 2016 in the US, dedicated to developing the intelligent fibers and textiles involving multiple materials, multiple structures, and multiple textiles, effecting the change in fiber materials from military use to civil use, and facilitating the integration of textiles and fibers with other disciplines and fields. In 2016, a team of interdisciplinary experts, dominated by academicians, proposed the concept of “great fiber” in China, which refers to the new generation of fibers that are based on technical breakthroughs and interdisciplinary integration in such disciplines and fields as materials, information, machinery, biology, and energy, have the features of “being intelligent, having ultra-high-performance, and being green”, feature multiple functions, multiple structures, and multiple materials, and are able to have the effect of highly affecting, essentially changing, revolutionizing, and improving conventional industrial clusters.

Two. Design of intelligent fibers

1) From the perspective of materials, multiple components represent an effective method for making intelligent fibers. The emerging materials represented by carbon nano-tubes and graphene have special physical properties and excellent performances, becoming the major materials for intelligent fibers. Graphene is a two-dimensional slice-like nano material made of carbon atoms linked in a cellular way, having the currently highest tensile strength and Young modulus, featuring the fastest transfer of carriers and the fast heat conductivity, with huge potential for application. Graphene fiber is a type of fiber that began to be developed as late as in 2011. Graphene fiber inherits many excellent properties from graphene. Carbon nano tubes are mainly the coaxial circular tubes consisting of several to tens of layers of carbon atoms arranged in the shape of hexagon, and they are a type of one-dimensional nano material, having good mechanical, electrical, and chemical properties. Carbon nano tube fiber inherits many excellent properties from carbon nano tube.

2) From structural perspective, multiple structures represent an effective method for making intelligent fibers. Different cross-sections enable fibers to have additionally special features, for example, when fibers are shaped into triangle, pentagon, and octagon, the light shed on fiber surface can be scattered to the highest extent, so that the textile does not looks dazzling, but appears more colorful. Meanwhile, such structures as internally hollowed structure, graded structure, and skin-core structure can make fibers highlight their intelligent features.

Three. Intelligent fibers at initial stage

1) Electricity-conductive fibers: this research team has obtained graphene fiber through continuous preparation with wet spinning method, the conductivity of which reaches 10^4 S/m. In addition, Zhu Meifang’s team with Donghua University has obtained electricity-conductive textiles through coating polyphenyl thioether with graphene using surface engineering method, the electric conductivity of which can be regulated between 10^{-2} and 10^1 S/m. The electricity-conductive textiles have a good flexibility, and their electric conductivity is not affected even if they are bended. These electricity-conductive

3）储能纤维。目前主要有超级电容器纤维和锂离子电池纤维。例如两根石墨烯 / 二氧化锰复合纤维相互缠绕，中间隔离电解液即可作为超级电容器纤维，该纤维可以持续点亮一个 LED 灯长达 8 小时。而对于锂离子电池纤维，如果采用碳纳米管 / 钛酸锂纤维作为负极，碳纳米管 / 锰酸锂纤维作为正极，该锂离子电池纤维如果编织成 A4 纸张大小的织物，可以为一部手机充电 2 ～ 3 次。

4）传感纤维。东华大学朱美芳研究团队制备了一种苯乙烯 / 碳纳米管复合纤维，可以实现对氨气、甲苯、丙酮、四氢呋喃等有害气体的精确检测，该纤维具有快速响应（小于 40s），高灵敏性和重复使用等优点。

5）致动纤维。东华大学王宏志团队通过湿法纺丝获得石墨烯 / 聚丙烯酸钠复合纤维，该纤维对近红外光有强烈的感知能力，在光照下可以转动自身体重 20 倍的材料。北京理工大学曲良体团队制备了具有截面不对称结构的石墨烯纤维，对湿度拥有良好的响应特性，该纤维编织成的布料在不同的湿度环境下可以实现不同的弯折情况，并且随着湿度的周期性变化，实现布料的周期性运动，有望实现全新的机器人驱动方式。

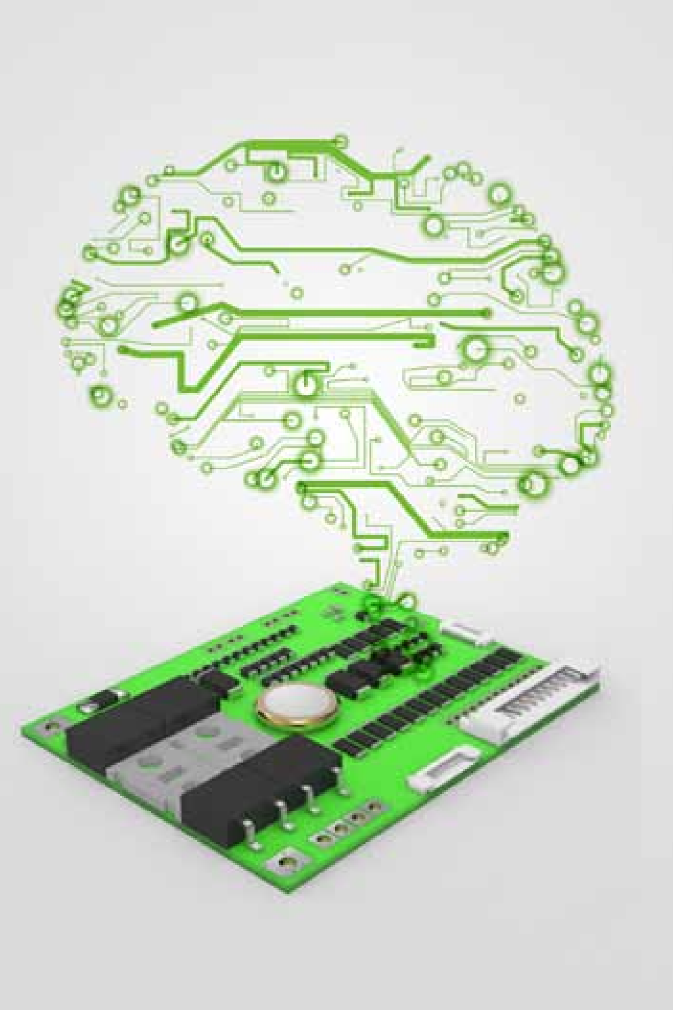
结语

智能纤维正在蓬勃发展，但是目前还处于初级的阶段，从纤维组分、结构、制备工艺、设备到最终的应用领域，都将面临重大的挑战和革新。智能纤维不仅仅关乎材料学科、化纤和纺织行，还将会融合数学、IT、电子等众多学科和医疗、军工、航天等多学科、多行业。1985 年电影中出现的自动系鞋带鞋子到 2016 年才得以实现，那么 2008 年在电影中出现的钢铁侠战袍，什么时候能够实现？这对智能纤维提出新的挑战。

纤维材料改性国家重点实验室

东华大学材料学院

翁巍，杨俊杰，张扬，刘强，朱美芳



fibers and textiles have the prospect of being applied in wearable equipment.

2) Electricity-generating fibers: Peng Huisheng's team with Fudan University prepared a type of carbon nano tube/titanium dioxide composite fiber, and built solar cell fiber with it, the conversion rate of which is 2.73%. After that, this team also prepared a type of graphene/platinum nano particles composite fiber, and built a solar cell fiber, the conversion rate of which is 8.45%, close to 12%, at which, applications have practical significance, providing the possibility for solar electricity-generating clothes.

3) Energy-storing fibers: at present, there are mainly super capacitor fiber and lithium ion fiber. For example, if two graphene/manganese bioxide composite fibers twin around each other, the intermediate insulating electrolyte can be used as super capacitor fiber. This fiber can keep a LED lamp lit up for as long as 8 hours. However, for lithium ion cell fiber, if nanotube/lithium titanate fiber is used as cathode, nanotube/lithium manganese oxide as anode, and this lithium ion fiber is woven into a textile the size of A4, it can charge a handset 2~3 times.

4) Sensing fibers: Zhu Meifang's team with Donghua University prepared a type of phenylethylene / carbon nanotube composite fiber, able to accurately detect such harmful gases as ammonia, toluene, acetone and butylene oxide. This fiber has such features as fast response (less than 40s), high sensitivity and repeatable usage.

5) Actuating fibers: Wang Hongzhi's team with Donghua University obtained graphene / sodium polyacrylate composite fiber. This fiber is highly sensitive to near infrared, able to move the material that is 20 times as heavy as its weight under illuminated conditions. Qu Liangti's team with Beijing Institute of Technology prepared the graphene fiber with its cross section having an asymmetric structure, which features a good response curve to humidity. The fabrics woven with this fiber can achieve different bending effects in different wet environments, and vary with humidity in regular cycles, achieving the periodical movements, and are expected to realize a brand new method for driving robots.

Conclusion

Intelligent fibers are booming, but are still at initial stage at present. From fiber components, structures, preparation processes, equipment, to final applications, they will face serious challenges and innovations. Intelligent fibers are not only related to the subject of materials, chemical fibers and textiles industry, but also involve many disciplines and industries such as mathematics, IT, electronics, medical care, military industry, and aerospace. A film in 1985 shows a shoe that can be tied automatically, but it wasn't until in 2016 that such a shoe became true. Well, a film in 2008 shows Iron Man wearing coat armor, when will that come true? This poses challenges for intelligent fibers.

By Wong Wei, Yang Junjie, Zhang Yang, Liu Qiang, and Zhu Meifang

State key lab for modification of chemical fibers and polymer materials

Donghua University

二 . 下游趋势预测
DOWNSTREAM OF FIBER TREND FORECAST

海派流行趋势下的面料设计方向与依据基点
Direction & basis point of fabricsdesign in Shanghai-styletrend

2019 年是“五四运动”100 周年，中国时尚亦步亦趋跟随西方主流时尚文化也几乎百年有余。过往缺乏自我的主张，在国际时尚价值链上将一直处于低端、低效益被动地位。如今“一带一路”互联互通战略眼光，我们有了扎根本土文化同时，视全球文化为灵感源泉，全球人才为可靠保障，兼容并蓄地将国际流行大趋势与我们本土生活方式与审美结合。这也是海派文化的本质，是中国传统文化与西方文化一次转基因，锻造中华文化“天下”普世价值观。

中国 GDP 总量首超 80 万亿元，同比增长 6.9%。变革调整期的中国，已经呈现更多的新机会与格局。供给侧结构性改革深入推进，消费升级态势显著。

社会结构扁平化与中产危机叠加，层级意识上逐步弱化，但经济缓行与人口红利的丧失，中产阶级将面临改革开放三十多年来峰值回落后经济上的再分级。市井文化人竭力使经典时尚化与时尚再传统化不断演绎。

新商业模式显现出强大的号召力，新一轮的产业结构在经历“互联网 +”的冲击与洗牌下不仅超越正常速率的其他发展中国家，成为当下全球未来发展方向的试金石，其模式更是超越西方主流经济学范畴。

多元互动文化的全民传播，其重要特征是视角的多样混合型，偶发样式潮起潮退文化形式。振奋人心的是文化话语权的振兴与回归。

大数据让人变得透明，个性被分门别类为时代符号成为某种共性的代言，每个个体在大数据中运算出过往和未来，并能直指理想的镜像！

海派流行趋势依据以上基点在文化的经典、自然的归宿、都市的寄居、未来的期盼中匹配、判断：

The year of 2019 will see the centenary for the May 4th Movement in China.It also has been more than a century for China’s fashion to blindly follow western mainstream fashion culture. In the past, China was lack of its own perspective, which made itin a low-end and low-efficiency negative position ininternational fashion value chains. Nowadays, The Belt and Road Initiative shows China’s strategic insight of establishing and strengthening partnership with other countries. Entrenched in indigenous culture, China takes global culture as its source of inspiration and global talents as its reliable guarantee, and combines international fashion trend withlocal lifestyle and aesthetic concept in an all-inclusive manner It is also the essence of the culture of Shanghai-style culture and the genetically modification of Chinese traditional culture and western culture, which forges the universals values of “world under heaven”in Chinese culture.

The aggregate GDP of China surmounted was firstly over 80 trillion yuan, with a year-on-year growth up 6.9%. China has taken on more new opportunities and patterns in the period of reform and adjustment. The supply-side structural reform has been intensified, with remarkable upward trend in consumption.

Flattening social structure and middle-class crisis overlay, andsenses of hierarchy gradually weaken. Meanwhile, economic slow-down and demographic dividend loss resulted that the middle-class will face re-grading of economy after its fallbackfrom the peak value throughout the three decades of reform and opening up. Marketplace culture spares no efforts in makingfashionable classics and re-traditional fashion continuously popular.

New business modes manifest strong appeal. After experiencing theimpactand reshuffle of "Internet plus", the new round of industrial structure surpasses other developing countries with normal rate of growth to become the touchstone for future global development, with the new mod transcending the mainstream economic sphere of western countries.

The important feature of the whole-nation dissemination of multi-interactive culture is the combination of various angles of view, occasionally with the ebb-and-flow of culture. What is inspiring is the revitalization and return of the cultural discourse right.

Big data makes people’s information transparent. Personality is classified into symbols of age representing certain similarity. Each individual can speculate the past and future in big data that is directed to the ideal vision.

According to the above basic points, Shanghai-style trend makes alignment and judgment in cultural classics, natural destination, urban aboding and future expectation.

1、海派经典的基调
Tone of Shanghai-style classics

新一季的趋势里，我们将看到更加注意文化交融、跨界，类别的边界在重整。那些故往的经典模范通过传播、消费的异化在基层的通行，通俗在当代再平衡赋予正统、经典混合于潮流特征下。

In the new season, we will find more attention to cultural blending and transboundary with reorganization of boundaries of categories. Those outmoded classic models become popular at grass-roots level again through the dissimilationof communication and consumption. Popularityrebalances the tradition and classics that are blended with the momentum in contemporary era.

(1) 金色时代与功能浮夸
Golden age & function exaggeration

浮夸的华丽的金色一直是世俗社会财富的象征。亮闪特点的光泽材料、百褶、荷叶边造型将再次成为时尚符号。再装饰直至极限闪耀的光芒与经典的造型特征连贯转换仿佛世俗也神圣了。

The flamboyant golden color has always been a symbol of wealth of secular society. Flashing glossy materials, pleats and falbalapatterns become signal of mode again.Sparkling redecoration and classical styling features make alternative conversion in a coherent way, which makes the secularity sacred.

(2) 越界趣味与新潮华丽
Cross-border interest &new-wave magnificence

精英与平民，次序与随意、光洁与毛糙、单色与彩色，我们尝试将不同属性的东西并置混合在一个体系里，形成多层次搭配。80 年代的华丽风格再次回潮，随性夸张的线条与炫丽，当代的材质、色彩与传统造型共同解构与对比创造出带有复古调子的创新华丽感。

We try to blendthings of different attributes, such as the elite and the civil, the order and the random, the smooth and the rough, the monochrome and the chromatic, with a view to make multi-leveled collocation. The ornate style in 1980sresurges again, with the deconstruction and comparison of exaggerated random lines, flashy colors, contemporarymaterials and traditional patterns to create gorgeous feelings in a vintage tone.

2、海派自然的物境
Natural matters' image of Shanghai style

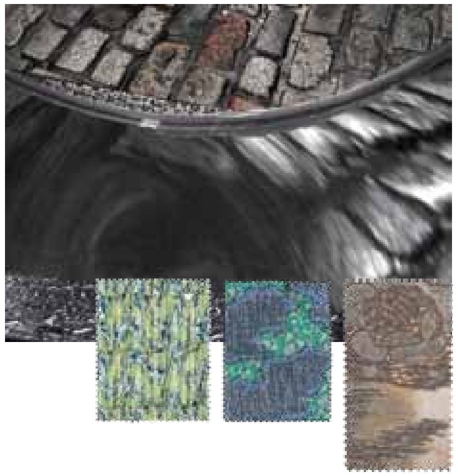
物质的繁荣侵消了精神空间，物质的叠加，以精神体验相伴，人类基因中自然的向往通感：趣味、生命、亲和向人为化影响自然方向激进。

The prosperity of matters has eroded mental space, with the superposition of matter and theaccompanying of spiritual experience. The gene of human beings is born to desire for the synesthesia of interest, life and affinity that artificially influence theevolving of the nature.

(1) 感知剪辑与人工自然
Perceptual editing & artificial nature

自然是感悟与片段，城市住久了往往有出离冲动。旅行的经历化作蒙太奇感的视觉呈现伴随着真实的生活。追求自然的自由感，装饰真实却枯燥的生活，虚幻的形式美以原生态，自然肌理呈现，实现心里上的出离。

The nature is often related to the fragment of feelings. The dwelling in urban areas for quite a long time often provides us with impulseof leaving away. The experience of travel is transformed into montage-likevisional appearance accompanied with real life. The pursuit of natural sense of freedom to decorate real but boring life realizes the spiritual far-away by means of virtual formal beauty that presents in natural texture.



(2) 写实装饰与质感技艺
Realistic decoration &texture technique

长焦的冲击感让视觉往抽象微观世界发展，其放大与逼真效果的装饰是一种陌生的真实。这两年随着新材料及新技术的创新应用，越来越多的非服装材料与服装材料的组合或复合重组等手法成为新卖点，大量二次加工材质与改造重组加工成为创新的设计手法，不停重构与组合。

The impact of long-focus leadsthe visual sense towardabstract micro-world, with the effect oflife-like and amplification as the decoration of an alien reality. Over the past two years, with the innovation and application of new materials and new technologies, more and more techniques of combining or multiple regrouping non-garment and garment materials have become new credits. A large number of secondary operation materials, remolding and reconstruction have become innovative designing skills, which are constantly reconstructed and combined.

3、海派都市的繁序
Manifold order of the Shanghai-style urban

政府试图规范市井，街头文化与主旋律交融，使都市系列原本潮流前卫的质感上平添了些拿腔拿调，新阶层涌现与固化并存，随机的自由被人为碰撞缔造出叠加的秩序感。

The government strives to standardize the marketplace by combining street culture and mainstream theme, which makes the originalavant-garde texture of the urban series become a bit affected. The emergenceand solidification of new stratums coexists, with random freedom being artificially superposed with senses of order.

(1) 工装再造与亚文化流
Tooling reconstruction& subculture flow

山峦起伏连亘绵延，阳光下山坡上斑斓的肌理似锦被叹为观止。人工的真实甚至是超越自然真实，个性中美与丑都被放大，设计唯美不是唯一，而追求真实的甚至是超真实的残缺与不完美，成为工装再造的精髓，科技感的自然在都市大行其道。

Thebrocade-like texture with continuousrise and fall of chain of mountains and multi-colored hillside under the sun is amazing. Artificial reality even surpasses natural reality, with amplification of beauty and ugliness in personality. Design aestheticism is not the only vital thing, while the pursuit of authenticity or even hyper-real defects and imperfections has become the quintessence of tooling reconstruction. The nature in the sense of technology prevails in the city.

(2) 复古前卫与优柔符号
Symbol of retro avant-garde &leisure

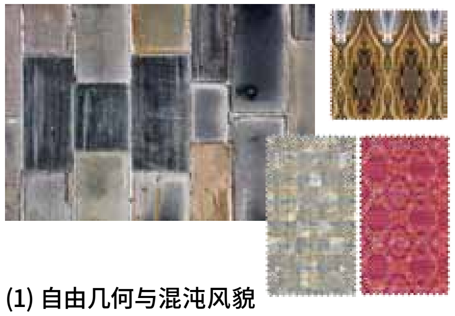
文化更新往往是通过早期风格的探寻及复古风格的再造，年代的打散重组成为新文化的诠释。新工艺打磨旧造型以便衍生时间痕迹。在设计中新文化其实就是旧文化符号的重视甚至夸张及戏谑。

Cultural renewal often becomes the interpretation of the new culture through the exploration of early styles, the reengineering of retro styles, and mixture and reconstruction of ages. The new technique grinds old patterns to derive time trace. In the design, the new culture is actually the recurrence, exaggeration and even banter of the symbols for the old culture.

4、海派未来的反构
Counter structure of future Shanghai-style

自由主义在中国特色的规划影响下既有无序、随机，轻松的直觉理想，充满未知的想象力与不可预测性的一面，更有可控可期可施未来理念。反之貌似俨然的次序下，传统不断被突破又不断被规范。

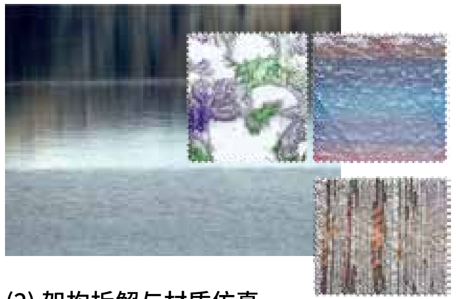
Under the influence of Chinese characteristics, liberalism has an out-of-order random light-hearted idealof intuition, full of unknown imagination, unpredictability, and even the concept of building a controllable, expectable and applicable future. On the other hand, it seems that the tradition is constantly being broken through and regulated in the orderly atmosphere.



(1) 自由几何与混沌风貌
Random geometric& chaotic look

运用通感而表达的秩序与理念，在外在单一而纯粹的几何领域，混合了错位、折回、迭代的手法，将原本可归类、可循序的几何元素重构为更加自由而丰富的抽象元素，几何的特点仅保留为碎片式的痕迹！过程美感成为研发的重点，未知的方向性，眼花缭乱的模拟，而并行的去因果关系的载体，如混沌学说般风格与元素，细节与整体，色彩与材质都不可统一或层出不穷的尝试与实验。

In the geometric sphere for single and pure appearance, the expression of order and conceptviasynesthesiamixesthe methods of dislocation, retracing and iteration and reconstructs the geometric elements that could have been classified with sequence into morerandom and affluent abstract elements, with only geometric characteristics of fragmentary trace preserved. Process aesthetics has become the focus of research and development, among which involves the direction to the unknown, the dazzling simulation and collateral carriers without causal relationship, in particular, theattempts and experiments on the endless non-uniformity between styles and elements, details and entirety, colors and materials, as the theory of chaos proposed.



(2) 架构拆解与材质仿真
(2)Architecture disassembly& material simulation

表象之下的规律或构成要素的解构与重组，非具体造型或解构手法强调构成核心的转移。仿真为了更加创新，逼真的想象力，借助高科技材料与实现技术，如 3D 打印的材质的优化，细腻、丰富的细节与夸张造型的组合，形成实用价值很高的创意感产品，同时高仿真的细节将出现在材质的改变上，如运动感中融入高仿幻影风格的自然外观的材质等！

Under the image, the deconstruction and reorganization, non-specific modeling or deconstruction techniques of rules or elements emphasize the transfer of constitution core. In order for more innovative and realistic of imagination in simulation, high-tech materials and other realistic technologies are applied, such as the optimization of 3D printing material. The combination of subtle and abundant details and exaggerated shapes form with creative products with high practical value. Meanwhile, high-simulation details will appear in material changes, such as the integration of high-imitation phantom style with sense of movement in the materials with natural appearance.

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冬奥运动服装中的运动时尚与纤维科学
Fashion Design and Fibre Science in Winter Olympic Sportswear

2018 年平昌冬季奥运会（2018 The winter Olympics in Pyeongchang 已经于 2 月 9 日至 25 日在韩国平昌郡举行，其中大部分雪上运动在平昌郡，所有冰上运动在江陵市，高山滑雪滑降比赛在旌善郡进行。四年之后的 2022 年北京冬季奥运会将在 2022 年 2 月 4 日，即大年初四开幕，北京将承办所有冰上项目，延庆和张家口将承办所有雪上项目。北京冬奥会更因为“带动 3 亿人上冰雪”的承诺，必将兴起“大众冰雪”的热潮。

纵观本届平昌冬奥会，各大服装品牌纷纷赞助各国家代表队，在开幕之前 Ralph Lauren 就爆出可加热外套黑科技，The North Face、Anta、Mizuno、Phenix、Scott 等品牌都有不俗表现，助力运动员取得好成绩。本文将从服装科技、材料科学、时尚表达三方面分析冬奥服装中所蕴含的功能与时尚。

1. 冬奥装备中的服装科技

在竞技场上，千分之一秒的时间都可能影响比赛胜负，能够有效减小运动阻力、提高运动舒适性的服装，对运动员在竞技场上取得优异成绩有至关重要的作用。其中，减小整个装备系统的风致阻力是目前的热点研究问题，涉及服装的要素则包括织物表面粗糙度、弹性、透气性，服装接缝线位置，需要从空气动力学、纺织纤维科学、生物力学、人体工程学等多方面进行研究。在已有的研究中，Dias 报告了表面轮廓和织物结构参数之间的关系，表明织物表面粗糙度和透气性可以通过不同的编织参数来控制；Hoerner 提到气动阻力可能与织物的透气性有关；Moria 提出织物的表面粗糙度与抗风阻性能有直接关系。Brownlie 根据研究提及速滑运动员在赛场上穿着的比赛服应该为多片式结构，即运动员身体的每个部位应覆盖不同性能的面料。2002 年，在盐湖城冬季奥运会上，Nike 研发团队为美国速度滑冰队研发的“The Swift Skin Suit” 比赛服就是多片结构（见图 3），结合速度滑冰

图 3 Nike 为美国速度滑冰队研发的 Swift Skin Suit 比赛服（2002）

Figure 3: The Swift Skin Suit developed by Nike for the United States Speed Skating Team (2002)

PyeongChang 2018

图 1 2018 年平昌冬奥会会徽

Figure 1: The emblem for the 2018 Pyeongchang Winter Olympic Games

BEIJING 2022

图 2 2022 年北京冬奥会会徽

Figure 2: The emblem for the 2022 Beijing Winter Olympic Games

The 23rd Winter Olympic Games have taken place in Pyeongchang, South Korea, between 9-25 February 2018. Most of the snow sports were held in Pyeongchang County, whereas all the ice sports were competed in the coastal city of Gangneung and Alpine speed events in Jeongseon. In four years time, in 2022, the Beijing Winter Olympic Games will be kicked off on February 4, 2022, the fourth day of Chinese New Year. Beijing will host all of the competitions on ice and all the snow events will take place in Yanqing and Zhangjiakou. Beijing Winter Olympic Games will surely promote the sports on "ice and snow", to be participated by " 300 million people" as promised by the government.

Throughout the Pyeongchang Winter Olympics, it can be seen that the major clothing brands have sponsored all different national teams. Before the opening ceremony, Ralph Lauren has shown the black technology on self-heating coats. The other companies, such as The North Face, Anta, Mizuno, Phenix etc. are all doing well in promoting the good performance from athletes. This article will explore the function and fashion of winter Olympic clothes through fashion technology, materials science and fashion expression.

1. Technology in Olympic Clothing and Equipment

In the arena, the result of a competition may be split by a thousandth of second. Therefore, the clothing may play very important role in terms of reducing that can effectively reduce the resistance to movement and improve the comfort of the wearer. For instance, how to reduce the wind resistance of the outfit is one of the hottest research areas. Other important factors concerning clothing include fabric surface roughness, elasticity, breathability, seam line position, to be studies from different research areas such as aerodynamics, textile fiber science, biomechanics and ergonomics.

In the existing literature, Dias, for instance, reported the relationship between surface profile and fabric structure parameters, indicating that the fabric's surface roughness and breathability can be controlled by using different weaving parameters. Hoerner suggested the relationship between the aerodynamic drag and the breathability of the fabric; Moria proposed that the surface roughness of the fabric is directly related to the resistance to windage. Brownlie asserted that the speed skaters should wear a multi-panel suit in the arena, that is, each part of the athlete's body should be covered with different performance

运动的动作特点，选用六种面料放置在不同位置来完成这件衣服。在手臂以及小腿区域运用表面粗糙的面料，在躯干和大腿区域运用光滑的聚氨酯涂层织物。此外，手臂和右大腿内侧都放置了低摩擦系数面料以减少身体摩擦，改善整体运动效率。The Swift Skin Suit 使比赛服的摩擦系数降低高达 55%，Nike 公司的测试表明，在 1500 米的比赛中同一名选手要比穿其他比赛服快 0.2 秒左右，对于竞技运动来说无疑是科技带来成绩的巨大提高。

图 4 为 Descente 研发团队为加拿大速度滑冰国家队研发的 Vortex C2 比赛服，也在 2002 年盐湖城冬季奥运会上亮相。比赛服在面料肌理结构上进行了优化，在服装的大腿和小臂区域设计了螺旋盘绕的凸起硅胶肋条，这些肋条能够引导空气流动，从而增强服装的抗风阻性能。

在本届平昌冬奥会上，Odlo 为斯洛文尼亚、法国和瑞士三国冬季两项和越野滑雪国家代表队设计了比赛服（见图 5）。Odlo 采用了无缝针织结构和人体分区结构设计，使得服装重量极轻又保证运动舒适感。

保暖新科技在冬季奥运会上也备受瞩目。Ralph Lauren 为美国国家队定制的本届冬奥会开幕式夹克，一经亮相立刻引来关注（见图 6）。这款夹克采用了导电墨水技术，加热系统以美国国旗的形状设计，由导电碳以及银色油墨制成，可调节三种不同的半暖温度。设计细节上，一根细长的电源线隐藏在外套蓬松的衬垫下方，从右侧前袋伸出，电池组放置在口袋里面。电池组通过两个简单的按钮来控制加热设置。同时装置可以与手机连接，能够直接通过手机直接检测以及调节温度。此款加热服在 Ralph Lauren 官网上一出现就也立刻脱销。

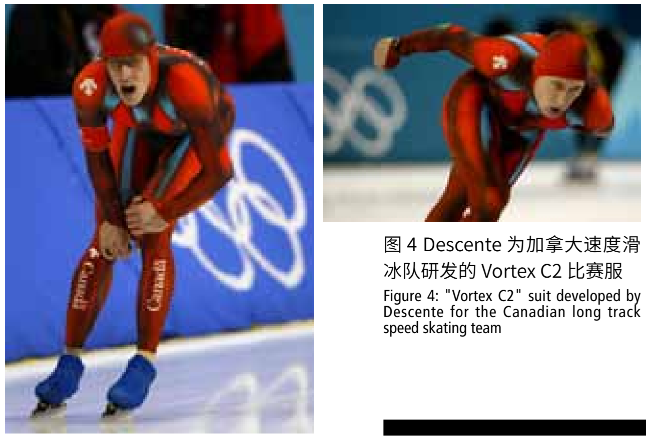


图 4 Descente 为加拿大速度滑冰队研发的 Vortex C2 比赛服

Figure 4: "Vortex C2" suit developed by Descente for the Canadian long track speed skating team

图 5 Odlo 为冬季两项、越野滑雪国家代表队设计的比赛服装（从左至右：法国、斯洛文尼亚、瑞士）（2018）

Figure 5: the Biathlon and Cross Country skiing national team outfit designed by Odlo for France, Slovenia and Switzerland (From left to right: France, Slovenia, Switzerland) (2018)

图 6 Ralph Lauren 为美国国家队定制的 2018 年冬奥会开幕式夹克

Figure 6: US national team Opening Ceremony uniform for Pyeongchang 2018 Winter Olympics in Korea, by Ralph Lauren.

fabrics. In 2002, during the Winter Olympics in Salt Lake City, the "Swift Skin Suit" developed by the Nike R & D team for the American speed skating team was an example of the multi-panel suit (Figure 3). Combining the characteristics of the speed skating action and the movement of each body parts, six types of fabrics were used and placed in different positions in the skating suit. For instance, rough-textured fabrics were used at the arm and calf areas whereas the smooth polyurethane coated fabric is used for the torso and thigh areas. In addition, a low-friction fabric is placed on inside of the arms and right thigh to reduce body friction and improve overall movement efficiency. The Swift Skin Suit reduces the friction coefficient by up to 55%. Nike's tests show that in the 1,500-meter race, the same skater can complete the course 0.2 seconds shorter with this suit than the normal ones. This just demonstrates the effect of technology to the improvement of athletic performance.

Figure 4 shows the Vortex C2 suit, which was developed by Descente R&D group worn by Canadian national speed skating team in the 2002 Salt Lake City Winter Olympics. The suit has been optimized for fabric texture and used silicon strips forming a spiral pattern around the thighs and lower arms, which direct the flow of air and enhance the windshield resistance of the garment.

In the 2018 Pyeongchang Winter Olympic Games, Odlo has designed of the Biathlon and Cross Country skiing national team outfit for Slovenia, France and Switzerland (see Figure 4). Odlo uses a seamless knit structure and body partition structure design, making the weight of the garment light and ensuring the comfort of movement.

The technology for keeping warmth always draws a great attention at the Winter Olympic Games. In the opening ceremony of 2018 Pyeongchang Winter Olympic Games, the jackets designed by Ralph Lauren and worn by the US national team have proved to be attractive (see Figure 6). The conductive ink technology has been used in this jacket. The heating system is made of conductive carbon and silver ink, in the shape of the American national flag. There are three temperature settings. Based on this design, a slender power cord is hidden under the fluffy liner of the jacket, then extending from the right front pocket, with battery pack placed in the pocket inside. The heating settings were controlled by two simple buttons through the battery pack. At the same time the device can be connected with the mobile phone, which can directly detect and adjust the temperature. This product was sold out immediately after it appeared in the Ralph Lauren official website.

2. 冬奥服装的材料创新

服装的科技创新离不开纤维材料的创新，材料科学不断助力冬奥选手更快、更高、更强。早在 1982 年，Van Ingen Schenau 就发现不同材料在不同运动速度时的抗风阻性能不同。羊毛面料与莱卡面料相比，当速度低于 7m/s 时前者的抗风阻性能更好，但当速度更快时，莱卡面料的抗风阻性能则更好。莱卡面料被广泛用在各冰雪项目中。

为备战 2014 年冬奥会，美国知名运动品牌 Under Armour 和南密西西比大学（University of Southern Mississippi）联合为美国速度滑冰队研发比赛服，在服装的头顶以及手臂位置使用笼型聚倍半硅氧烷（Polyhedral Oligomeric Silsesquioxane，简称 POSS），POSS 是一种具有纳米尺度的有机无机杂化材料，是上世纪 90 年代中期，美国空军研究实验室（Air Force Research Lab，简称 AFRL）推进技术委员会为了满足空军对新一代超轻、高性能聚合物材料的需要，发展的一种多面体纳米结构杂化体系 。南密西西比大学的 Morgan 教授在研究中采用 POSS 纳米粒子衍生物 octaisobutyl POSS 与聚丙烯共混，制备 octaisobutyl POSS/ 聚丙烯纳米复合材料。研究发现 POSS 分子的几何形状、组成和浓度与摩擦性能、纳米机械性能、表面性能有关。共混物具有超低摩擦性能，能增强硬度、模量和疏水性，但共混对基体材料的影响很小。利用原子力显微镜，扫描电镜，透射电镜和光谱分析表明 POSS 在表面和本体中分布和聚集有显著差异，POSS 优先分布在表面。此外，掺入 POSS 纳米颗粒后能量和磁滞增加。在 Skin Suit 的头部及手臂位置使用该结构，整体有效减阻。详见图 7-8。

在 2018 年冬奥会上，DÆHLIE 研发团队特别为挪威越野滑雪队设计了“Race Suit Champion”比赛服（见图 9），助力挪威队取得奖牌榜第一的好成绩。比赛服是一体式紧身服，面料采用

图 7 使用笼型倍半硅氧烷 (POSS) 材料制备的减阻带
Figure 7: Drag Reduction Bands made by POSS

图 8 Under Armour 为美国速度滑冰队研发的比赛服装手臂区域
Figure 8: Arm areas of the United States speed skating team uniform developed by Under Armour

2. Material Innovation of the Winter Olympic Clothing

The technological advance in clothing is based on the innovation of fiber materials and the whole materials science, which constantly promote the Winter Olympics players to be faster, higher and stronger. As early as 1982, Van Ingen Schenau found that different materials can reduce the drag on the athletes at different speeds. Comparing with Lycra, wool suit has less drag at the speed below 7m/s. However, at higher speeds, the Lycra suit has lower drag. Thus, Lycra fabrics are widely used in various winter sport events.

In preparation for the 2014 Winter Olympic Games, the well-known sports brand Under Armor teamed with the University of Southern Mississippi to develop the USA national speed skating team suits. A special material called polyhedral oligomeric silsesquioxane (POSS) was used around the head and arms. POSS is a kind of organic-inorganic hybrid material in nanometer scale. It was initially developed by the Air Force Research Lab's (AFRL) propulsion technology committee in the mid-1990s to meet the requirement of a new generation of ultra-light and high-performance polymer materials (a polyhedral nano-hybrid system) from the Air Force. Professor Morgan of the University of Southern Mississippi used derivatives of POSS nanoparticles, octaisobutyl POSS, to react with polypropylene to obtain nanocomposite materials. It was discovered that shape, composition and concentration of POSS molecules have something to do with the frictional properties, nano-mechanical properties, and surface properties. The composite has ultra-low friction, as well as enhanced hardness, modulus and hydrophobicity, but with little effect on the matrix material. Atomic force microscopy, scanning electron microscopy, transmission electron microscopy and spectroscopic analysis showed that POSS is preferentially distributed on the surface, far more than in the bulk. In addition, the energy and hysteresis of matrix increase after incorporation of POSS nanoparticles. The use of POSS at the head and arms of the suit can reduce the drag overall. (see Figures 7-8 for details)

图 9 DÆHLIE 为挪威越野滑雪队平昌冬奥会研发的比赛服（2018）
Figure 9: the Norwegian cross-country skiing team uniform developed by DÆHLIE for PyeongMing Olympics (2018)

图 10 挪威越野滑雪男子队穿着 DÆHLIE 包揽 15 公里 +15 公里比赛双追逐前三名

Figure 10: Norwegian cross-country skiing men's team wearing DÆHLIE claimed a clean sweep of the men's 15km/15km Skiathlon podium

图 11 短道速滑队员武大靖身着 Anta 比赛服（2018）

Figure 11: Short track speed skater Wu Dajing wearing designed by ANTA

意大利 Carvico 生产的聚酯和氨纶混纺的轻型弹力面料，减少接缝数量以减轻整体服装重量。DÆHLIE 研发团队将女款越野滑雪比赛服降到 250 克以下，成为现今市场上最轻的比赛服。在腋下区域、膝盖后侧以及背部中央区域采用网状面料，增加运动员的可活动范围，并提升比赛服的通风透气性。在小臂以及小腿区域采用 Schoeller 生产的凹坑面料 “Eschler Dimplex”，这种材料表面结构与高尔夫球表面结构相似，能够有效减阻，可以在 22 至 75 公里 / 小时的速度下将阻力降低 10%。同时，这款比赛服还有效应对平昌冬季介于 +5 至 -10 摄氏度之间的气温，真正做到轻质保暖。如图 10 所示，挪威越野滑雪队员身披这款战袍，在 23 届冬奥会所向披靡、取得优异战绩。

在本届冬奥会上，中国品牌 Anta 则为中国速滑队设计了战服也有不俗战绩（见图 11），服装采用梭织 dyneema 防割纱线，通过 ISU 防割裂标准，压缩系统相比市场同类产品重量轻 50%，有效减小风致阻力。助力武大靖为中国队获得唯一一枚金牌。

3. 冬奥服装的时尚表达

冬奥服装不仅蕴含着服装科技、材料科学的最新发展，同样也包含着视觉的时尚冲击，只有当功能与时尚都同样出色，才是完美的运动服装。以下解读两个冬奥会服装设计的案例。

第 22 届索契冬奥会的核心图形充分体现了俄罗斯传统民间文化的精华 - 拼布被子（patchwork）。志愿者服装设计从核心图案出发，别样快乐活泼。索契冬奥会的核心图案展现了俄罗斯的多面性，这包括在其辽阔国土上丰富多彩的地域风情的多面性，以及俄罗斯的激情和柔情多面性。讲述了俄罗斯这个国土面积最大的国家——占世界大陆的八分之一、1700 万平方公里、跨越 9 个时区、3 个气候带、13 个内海，众多的民族与多种语言。这些千姿百态的文化艺术镶嵌在俄罗斯辽阔的国土上，总的看起来就像覆盖在地球上的一面有着美丽图案的被子。核心图案采用了拼贴的设计手法，专门开发了供有效拼贴与拆分切割的网格母版，网格的

In the 2018 Winter Olympic Games, DÆHLIE's R & D group designed the Race Suit Champion race suits for the Norwegian cross-country skiing team (see Figure 9), which helps Norway to secure the first place in the medal table. The suits are of all-in-one body type, made of polyester and spandex-blended lightweight stretch fabric (made by Carvico in Italy), reducing the number of seams and the overall garment weight. DÆHLIE has decreased the weight of female cross-country skiing suits to under 250 grams, which is the lightest in today's market. The mesh panelling is placed under the arms and to the back of knees as well as at central back for enhanced mobility and ventilation. The 'golf ball' dimpled material "Eschler Dimplex", made by Schoeller, is used at strategic points of legs and arms, which can reduce drag by as much as 10% at speeds between 22 and 75 km/h. Meanwhile, this suit is also effective against the winter temperature in Pyeongchang varying between -10 to +5 C, being light-weighted and thermally isolating. As shown in Figure 10, the Norwegian cross-country skiing team, wearing this shirt, has achieved excellent results in the 23th Winter Olympic Games.

In the 2018 Winter Olympic Games, one of China's largest sportswear brands, ANTA, has designed the Chinese Speed Skating Team outfit and also demonstrated good performance (see Figure 11). The apparel uses woven dyneema cut-resistant yarns and has passed the ISU anti-cutting standards, which is 50% lighter than similar products in the market, effectively reducing the drag. The suit helps Wu Dajing to win the only gold medal for the Chinese team.

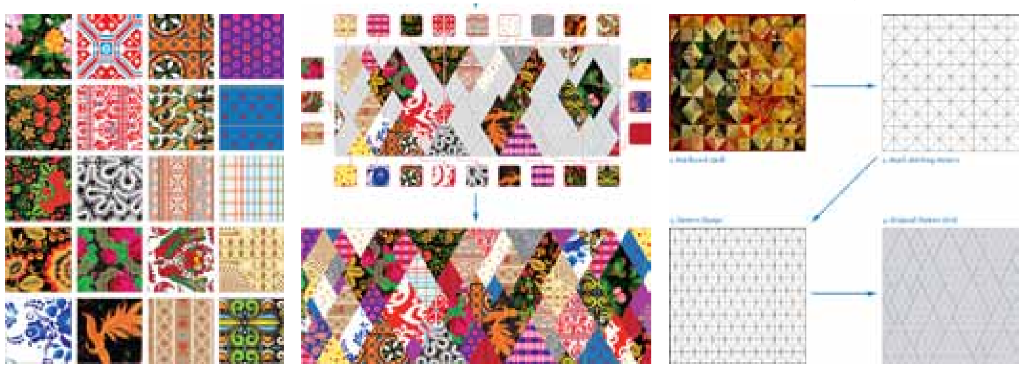
3. Fashion Expression of Winter Olympic Clothing

Winter Olympic clothing is not only about the frontline of apparel technology and material science, but also concerning the visual impact of fashion. It can only be regarded as perfect sportswear if both the function and fashion are equally excellent. We will look at two case studies of Winder Olympic costume design.

The core pattern of the 22nd Sochi Winter Olympics fully embodies the essence of Russian traditional folk culture - patchwork. The design of volunteer costumes uses the core pattern to express joy and liveliness. The core pattern of the Sochi Winter Olympics demonstrates Russia's versatility, which reflects the multifaceted nature in terms of its vast territory, both passion and tenderness.

图 12 第 22 届索契冬奥会俄罗斯核心图形“拼布被子”图案演化

Figure 12: The core pattern of the 22nd Winter Olympics - "patchwork quilt"



构成是纵向菱形的四方连续。通过这些网格提取，拼组成一幅连续的图案。图 12 是索契冬奥会俄罗斯核心图形“拼布被子”图案演化。图 13 是直接将核心图形应用在比赛的号码背心上，传递活跃和快乐的情绪。

Anta 为 2018 年平昌冬奥会中国体育代表团设计了第五代“冠军龙服”（见图 14）。核心概念仍旧围绕中国传统精神图腾“龙”概念展开，将书法龙形与冬奥会“冬”字相结合，龙头昂扬向上，寓意中国体育精神奋发进取；颜色更为简洁大气，采用大面积白色拼接红色，在拉链和字母印花上做黄色点缀，款式简洁大气；在版型设计上采用修身版型；加工工艺采用立体钢压技术，在钢压的基础上印红色 CHINA 凹凸，富有立体感。

平昌冬奥会刚刚落下帷幕，开始期待着四年之后的 2022 年北京奥运会的到来，作为东道主，我们将以最佳状态展示四年努力之后的冰雪风采。也希望纺织行业能为北京冬奥会编织更多华彩风光。

北京服装学院 刘莉 任佳艺

图 13 第 22 届索契冬奥会俄罗斯核心图形时尚化应用
Figure 13: The application of the core pattern of the 22nd Winter Olympics

图 14 第 23 届平昌冬奥会中国队领奖服（2018）
Figure 14: PyeongChang 2018 Award Ceremony Outfit for the China Winter Olympic Team (2018)

It tells the story that Russia has the largest land area in the world - with area of 17 million square kilometers, nine time zones, three climatic zones, 13 inner seas, as well as numerous ethnic groups and languages. These diversified forms of culture and arts are embedded in the vast territory of Russia, which look like a beautiful quilt covering the earth. The core pattern uses the patchwork technique, developed specifically for the effective collage and split the cut mesh master, the grid is composed of longitudinal diamond four continuous. Through such grid extraction, a continuous pattern can be composed. Figure 12 is the evolution of " patchwork quilt" pattern of the Russian core figure for the Sochi Winter Olympics. Figure 13 is the development of core pattern on number vest in the competition, which Convey an active and happy mood.

ANTA designed the fifth generation "dragon champion outfit" for the Chinese sports delegation in 2018 Pyeongchang Winter Olympic Games (see Figure 14). The core concept of design is around the Chinese traditional spirit totem --- dragon, combing the written "dragon" in calligraphy and Chinese word "winter". The dragon's head is holding up high, demonstrating the determination and spirit of Chinese sportsmen. A large area of white and red colours is used, with yellow colour decorations at zips and imprints. The pattern of the outfit is semi-close fitting; The processing technology is steel pressure technology, on the basis of the steel pressure printing red CHINA concave and convex, which has the rich stereo feeling.

Following the close ceremony of the Pyeongchang Winter Olympic Games, people start to expect the next on in Beijing. As the host country, we want to show the best performance on the snow and ice after another four years hard work. We also hope the Chinese textile industry will shine in the Beijing Winter Olympic Games.

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面向运动的智能可穿戴应用的挑战
Challenge against sports-oriented smart wearable applications

当前的智能可穿戴技术正面临新的挑战和机遇。常规监测例如血流、心率、步数、定位等已经随着基于传统芯片的电子设备，如智能手表、智能手环的普及而充足的发展而至瓶颈。最适合于可穿戴的柔性传感技术，包括柔性传感单元和柔性电路，则开始崭露头角。2015年Berkley全球智能穿戴市场报告表明，常规芯片电子设备的市场发展预期已逐渐冷却，而之前仅被约20%消费者了解的智能服装的市场预期则疾速上升[图1]。其中，针对医疗健康和运动的智能穿戴，因其专业性和对传感精度的更高要求，将引领柔性传感技术的前沿。

图1近年来传统穿戴和智能服装的市场预期趋势
Figure 1 Tend of market expectation to traditional wear and smart clothes in recent years

运动装备中的织物和纤维有其特有的较为苛刻的工作环境，例如肢体大幅度动作带来的运动服装大应变、织物之间以及皮肤与织物之间的剧烈摩擦；伴随运动中高强度代谢的而产生的大量热量、汗液和汗蒸汽；竞技体育中对舒适度的更高要求以及针对具体体育类别的功能优化(如保温、速干)。这样的终端需求使得运动装备的智能化面临着严峻的挑战：不仅需要维持传感系统在运动环境下的性能、稳定性，保证运动装备的舒适、辅助功效，还需要能够提供较为专业的数据分析结果。智能运动装备的解决方案总的来说有两大类别：一种是最常见和最直接的，即在维持传统运动装备的性能的同时，附加柔性传感单元、传感网络或伺服单元；另一种则是通过从纤维、织物结构做出改良和优化以获取特殊功能。由于运动装备市场本就是具细化的、专业化的趋势，不同功能的智能运动装备所面临的机遇和挑战也分门别类。

The current smart wearable technology is facing new challenges and opportunities. Routine monitoring indicators, such as the blood flow, heart rate, step frequency and location, havemet with bottleneckwith thecomprehensive popularity and development of electronic devices based on traditional chips, such as smart watches and smart bracelets. The most wearable soft sensing technologies, including soft sensing elements and soft circuits, are emerging. A market report onglobal smart wearables by Berkley in 2015 showed that the market's expectation to the development of conventional chip electronic devices had cooled down, while that to smart clothes that only about 20% consumers previously knew were drastically increasing [Figure 1]. Among them, intelligent wear for medical treatment, health and sports will lead the frontier of soft sensing technology because of its professionalism and higher requirement for sensing precision.

The fiber and fabric in sports equipment are made in distinguished harsh working environment. For example, the great strain in the sportswear caused by drastic motions, as well as the fierce friction between fabrics and between skin and fabrics;a great deal of heat, perspiration andsweat steam resulted from high-strength metabolism accompanying with movements; higher requirement for comfort andfunction optimizationof specific categories of physicalexercisein sports, like heat preservation and quick drying. Such demands for terminals make the intellectualization of sports equipment meet with severechallenges. Itrequires not only the maintenance the stable performance in motive environment of the sensing system to ensure the comfort and auxiliary functions of sports equipment, but also the ability to provide professional data analysis results. In general,there are two categories of solutions to intelligent sports equipment: one is the most common and most direct kind, namely, it is additionally equipped withsoft sensing elements, sensor network or servo unitsin maintaining the performance of traditional sports equipment; the other one is to obtain special functions via improvement and optimization of fiber and fabric structure. Asthe sports equipment market is on aspecified and professional trend, the opportunities and challenges confrontingsmart sports equipment with different functionsare also categorized.

从纤维材料的角度，高弹、耐磨、散热、透湿、防静电在传统运动服装里面已经通过引入相应比例的聚脂、氨纶纤维和调整防止结构而已趋成熟。智能运动服装所要应对的难点本质上则是在运动环境下保证传感单元、网络的稳定性和可靠性。基于芯片的常规运动监测例如血流、心率已经足够成熟。对于剩余的运动环境下的生理、物理检测需求，将着重覆盖 3 大类传感技术，力学测量，姿态跟踪，生物电分析。对于力学测量而言，基于弹性导电体的支持大应变测量的柔性应变传感器，压、扭力传感器，将有机会被大量采用 (例如织物基底应变 \ 压力传感器)。这些柔性传感器要求织物作为基底和承载体，本身需具有较好的拉伸回复力、回复速度和很小的蠕变，并且其拉伸、压缩刚度需要和传感器的刚度适当匹配以保证应变信号强度和稳定性。基于导电聚合物的柔性传感单元均面临这个挑战。另一方面，姿态跟踪是竞技体育优化 (优化动作轨迹、发力策略) 的重要数字化手段，也是长时间数字化康复监控的基础。对人体而言，姿态跟踪的本质是关节角度的测量。当前大部分的解决方案是通过在关节两侧附加外挂式的集成了加速度计、陀螺仪、磁感应的微芯片 (例如 Nadi X 瑜伽训练服，图 3 左)，但普遍存在漂移导致的时间积分误差，特别是运动中收到冲击而导致测量偏差。真正的柔性的角度传感单元的开发和应用还十分匮乏 (当前仅有比萨大学的 De Rossi 教授的团队在推进，图 3 右)，而且作为测量单元精度仍有待提高。另外，足底压力 / 步态监测较为特殊：既有以鞋底 / 鞋垫为载体，集成成熟的压力传感器的方案，也有以袜子为载体配合柔性传感器的方案。两者都需着重应对温湿度对传感单元 / 网络的影响。对生物电测量来说，比如心电、肌电穿戴设备，最大的挑战在于承载体从设计上需保证电极的最佳工作环境，即在人体上皮肤接触紧密、相对位置稳定、同时保证环境温度、湿度稳定。织物电极可以极大改善舒适度 (图 4，织物电极心电衣)。对于稳定的电极位置，则要求承载体的刚度有良好的刚度分布。电信号的稳定性还对纤维和织物有透气、温度平衡的要求。因此，温度、湿度驱动的智能纤维材料 (受温、湿度影响而改变形态，从而保证内外温湿度平衡，比如温度驱动的形状记忆材料) 可提高生物电传感的信号可靠性。特别地，由于运动装备更多面临的是散热、排湿、速干需求，因此感温和过热提醒、湿度检测显得并不必要。伺服器目前有微电流刺激和微震动器两种。前者在运动训练、减少疲劳和损伤、提高激烈运动后恢复效率等方面已显示较好的效果。后者用在大场地训练教练和运动员之间的通讯。

图 2 安润普 ®（左）织物底应变传感器和（右）基于柔性压力传感器的智能跑鞋
Figure 2 ADVANPRO®: fabric bottom strain sensor (left) andsmart running shoes with soft pressure sensor (right)

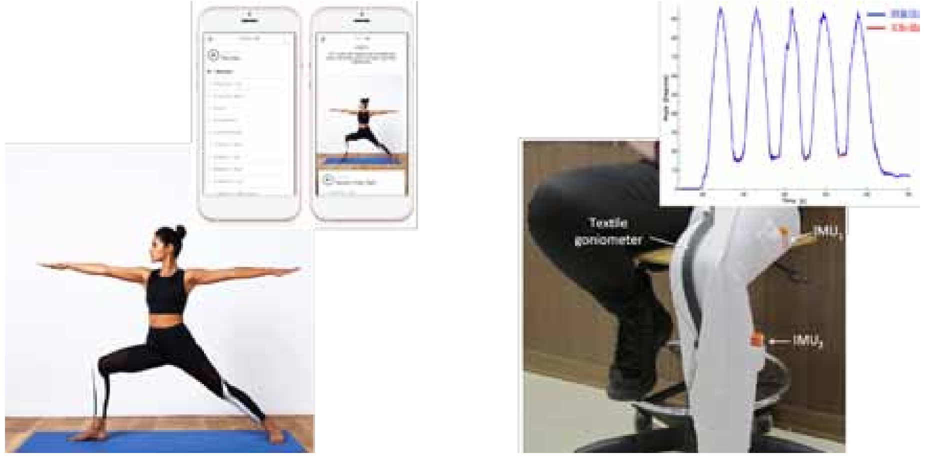

图 3 （左）Nadi X® 瑜伽训练装 （右）IMU 辅助的柔性角度仪
Figure 3 Nadi X® yoga training assembly(left) and IMU auxiliarytextile goniometer (right)

From the perspective of fiber materials, the performances of high elasticity, abrasion resistance, heat dissipation, moisture permeability and antistatic in traditional sportswear have become more and more mature byadding certain proportion of polyester and spandex fiber and adjusting textile structure. The challenges confronting smart sports clothes are to ensure the stability and reliability ofsensing elements and network in motions. Conventional motion monitoring means based on chips, such as the blood flow and heart rate, are mature enough. The physiological and physical requirements in motion environment will focus on the three major sensing technologies of mechanical measurement,attitude tracking and bioelectrical analysis. For mechanical measurement, soft pressure sensors supporting large strain measurementbased on elastic conductors, as well as pressure and torsion sensors, will have chances to bewidely applied, such as fabricsubstrate strain and pressure sensors. These soft sensors demand fabric, as the substrate and bearing body, to perform well in stretching restoring force, restoring speed and small creepage, and the latter's stretching and compressive stiffness to match with that of the sensors to ensure the strength and stability of strain signals. Softsensing elements based on conductive polymerall meet with the challenge. On the other hand, attitude tracking is an important digital means of athletic sports to optimize movement track and force strategy, as well as the foundation of long-term digital rehabilitation monitoring. For the human body, the essential part of attitude tracking is the measurement of joint angle. Most of the current solution is to integrate the micro-chips of accelerometer, gyroscope, magnetic induction instrument throughthe additional plug-in devices on both sides of the joints (e.g. Nadi X® yoga training suit inthe left of Figure 3). However,the drifting commonly causedintegral time errors, especially, the movement received impact often leads to measurement errors. The development and application of the real soft angle sensing elementsare still in scarcity. At present, only the team led by Professor De Rossi of theUniversity of Pisa is advancing, which can be seen in the right one ofFigure 3. In addition, the accuracy of measurement units still needs improving. Besides, sole pressure / gait monitoring uniquely integrates mature pressure sensors with the carrier ofthe shoe sole or insole,and meanwhile coordinates soft sensors with the carrier of socks. Both of them need to deal with the influence of temperature and humidity on the sensing elements and network. For bioelectricity measurement, such as ECG and EMG wearable devices, the biggest challenge is that the design of the bearer needs to ensure the best working environment of electrodes, that is, to keep close contact with human bodies in relatively fixed position and maintain the

柔性电池、发电单元作为可穿戴设备的最佳驱动力，正开始慢慢取代当前穿戴设备中普遍使用的小体积的固体包装充电型电池。研究前瞻性地开发了诸多基于光能、热能和机械能的柔性能量收集单元。对于运动、体育训练而言，虽然热能和机械能的能量转换的基数最大，但是激烈运动往往伴有较高的肢体散热需求，这与依靠热量采集的条件相违背。因此机械能发电单元将会迎来更大的机遇，比如摩擦电和压电。其中，摩擦作为能量内耗，更适用于健身类运动而非竞技类；而惯性驱动的压电单元，尤其是置于足底的采集单元较之而言对全身运动的动作影响最小，可能会在攻克了发电功率的难点之后优先被应用。

自供电的实现必将对供电的连接稳定性提出更高要求，而随着专业运动数据分析的要求，智能装备也要开始从单数据流检测向相互连接的多通道的同步数据流采集网络迈进。这使得导电线的稳定性在运动状态下要求更为严苛。由于当前的导电纤维的耐用和耐水洗性尚未解决，而将金属质导线埋在织物基底的传统的方法只适用于刚度大、变形较小的部分。如何在加入导电线的同时保证织物弹性、舒适、耐汗、耐磨损的性能仍是一个挑战性课题。

香港理工大学 王玺，陶肖明

图 4 爱邦® 织物电极心电衣
Figure 4 aibio®Flextrode ECG sportswear

stability of the environment temperature and humidity. The fabric electrode can greatly improve the comfort, as shown in Figure 4, the Flextrode ECG sportswear. The fixed electrode positionrequires forgood distribution of stiffness of the carriers, while the stability of electrical signals requires for airpermeability and temperature balance of fibers and fabrics. As smart fiber material driven by temperature and humidity can be transformed due to temperature and humidity elements to ensure the balance of temperature and humidity inside and outside, like temperature-driven shape memory material, so as to improve the reliability of signals sensed by bioelectricity. In particular, as sports equipment more often faces the needs of heat dissipation, moisture exhaustion and quick drying, it is not necessary to focus on the functions of temperature sensing, overheat alarming and humidity detecting. Currently there are two kinds of servers, for micro-current stimulators and micro-vibrators. The former has shown good effects in sports training, reducing fatigue and damage, and enhancing recovery efficiency after intense exercise. The latter is used in the communication between coaches and athletes in large-playground training.

As the best driving force of wearable devices, soft batteries and power generation units are graduallyreplacing the small-volume solid packaging rechargeable battery that is commonly used in current wearable devices. A number of soft energy collection units based on light, thermal and mechanical energy are developedprospectively. For sports and physical training, although the basic value of energy conversion between thermal and mechanical energy is the largest one, violent exercise often hasgreat demand for limb heat dissipation, which is against the conditions that rely on heat collection. Therefore, there will be more chances for mechanical power generation units, such as triboelectricity and piezoelectricity. As the way of internal friction of energy, triboelectricity units are more suitable for fitness than for athletics; while the inertia-driven piezoelectric units, especially the collection unitsunder the sole,have minimal impact on the whole body movement compared with the former, and may be prioritized in application solving the difficulties in generated power.

The realization of self-contained electric systemis bound to bring higher requirements for the connection stability of power supply. With the increase of requirementsfor professional motion data analysis, smartequipment will develop from single data flow detection to interconnected multi-channel synchronous data flow collection network. It makes the stability of conducting wires more demanding in motions. However, the durability and washability of the conducting fibers are not yet solved, and the traditional method of embedding metal wires into fabric substrates is only suitable for the parts with great rigidity and small deformation. As such, how to ensure the elasticity, comfort, sweat-quick-drying and wear resistance of fabricsat the same time of inserting conducting wires into the fabrics is still a challenging topic.

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创新高性能纤维材料与医疗跨界的新市场新机遇

New Markets and New Opportunities for Extension of Innovative High-performance Fiber Materials into Medical Treatment

每日我们无时不刻在接触的正是自己穿着的贴身衣物和家中的床上纺织用品，他们恰犹如身体的第二层皮肤。如今伴随着对所处环境的健康舒适程度越来越高的敏感度，对生活工作质量和效率越来越高的要求，大众对纺织品的要求不再停留于传统的遮盖、保暖、舒适等，而更多地关注他们还能带来何种健康功效，这种功效也正是产品的高附加价值，是传统企业通过学习创新可获得的技术突破，是传统纺织跨界医疗的新利益增长点，也是产业早日实现技术转型的关键。

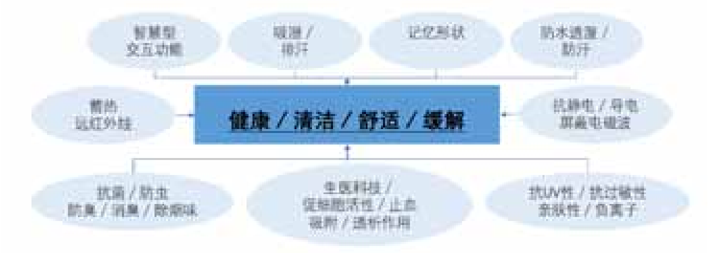

图 1 医疗纺织的不同功能领域

1. 跨界医疗的细分市场

在这场纺织和医疗跨界合作的领域中已细分出诸多不同功能领域和其运用场景，如图 1 所示，大致分类归纳，其中主要包括在热湿平衡方面的高度舒适性能、抗菌免疫系统方面的防护性能、抵抗外界侵害、智能型 (监护诊断、交流通讯、主动调节等) 四方面的功能。同时，这四大类中的细分功能也可相互借鉴结合，得到同时具有多功能的医疗纺织用品，这也正是当下发展的大趋势之一。当前我国医卫用纺织品性能正呈现出多样化的发展趋势，例如在纳米纺织技术、防病毒防渗透、高阻隔、抗静电、轻量化、超薄舒适、透气性好、无刺激、可降解等特性方面，取得了瞩目的突破性创新成果。

Everyday, we are in contract all the time with the clothes next to the skin and the textiles on the bed at home, which are just like the second layer of skin in our bodies. Today, as we become more sensitive to a healthy and comfortable environment, we have increasingly higher requirements for quality and efficiency in life and at work. Our requirements for textiles are no longer limited to the conventional purposes such as of covering bodies, preserving heat, and feeling comfortable, but instead have more to do with what kind of healthy effect they have, and this kind of effect is just the high additional value of a product, a technical breakthrough that conventional enterprises can make through learning and innovation, a new point of growth in the extension of conventional textiles into medical treatment, and also a key to early achievements in technological transformation.

1. Segmented market for the extension into medical treatment

The field of this extension of textiles into medical treatment has been divided into several sectors that have different features and applications. As shown in Fig. 1 below, if broadly classified, it mainly includes the functions in four categories, being highly comfortable in terms of the balance between heat and moisture, being protective in terms of bacterial resistance and immune system, protecting against external attacks, and being intelligent (monitoring and diagnosis, exchange and communication, active regulation etc). Meanwhile, the finely classified functions in these four major categories can use for reference and combine each other, resulting in the medical textiles that serve multiple purposes at the same time, and this is one of the major developmental trends for the time being. At present, the features of medical textiles in our country are showing a trend towards diversification, for example, remarkable, revolutionary and innovative achievements have been made in such features as adopting nano-textile technology, resisting virus and seepage, having a better insulating effect, resisting static electricity, being lightweight, being extremely thin and comfortable, having a good air permeability, causing no irritation, and being degradable.

医疗纺织的市场背景

21世纪这个互联网的时代，伴随大数据、人工智能、无线通讯技术的滚滚车轮向前，工业4.0和智能制造技术等话题被不断热议，尤其在中央推行《第十三个五年规划纲要》和《中国制造2025》两大总体指导方针下，纺织工业寻求转型升级。并在《纺织工业发展规划(2016-2020)》中的纺织科技创新重点工程中，进一步提高产业用纺织品技术，尤其在医疗方面的高性能纺织材料，例如突破功能性敷料、肾透析纤维材料、植入修复等医用纺织材料关键技术，研究开发高防护性能纺织品和高智能感知的功能性材料及服装等，成为重中之重。在其具体的推行方案中，一方面需要增强天然、化纤等新型原材料的创新开发能力，另一方面则是医疗健康性智能产品生产技术的开发，研发和推广高端医疗纺织产品，例如生物医用敷料，医用植入型纺织材料，老年疾病的保健、缓解和康复和婴幼儿健康守护等功能型纺织品，可穿戴体征监测智能型纺织品等。

• 市场规模

我国是外科用非植入纺织品和卫生保健用纺织品的世界生产大国，2010~2014年中国医疗与卫生用纺织品年均增长14%。 2014年医卫用纺织品行业产量达到118.8万吨，但医卫用纺织品的外贸依存度仍然较高，共出口31.5亿美元，同比增长14.73%。产品涉及一次性医用服装、医用敷料、卫生巾、纸尿裤等，出口价格远低于国外同类产品。而同时，依据英国WTiN纺织专业机构预测，2017年全球高性能纺织品市场总额为1660亿美元，并将以4.6%的年均复合成长率(Compound Annual Growth Rate, CAGR)呈现出成长态势，商机无限，其中健康智能硬件的市场份额增长表现尤为突出(如图2所示)。同时，美国Global Industry Analysis and Opportunity Assessment市场研究机构也指出，2017年全球高性能纺织品约共计3400万吨的消费量，预计到2027年则将达到5700万吨。其中，从生产销售市场区域角度来说，全球的高性能纺织品市场的亮点区域集中在亚太市场，因为超过50%的成长比率来自此亚太市场，其中中国和印度成为最大的出口市场，应增设投资与进出口比重。从不同消费者群体和不同产品市场潜力的市场角度来说，母婴市场和老龄化人口市场将是中国正在出现的两个急剧增长的市场，相应的婴幼儿和老人的医卫纺织用品将会是未来市场发展的重点，尤其是可用于保健、疾病预防、监测、诊断和治疗的智能纺织产品，人体器官组织的替代和修复医疗纺织产品。其中，市场调研公司Allied Market Research的报告预测，到2022年，全球智能纺织品市场规模将从2015年的9.43亿美元，增长到53.69亿美元，2016年到2022年间的复合年增长率将为28.4%。

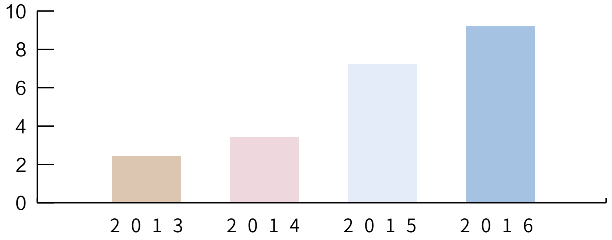

图2 中国医疗健康智能硬件市场份额（亿元）

Fig.2. China's market share in medical and health intelligent hardware (source: iResearch, and Xtecher)

Market background in medical textiles

In such an Internet era as the 21-century, as the wheels of big data, artificial intelligence and wireless communication technology rolls on, the topics about Industry 4.0 and intelligent manufacturing technologies have been debated unceasingly, and especially, under the two general guidelines of the "Outlines of the Thirteenth Five-year Plan" and the "Made in 2015" issued from the central government, the textile industry is seeking for transformation and upgrading. And in the key projects to innovate textile technology and science in the "Plan to Develop Textile Industry (for 2016-2020)," industrial textile technologies, particularly the high-performance textiles for medical treatment, such as the key technologies for medical textiles, e.g. revolutionary functional dressing, renal dialysis fiber materials, and implant restoration, will be further improved, and among them, highly protective functional textiles and highly intelligent sensing materials and clothes will be the most important to be developed. In the specific plan for implementation, on the one hand, the ability to develop new type of raw materials such as natural fibers and chemical fibers should be intensified, and on the other hand, concerning the development of the technologies for producing medical and healthy intelligent products, high-end medical textiles should be developed and promoted, such as biological medical dressing, medical implemented textile materials, the functional textiles for treating, alleviating, and improving the illness for the old and for ensuring the health of infants , and the wearable intelligent textiles for monitoring physical condition.

• Marcke scale

Our country is a major world player in producing surgical textiles and healthcare textiles for use in no implantation, with China's medical and sanitary textiles growing at 14% annually from 2010 to 2014. In 2014, the output in medical textile industry reached 1.188 million tons, but was still relatively dependant on foreign trade in medical textiles, with exports totaling 3.15 billion US dollars, up by 14.73% on a year-on-year basis. The products include disposable medical clothes, medical dress, sanitary towels, paper diapers etc, with export price far lower than foreign products in same categories. According to the forecast by British professional textile organization WtiN, however, the total value of the global market for high-performance textiles is 166 billion US dollars in 2017, and it indicates a trend towards a Compound Annual Growth Rate of 4.6%, providing huge opportunities, where, the market share of health and intelligent hardware grows in an especially outstanding manner (as shown in Fig.2). Meanwhile, American market research organization Global Industry Analysis and Opportunity Assessment also points out, global consumption of high-performance textiles totals about 34 million tons in 2017, and is predicted to reach 57 million tons by 2017. Among them, in terms of sales and market areas, the highlighted areas in global high-performance textile market are concentrated on Asia-Pacific markets, because Asia-Pacific markets contribute to over 50% of the growth rate, where, China and India are the biggest exports markets, and the proportion of investment to imports should be increased. From the market perspective of different groups of consumers and the market potentials of different products, the market for the maternal and infant and the market for the old will be the two ones that are growing dramatically, and relevant medical textiles for the infant and the old, especially

此外，近年来智能家居的概念不断普及，国内的导电纺织技术取得极大突破，配以无线通讯技术，I-home 的概念正在积极推行，其不仅在热议的柔性、贴身的可穿戴设备和整个家居环境之间建立无线通讯联系，也在穿着者、多方家庭成员、背后云端数据处理系统和医疗救助机构四方之间建立实时通讯，了解诊断和共享穿着者的实时身体状况，这种实时的监测和多端的共享，完美契合了老人和儿童这两类人群无时不刻的看护照料需求，是目前增长最快的高性能纺织品之一。目前，德国在可穿戴式智能型纺织品位于全球领导地位，瑞士次之。目前有高传道性能的梭织布和针织布，可广泛运用于军事、个人护理、医疗救助、健康看护、运动健身等不同领域，根据美国 Global Industry Analysis and Opportunity Assessment 的预测，接下来的 5 年将迎来高导性能纺织品在医疗领域的爆发式增长。虽中国在此领域较为落后，但医疗健康智能硬件市场份额正在快速成长并迎头赶上。因此，预计在 2018-2021 年间，可达到 15.6% 的年均复合成长率，即至 2021 年，达 21.1 亿的市场规模，商机庞大。

细分的消费群体

生产技术的不断提高也使得人们对这第二层皮肤的健康舒适性能的要求越来越高，尤其是儿童和老人这两者特殊群体，除了基本的舒适性能，也要求附加更多的功能价值，例如抗菌、促进伤口愈合、改善微循环系统、提高新成代谢、抗辐射等功能，因此针对特定的老年群体和婴幼儿市场，两者的诉求和消费群体特点应被仔细分析。

• 中国的老龄化人口

推动医疗纺织业快速发展的一大重要背后原因正是快速加剧的中国人口老龄化问题：如今中国的出生时平均期望寿命已经从 1950 年的 44.6 岁上升到 2015 年的 75.3 岁，而在 2050 年将有望达到约 80 岁。期中，在以后的 25 年里中国 60 岁以上老年人在全人口中的构成比将预计增加一倍以上，在 2040 年达到 28%(4.02 亿)，而到 2050 年，80 岁及以上老年人则可达到 9040 万人——成为全球最大的高龄老年人群体。此外，农村人口迅速老龄化的问题将比城市人口迅速老龄化更加严重，预计到 2030 年，中国农村和城市地区 60 岁及以上人口的比例将分别达到 21.8% 和 14.8 % 。随着中国社会老龄化问题越来越凸显，同时也随着年轻人向东南沿岸和一二级城市的迁移，内陆和农村地区的老年化比例远远高于集中程度较高的城市。

the intelligent textiles that can be used for healthcare, disease prevention, monitoring, diagnosis, and treatment, the medical textiles that replace and repair the organs in human bodies, will be the focus for market development in future. In this regard, the report by the market research company Allied Market Research predicts, by 2022, the market scale of global intelligent textiles will increase to USD 5.369 billion from USD 943 million in 2015, and the compound annual growth rate from 2016 to 20p22 will be 28.4%.

In addition, the concept of intelligent house has been constantly popularized for recent years, and a great breakthrough has been made domestically in the technology for electricity-conductive textiles, on top of wireless communication technologies. The concept of I-home is being actively promoted, which not only establishes the wireless communication of the flexible and wearable equipment next to the skin with the entire house environment, but also enables the real-time communication between the four parties, the wearer, family members, background cloud data processing system and medical aid organization, so that the physical status of the wearer can be known and shared. The monitoring in real time and the sharing by multiple parties perfectly satisfies the requirement that the two groups of the old and children are taken care of all the time, and become one of the high-performance textiles that grow at the fasted rate. At present, German is the leader in global wearable intelligent textiles, with Switzerland next to it. Currently, highly conductive woven and knitted fabrics can be extensively used in a variety of fields such as the military, personal care, medical aid, health care, and sports and fitness. According to the forecast by American Global Industry Analysis and Opportunity Assessment, the next 5 years will see the explosive growth of high-performance textiles in the field of medical treatment. Although China relatively lags behind in this field, its market share in medical and health intelligent hardware is growing fast and catching up head-on. Therefore, a compound annual growth rate of 15.6% is predicted for the years from 2018 to 20121, that is, market scale will reach 2.11 billion by 2021, offering huge opportunities.

Finely-categorized consumer groups

The continuous improvement on production technologies has also caused consumers to have increasingly higher requirements for the healthy and comfortable effects of this second skin. Especially, these two special groups of children and the old also require more functions in addition to the basic comfortableness, such as the functions of speeding up the healing of cut, improving micro-circulation systems, enhancing metabolism, and resisting radiation. Therefore, for particular markets catering for the old and the infant, the requirements from these two groups and their characteristics should be analyzed carefully.

• China's aging population

The fast-growing problem of ageing Chinese people is just one of the underlying reasons that rapid development in medical textile industry is pushed forwards: today, China's average life expectancy at birth has increased to 75.3 years in 2015 from 44.6 years in 1950, and is expected to reach 80 years in 2050. In the meanwhile, for the next 25 years, the proportion of the old aged over 60 to national population is predicted to double, reaching 28% (402 million) in 2040, while the old aged at 80 or above can reach 90.4 million persons in 2025, becoming the globally largest group of elders. Moreover,

与中国人口的老龄化这一人口密度改变息息相关的是健康状况和流行病学方面的变化，例如疾病负担逐渐从妇幼卫生问题和传染性疾患向慢性非传染性疾病转变：与老龄化相关的主要问题之一就是急剧增加的慢性疾病负担，尤其是与年龄密切相关的疾病，例如心脏病、癌症、脑卒、关节炎、老年痴呆症等慢性 (非传染性) 疾病。这些疾病往往使患者慢慢失去生活自理能力和自由活动的能力，出现个人卫生防护、实时健康状态监护等种种问题，且所累及的人口数量将持续增加。在2012 年，中国 60 岁以上人口中近 80% 死于非传染性疾病，而预计到 2030 年此数据会增加 40%。因此，高性能的医疗纺织产品需要被运用在日常的健康护理、高要求的临床手术治疗等不同医疗领域，例如体内临床的手术缝合线，体外的伤口敷料促进愈合，可穿戴智能医疗纺织品监测身体健康情况等多种功能，软组织替代组织、矫正外科植入物等。

- **婴幼儿市场**

针对婴幼儿这一特殊的群体，皮肤较为敏感、身体免疫能力弱，对外界有害物质或危险因素的抵抗能力弱、易受到病毒、细菌和疾病的交叉感染、对长者实时照看的依赖性高，因此天然具备抗菌功能的生物基纤维纺织品和智能可穿戴纺织设备具有良好的婴幼儿市场推广前景。其中婴儿纸尿裤纺织产品所占的市场比例较大，且每年保持 20% 的年均增长速度，预计到 2020 年，中国的 2 岁以下婴幼儿将会达到4520 万人，按人均每天消费 3 片计算，2020 年全年纸尿裤的消费数量将达到 297.5 亿片，而在这类产品中，亲肤的、抗菌的、保健的、实时健康情况监护的需求变得尤为突出。

细分的医疗纺织产品种类

医疗纺织品涵盖面极广，是“既可用于卫生、健康和个人护理，也可用与外科手术的纺织制成品”。换句话说，医用纺织业市场大而复杂，它包含了纺织品和无纺业，由众多产品类别和部门组成，其产品形状、尺寸和配置也多种多样，诸如尿布、擦拭布一类的市场价值本身就高达数十亿美元；而外科植入品、研发项目和其他小规模生产则属年销售额低于 10 万美元的产业。介于两者间还能细分出多个领域。但简而言之，可以分为两大类：外用和内用，和其下的分支。不同医疗纺织品种类的运用被细分如表 1 所列。

表 1 智能纤维在医疗健康领域的不同运用功能

用途	体外的	活体内的
手术	纱布、绷带、伤口敷料等	手术缝合线，软组织，矫形外科植入物，心血管植入物。
卫生用品	医疗防护服，医疗公共用纺织产品等	-
药物控制释放系统	智能绷带、敷料和膏药。	-
生物监测	心血管、血液循环系统，神经活动，运动肌肉活动，呼吸运动，身体热平衡等信息的探测和分享。	-
医疗保健	电刺激理疗，物理理疗，辅助系统，积极主动的热平衡维持系统。	-

the problem of rural aging population is more serious than urban fast-aging population. It is predicted, by 2030, the proportions of the old aged over 60 in China's rural and urban areas will reach 21.8% and 14.8 % respectively. As the problem of China's ageing society is increasingly serious, and young people are migrating to the first- and second-tier cities along the southeast coast, the proportions of the aged in inland and rural areas are far higher than in densely populated cities.

The change in the density of China's such an ageing population closely relates to the change in health condition and epidemics, for instance, the burden of illness has gradually shifted from the issue of maternal and infant health and infectious diseases to chronic non-infectious diseases: one of the major problems relating to ageing is the dramatically heavier burden of chronic diseases, in particular, the illness closely related to age, including the chronic diseases (non infectious) such as cardiac disease, cancer, stroke, arthritis, and dementia. These diseases usually cause patients to gradually lose their ability of self-care and free movements, leading to various problems such as the protection of personal health, and the real time monitoring of health condition, and the number of persons involved will continue to increase. In 2012, nearly 80% of the old aged over 60 in China died of non-infectious diseases, and it is predicted to increase by 40% by 2030. Therefore, it is necessary to apply high-performance medical textiles in various medical fields including daily health care and highly demanding surgical treatment, e.g. in vivo clinic surgical sutures, in vitro wound dressing for fast healing, wearable medical textiles for monitoring health condition etc, soft tissue substitutes, and corrective surgical implants.

- **Market for infants and young children**

For infants and young children as a special group, who have the relatively sensitive skin and the weak immune system, they are weak in ability to resist external harmful substance or dangerous element, vulnerable to the cross infection with virus, bacteria and diseases, and highly dependant on their care takers. Therefore, the naturally bacteria-resisting bio-based fiber textiles and intelligent wearable textile equipment have a good prospect of being introduced into the market for infants and young children. Among them, the textiles for baby paper diapers have a relatively higher market share, maintaining an average annual growth rate of 20%. It is predicted that China's infants and young children aged less than 2 years will reach 45.2 million persons by 2020. If calculated according to 3 pieces consumed per day on average, the consumption of paper diapers will reach 29.75 billion pieces for the whole year of 2020. Among the products of this type, the requirements for skin friendliness, bacteria resistance, health care, and real time monitoring of health condition become particularly outstanding.

Finely classified varieties of medical textiles

Medical textiles are extremely wide in scope, applicable for sanitation, health and personal care, as well as for surgical operation. In other words, the market for medical textile industry is big and complicated, including textiles and non-woven cloth, consisting of many varieties and departments, and diversified in shape, size and composition. The value of the market itself in such a category as diapers and cleaning cloth can reach as high as several billions of US dollars, while surgical implants, R&D projects, and other small-scale production belong to the industry with an annual sales less than USD 100,000. What is between these two can still be divided into several sectors. To make it simple, however, it can be divided into two major categories: external and internal use, which can be further broken down. The applications of different varieties of medical textiles are listed, as shown in Table 1.

Table 1. Different purposes served by intelligent fiber in the field of medical treatment and health

Purpose	In vitro	In vivo
Operation	Gauze, bondage, wound dressing etc.	Surgical suture, soft tissue, orthopedic surgical implants, and cardiovascular implants.
Health products	Medical protective uniforms, medical textiles for public use etc.	-
Drug control and release system	Intelligent bondages, dressing and plaster.	-
Biological monitoring	Monitoring and sharing information on heart and blood vessels, blood circulation system, neural activity, movements and muscular activity, respiratory movement, and thermal balance in body.	-
Medical care and health care	Electricity-stimulated physical therapy, physical therapy, auxiliary system, and active thermal balance-maintaining system.	-

2. 天然高性能医疗纤维

生物医用高分子基纤维包括：1) 天然高分子基生物医用纤维，包含纤维状的天然物质直接分离、精制而成的天然纤维和用天然高分子为原料经化学和机械加工制成的纤维，如纤维素及其衍生物纤维 (氧化纤维素)、甲壳素及其衍生物纤维、蚕丝和骨胶原纤维等；2) 合成高分子基生物医用纤维、如聚酯、聚酰胺、聚烯烃、聚丙烯腈、聚丙烯、聚乳酸纤维等。其中新兴的高性能材料整理如表 2 所示，尤其是新兴被发掘的天然高分子基生物医用纤维。主要特别功能方向包含：抗菌抑菌，止血消炎镇静，促进伤口愈合，改善微循环系统，除臭抑臭，散热缓痛，亲肤舒适等。在医疗方面，可用于制造各种治疗性敷料、外科缝合线、透析材料、人工器官部件、个人卫生用品、吸收性卫生用品、医疗防护服、工作服、手术衣等。同时，这些纤维的主要成形方法有: 干法纺丝、湿法纺丝熔融纺丝、干湿纺丝、熔融纺丝、乳液纺丝、凝胶纺丝等。不同的纺丝方法可以赋予纤维不同的物理参数特征，例如熔融法和湿纺法纺丝的纤维直径与大多数动植物细胞尺度接近、而静电纺丝纤维更接近与病毒的尺寸，从纳米级到毫米级别不同。抑或是通过预设喷丝头的设计，可赋予纤维不同横截面形态，例如三角型、五角型、十字型、中空型等。目前，多功能化的产品也是目前的发展热点之一，因此将这些新型高性能材料通过混纺，多层、不同结构面料的设计织造，涂层或后处理等从开端的高分子原料，纤维纱线，织物结构到终端服装版型和后处理的整条生产链上的技术整合，以此提升穿着舒适、保健、感性、安全、防护与便利等性能至更好的效果，例如在纺纱环节通过不同的纺纱方式，例如包芯纱、竹节纱、花式纱、纤维纺、条纺、色纺、环锭纺等不同方法，将上述单种或多种高性能医疗纤维单独或与传统纺织材料混纺，形成不同结构的纱线，放大起医疗效用。在织造的过程中，这些医卫用纱线可经纺织手段制备成一堆 (线状) 二维 (平面) 或三维 (管状、多层的) 医疗纺织品，运用与不同的场景中。

表 2 不同种类的高性能医疗纺织品

天然纤维		合成纤维	
名称	功能 & 医疗健康领域用途	名称	功能 & 医疗健康领域用途
壳聚糖纤维	* 功能：具有抗菌、止血、促进伤口愈合、提高免疫力，吸附重金属、污染物等功能; 用途：用于术后愈合、伤口敷料，个人卫生 * 用品，看护纺织產品、家纺、美容纺织品、老年人 & 婴幼儿衣物类等产品。	铜改性聚酯纤维 (铜纤维) (相同原理：富鈦康纤维；银纤维)	* 功能：将抗菌铜材料经高科技纳米加工处理，熔入纺丝熔体之中，再经纺丝加工而制成的一种功能纤维。抗菌、杀菌、抑菌效果持久，且除臭自洁，防霉除螨、提高机体免疫力。 * 用途：术后愈合、伤口敷料，个人卫生用品；看护纺织產品、家纺、美容纺织品、老年人 & 婴幼儿衣物类等产品。

2. Natural high-performance medical fibers

Biomedical macromolecule fibers include: 1) natural macromolecule-based biomedical fiber, such as the natural fiber finely made through direct separation of fiber-like natural substances, and the fibers made by using natural macromolecule as raw materials and through chemical and mechanical processing, including cellulose fiber and its derived biological fiber (oxidized cellulose), chitosan fiber and its derived biological fiber, and silk and collagen fibers; 2) synthetic macromolecule-based biomedical fibers, such as polyester, polyamide, polyolefin, polyacrylonitrile, polypropylene, and poly lactic acid fiber. Among them, emerging high-performance materials, especially the emerging uncovered natural macromolecule-based biomedical fibers, are organized as shown in Table 2. Main special functions include: resisting and containing bacteria, stopping bleeding, reducing inflammation, and tranquilizing, speeding up the healing of wounds, improving microcirculation system, preventing and hiding odor, dispelling heat and mitigating pain, and being skin friendly. In the field of medical treatment, they can be used to make a variety of medical dressings, surgical sutures, dialysis-specific materials, artificial organ components, personal health articles, absorptive health products, medical protective uniforms, working uniforms, and operating gowns. Moreover, the methods for shaping these fibers mainly are: dry spinning, wet-melt spinning, dry-wet spinning, melt spinning, emulsion spinning, and gel spinning. Different spinning methods can give fibers different characteristics of physical parameters, for example, the fibers made with melt spinning and wet spinning have a fiber diameter that is close to the size of most animal and plant cells, while the fibers made through electrostatic spinning are more close to the size of virus, at different levels from nanometer to millimeter. Alternatively, through the design of a pre-installed spinning jet, fibers can have different cross sections, such as triangular, pentagonal, cross-shaped, and hollow ones. At present, the products with multiple functions are also one of the highlights of current development. Therefore, through the technological integration of these new high-performance materials in the entire production chain from the macromolecular materials, fiber yarns, and fabric structure at the beginning to the pattern design and post-treatment at the end, such as the spinning through blending, the design and weaving of the fabrics with multiple layers and different structures, and coating or post-treatment, such qualities as being comfortable to wear, being beneficial to health, being sensitive, being safe, being protective and being convenient can be upgraded to higher levels. For instance, in the process of spinning, through different spinning methods such as for core-spun yarn, nicked yarn, and fancy yarn, and such as fiber spinning, band spinning, dyed spinning and ring spinning, the above-mentioned one of more high-performance medical fiber(s) is spun separately or are spun through blending with conventional textile maters, so as to form structurally different yarns, and enhance medical effects. During the process of weaving, these medical yarns can make up one-dimensional (linear), two-dimensional (flat) or three-dimensional (tubular and laminated) medical textiles, applicable on different occasions.

Table 2. Different types of high-performance medical textiles

Natural fiber		Synthetic fiber	
Designation	Functions and uses in medical and health field	Designation	Functions and uses in medical and health field
Hitosan fiber	*Functions: resisting bacteria, staunching bleeding, speeding up the healing of wounds, improving immune system; Uses: postoperative healing, wound dressing, personal protective products, care-taking textiles, household textiles, cosmetic textiles, and clothes for the old and infants.	Copper-modified polyester fiber (copper fiber) (In the same theory as: titanium-enriched health fiber, and silver fiber)	Functions: it is a type of functional fibers made through spinning after bacteria-resisting copper materials are treated with nano-processing technology, and melt into the melted mess for spinning. It has the functions of fighting, killing and inhibiting bacteria with a lasting effect, removing odor and self-cleaning, protecting against mildew and mite, and improving physical immunity. Uses: postoperative healing, wound dressing, personal protective products, care-taking textiles, household textiles, cosmetic textiles, and clothes for the old and infants.

天然纤维		合成纤维	
名称	功能 & 医疗健康领域用途	名称	功能 & 医疗健康领域用途
海藻纤维	* 功能：吸液能力强，透气性好；释放负氧离子，促进新陈代谢，提高免疫力；抗菌抑菌、消炎防螨；促进修復伤口；吸附重金属、污染物的功能； 低频防辐射功能和防紫外线功能； * 用途：术后愈合、伤口敷料，个人卫生用品；看护纺织產品、防辐射服装、家纺、美容纺织品、老年婴幼儿衣物类产品。	改性 Lyocell 纤 维	* 天然纤维素溶解在有机溶剂甲基吗琳氧化物 NMMO 中 经湿法纺丝而成。比海藻纤维具有更高的吸水性；形成连续性较好的凝固。 * 用途：术后愈合、伤口敷料，个人卫生用品；看护纺织类等产品。
芦荟纤维	功能：良好的吸湿性、放湿性，呈弱酸性，与皮肤 ph. 值相近，提高细胞活性，促进伤口癒合，具有美容防晒功效，改善机体、皮肤的血流供应和微循环，提高新陈代谢。 用途：个人卫生用品； 防晒服、家纺、美容纺织品、老年 & 婴幼儿衣物等产品。	聚乳酸纤维	* 功能：以玉米为原料经微生物发酵制成乳酸经聚合、 熔法纺丝而得；具有和涤纶相似的强度且具有可生物降解性； * 用途：於医用缝线， 外科手术植人材料、 人工血管，以及一次性尿布、妇女卫生巾，老年人 & 婴幼儿衣物类等产品。
牛奶纤维	功能：以牛乳为基础原料，制成乳酪蛋白，通过纺丝与纤维素纤维共混，制得牛奶蛋白纤维。 柔软、亲肤、透气导湿、保暖性好，有大量对人体有益的氨基酸，延缓衰老，改善微循环。 用途：个人卫生用品，家纺，美容纺织品。	中空纤维	* 功能：指纤维轴向有细管状空腔的化纤，更加质轻、保暖透湿，需要与所载药物相配合，製得可控、持久释放的载药纺织品。 * 用途：可用於冬装、家纺、填充材料，亲肤的载药系统、过滤纺织材料，例如对人工肾定期进行血液透析可延长肾功能衰竭和尿毒症病人的生命。
珍珠纤维	将纳米级珍珠粉在粘胶纤维纺丝时加入纤维内，使纤维体内和外表均匀分布着纳米珍珠微粒，具有珍珠所特有的护肤功能和抵抗紫外线的功能，优良的吸湿回潮率，舒适的手感和服用性能。 用途：高档贴身衣物，家纺，美容纺织品。	远红外纤维	*功能：在合成纺织母粒中，加入高远红外放射率的陶瓷颗粒，通过熔融纺纱后得到远红外功能纤维，具有促进血液微循环，提高新陈代谢，缓解疲劳，疏导软化血管，提升身体免疫力等功能。 用途：个人卫生用品，家纺，康健设施等。
竹原纤维	防紫外线，身能產生负离子和防虫抗菌作用，有较强的抗菌和杀菌作用；有叶绿素铜钠，因而具有良好的除臭功能 用途：个人卫生用品，家纺用品等。	聚谷氨酸抗菌纤维	* 功能：强效抗菌、抑菌，效果持久，吸湿性好，吸水能力能达到自身重量的十倍。 * 用途: 贴身衣物、床上用品、卫生用品、医疗用品等。
胶原蛋白纤维	功能：又称为‘胶原质’，是组成各种细胞外间质的聚合物，在动物细胞中扮演结合组织的角色。它主要是以不溶性纤维蛋白的形式存在，在人体的组成中约占蛋白质的 25~30%，在体内的细胞间质中不单独存在，而是聚集成纤维，或是可重组或经处理成多种形态，如纤维、薄膜、管状、海绵状、粉末或柔软的纤维织品。 用途：应用在止血、神经重建、组织整形、烧烫伤、脱肠修补、尿道手术、药物释放、眼科、阴道避孕器、修补心瓣膜、血管壁手术和手术缝线等所需的高端医材料上。	EVOH 亲水性材料	* 功能：拥有亲水性的基团 (OH 基)，抗菌、抗发炎、 及具有生理活性，促进伤口愈合。 * 用途：慢性伤口的高阶敷料。

Natural fiber		Synthetic fiber	
Designation	Functions and uses in medical and health field	Designation	Functions and uses in medical and health field
Seaweek fiber	Functions: having an outstanding liquid-absorbing ability and a great air permeability, releasing negative oxygen ion, facilitating metabolism, improving immunity, fighting and inhibiting bacteria, reducing inflammation, preventing mite, speeding up wound-healing, absorbing heavy metal and pollutants, and protecting against low-frequency radiation and ultraviolet rays. Uses: postoperative healing, wound dressing, personal protective products, care-taking textiles, household textiles, radiation-resistant garments, household textiles, cosmetic textiles, and the clothes for the old and infants.	Modified Lyocell fiber	It is made through wet spinning after natural cellulose is dissolved in the organic solvent of n-methylmorpholine oxide (NMMO). It is more able to absorb moisture than seaweed fiber is, so as to achieve the effect of more continuous concretion Uses: postoperative healing, wound dressing, personal protective products, and care-taking textiles.
Aloe fiber	Functions: being good at moisture absorption and liberation, showing the quality of weak acid, having a similar ph value to the skin's, improving cellular activities, speeding up wound-healing, having cosmetic and sunburn-preventing effects, enhancing the supply of blood to the inner organs and the skin as well as the microcirculation, and facilitating metabolism. Uses: personal health products, sunburn-preventing clothes, household textiles, cosmetic textiles, and the clothes for the old and infants.	Polylactic acid fiber	Functions: it is made through polymerization and melting spinning after polylactic acid is prepared through microbial fermentation with corn as raw material. It has a similar strength to polyester's and is biodegradable. Uses: medical stitches, surgical implants, artificial blood vessels, as well as the products including disposable diapers, the sanitary towels for use of women, and the clothes for the old and infants.
Milk fiber	Functions: milk protein fiber is made through spinning and blending with cellulose fibers after milk protein is prepared with milk as basic raw material. It is soft, skin-friendly, and air-permeable, insulates heat, providing plentiful amino acid that is beneficial to human bodies, slowing ageing, and improving microcirculation. Uses: personal health products, household textiles, and cosmetic textiles.	Hollow fiber	Functions: it refers to the chemical fiber that has thin tubular cavities in axial direction. It is more lightweight, preserves heat, and allows the passage of moisture. If working with the drugs that it carries, it can make for controllable effect-lasting drug-carrying textiles. Uses: it can be used for winter clothes, household textiles, fillings, skin-friendly drug-carrying system, and filtrating textile materials, for example, if blood dialysis is performed on a regular basis for an artificial kidney, the renal failure or uremia patient's life can be extended.
Pearl fiber	When viscose fiber is spun, nano-grade pearl powder is added to the fiber, so that nano-grade pearl participles are evenly distributed on the inner and outer surfaces of the fiber. It has a pearl-specific effect of protecting the skin against ultraviolet rays, and a good ability to absorb moisture, offers a comfortable feel, and serves the purpose of being wearable. Uses: high-end underwear, household textiles, and cosmetic textiles.	Far-infrared fiber	Functions: in the process of synthesizing textile master-batch, the ceramic particles with high far-infrared radiation rate are added, and through melting spinning, the fiber with far-infrared functions is obtained, which has the functions of facilitating the microcirculation of blood, enhancing metabolism, relieving fatigue, smoothing and softening blood vessels, and improving immunity. Uses: personal health products, household textiles, and health care facilities.
Bamboo fiber	Protecting against ultraviolet rays, having the effects of producing negative ion and resisting insects and bacteria, and functioning better in destroying and fighting bacteria. Thanks to the presence of sodium copper chlorophyllin, it thus has a good ability to remove odor.	Polyglutamic acid antibacterial fiber	Functions: being highly effective in resisting and inhibiting bacteria, having a lasting effect, and being good at absorbing moisture and able to absorb ten times as much water as weighs equal to its dead weight. Uses: the clothes next to the skin, bedclothes, health and medical products etc.
Collagen fiber	Functions: it is also called "collagen", which is a polymer making up extra-cellular matrix for various cells, and plays the role of combing tissues in animal cells. It exists mainly in the form of insoluble fibrin, accounting for 25-30% of protein in the composition of human body. It does not exist independently in the extra-cellular matrix in vivo, but is gathered to form a fiber, or is reorganized or treated to be in different forms, such as fiber-like, membranous, tubular, spongy, powdery or soft fiber textile. Uses: it can be applied in the high-end medical materials that are necessary for staunching bleeding, regenerating nerve, shaping tissues, treating burns and scalds, repairing hernia, doing operation on urethra, releasing drugs, ophthalmologic applications, vaginal contraceptive devices, remedying heart valves, performing vascular surgeries, and surgical sutures.	EVOH hydrophilic materials	Functions: having a hydrophilic group (OH group), resisting bacteria, reducing inflammation, being biologically active, and facilitating wound healing. Usages: staged dressing for chronic wounds.

• 天然性功能性纤维的运用实例

一项由香港理工大学、香港纺织及成衣研发中心、香港政府、东华三院养老院共同发起的公益项目，制作的壳聚糖混纺面料，对金黄色葡萄球菌、大肠杆菌、白色念珠菌都具有良好的抗菌性能，同时，该面料具有良好的亲肤性能，提高人体的免疫机体性能，促进伤口愈合。并通过壳聚糖纺纱技术的改善提高，面料具有更好的舒适性能，通过面料手感舒适性能测试 (Fabric Touch Tester, FTT)，其在湿热平衡、柔软和光滑三方向性能都取得良好的效果。因此，在香港理工大学提供产品纺纱技术和产品设计支持下，政府提供资金支持，产业提供物料和生产设备及人力的支持，为老人群体设计柔软舒适、具有持久抗菌效果的看护用品。而在老人的长期护理照料中，个性化的私人护理产品是十分重要的，可以营造一种亲切轻松的氛围。因此，此研究项目研发了具有设计感和趣味性的功能性看护产品，产品套装包括床上三件套，老人口水肩及随身手帕。这些产品被批量生产并捐赠给香港东华三院养老院，义务向老人们提供更好的照料。

3. 智能可穿戴医疗纺织产品

智能可穿戴纺织品无疑是今后发展的重要趋势之一，并将成为人们日常生活的一部分。从广义上说，智能可穿戴纺织品是指应用纺织、电子、化学、生物、医学等多学科知识综合开发的具有高智能化的、可穿戴的纺织品，它基于仿生学概念，能够模拟生命系统，同时有感知和反应双重功能。狭义上的智能纺织品是指电子信息智能纺织品。它将微电子、信息、计算机等技术融合到纺织品中，是一个跨多学科的结合体，其在医疗健康领域中的应用前景十分广泛，例如包括可控的药物释放、药物靶向治疗、实时健康监护、急救室管理、物理治疗等多个领域。其中，最大的热点是将导电智能纺织、敷料、私人卫生护理用品或是贴身内衣产品与人工智能信息技术、电机工程技术相结合，可用于热敷缓痛产品、大面积蓄热保健敷材产品、可调控生物分解敷材产品、皮肤敷材产品、电促进愈合敷材产品、电促进美容敷材产品、电促进血液循环敷材产品等大量多重领域，为病人、老人、婴幼儿等缺乏自我照顾能力的群体，提供更好的看护照料和治疗效果，又或是降低医疗看护的时间、人力和物料成本，提供惠及给更多的受惠群体。其中，最大的运用场景为人体贴身穿着，智能纺织技术用于随时随地监测穿着人体的各项生理指标，同时根据其运用级别的不同 (健康级和医疗级两级)，采集的信号数据也不同，如下表 3 所示。这些采集

表 3 医疗级和健康级智能可穿戴设备的具体技术和探测参数对比

	健康级（普通大众基础）	医疗级（高端进阶级）
监测指标	运动步数、卡路里消耗、运动心率、睡眠、体脂、体重、BMI，脂肪、骨量、肌肉、水份等。	体温、血压、血糖、呼吸、胎心、血氧、心电辅助医生手术记录、疼痛治疗等;
硬件设备	手环、腕表、手机、贴片、电子秤、床垫等	腕表、贴片、血压仪、血氧仪、呼吸机、心电仪等;

• A case of applied natural functional fiber

In a public-interest project jointly launched by the Hong Kong Polytechnic University, HKRITA, Hong Kong government, and the home for the old under Tung Wah Group of Hospitals, chitosan blend fabric is produced, delivering a good antibacterial performance on all of staphylococcus aureus, bacterium coli, and albicans saccharomyces. Meanwhile, this fabric is highly skin-friendly, able to improve the performance of the immune system, and facilitate wound healing. After improved and enhanced with chitosan spinning technology, the fabric feels more comfortable. After the fabric is tested for how comfortable it feels by touch (Fabric Touch Tester, FTT), it has achieved good results in terms of the three aspects of thermal balance, softness, and slickness. Therefore, with the Hong Kong Polytechnic University providing the technology for spinning yarn and the support for product design, the government has offered financial aid, and the industry has given materials and production equipment as well as human resources, and the care-taking products that are soft and comfortable and have a long-lasting effect of resisting bacteria have been designed for the group of the old. During the long-term caring of the old, personalized protective products are very important, able to create a friendly and relaxed atmosphere. Therefore, in this research project, the functional care-taking product that provides a sense of design and is interesting is researched and developed. The product package includes the three-piece bedclothes, adult bibs and handy handkerchiefs. These products are manufactured in batches and donated to the home for the old under Tung Wah Group of Hospitals, and better fabrics are provided compulsorily to the old.

3. Intelligent wearable medical textiles

One of the important development trends undoubtedly is towards intelligent wearable textiles from now on, which will become part of people' daily life. Broadly speaking, intelligent wearable textiles refer to the highly intelligent wearable ones that are comprehensively developed with the application of interdisciplinary knowledge such as of textiles, electronics, chemistry, biology and medical science, and they are based on the concept in bionics, able to emulate a life system, while having the dual functions of sensing and reacting. In a narrow sense, intelligent textiles refer to electronic information-enabled intelligent textiles. They integrate such technologies as microelectronics, information, and computer into textiles, becoming an interdisciplinary combination, and having a bright prospect of being applied in medical treatment and health, for example, including many fields such as drug release, drug-targeted therapy, real-time health monitoring, emergency room management, and physical treatment. Among them, electricity-conductive intelligent textile, dressing, personal health care product, and the integration between underwear, AI information technology, and electric engineering technology are the most discussed; able to be used in a variety of fields such as pain relieving heated dressing, large-area thermal storage health care dressing, controllable biodegradation dressing, skin care dressing, electrically enhanced healing dressing, electrically enhanced cosmetic dressing, electrically enhanced blood circulation dressing. Better care-taking and medical effects are achieved for the groups of patients, the old, and infants who are lacking in the ability for self-care, and the time, human resource and costs spent on medical care are reduced, with more people benefiting. Among these applications, the widest is of underwear. Intelligent textile technology is used to monitor all the physical condition indicators at any time and at any place. Meanwhile, according to different levels of application (two levels, of health and of medical treatment), different signals and data are collected, as shown in Table 3 below. These data collected will be shared in real time online through the cloud with family members, medical center, and community rescue station, so that rescue and daily care will be performed in time for patients in need for help. Therefore, the intelligent care in the era of

Table 3. Comparison of specific technical and detective parameters between pieces of intelligent wearable equipment at medical and health levels

	At health level (for ordinary people)	At medical level (for selective people)
Detctive indicators	Number of steps, calorie consumption, heart beat, sleep, body fat, weight, BMI, fat, bone mess, water content etc.	Body temperature, blood pressure, blood sugar, respiration, fetal heart, blood oxygen, auxiliary cardiac operation records, pain-relieving treatment etc.
Hardware	Bracelet, wrist watch, handset, patch, electronic scale, mattress etc.	Wrist watch, patch, blood pressure meter, blood oxygen meter, respirator, electrocardiogram equipment etc.

的数据将通过在线云端与家庭成员、医疗中心、社区救护站实时共享，及时为需要帮助病患提供急救和日常看护治疗，因此物联网时代的智慧照护，让长者更适合“在家养老”。而这种可穿戴的医疗纺织技术并不是一个全新产品的出现，它已有近 20 年的发展历程，如下图 3 所示，其发展的特点已经从过去的小型化转变为现在的智能化、互联性，而将来将向着服务价值、数据分析判断政治的方向发展。

随着在纤维、纱线微观规模上对纺织材料的多功能化改性，单根的纤维、长丝或者纱线都已经能够起到传感器、制动器和甚至电池的功能，进而将这些不同元素的柔性导电功能性纺织材料在不同的面料结构中相互组合连接成完整的功能性电子回路 (或者连接外部功能性元件)，这些带有完整功能性回路的电子纺织品，于先前的可穿戴产品相比，更加柔软舒适化、纺织品化，可被皮肤敏感性的儿童和老人人群长时间穿着，长时间记录生活活动特征，同时传感器接触面积变大，采集的信号更加全面多样，从而分析结果更为准确，因此隐形的健康隐患将被更早的发现。同时，通过身体机能的实时监测，也能更有效得预防很多突发急性的健康安全问题，尤其是老人的摔倒、中风、突发的心肺功能障碍等问题都可以被预防，或被检测并提供及时的治疗，例如像糖尿病、酒精中毒、尿毒症、免疫不全或营养欠缺症等等疾病都是导致周边神经病变的常见原因，这类患者会遭遇到肢体疼痛、麻木、刺痛、烧灼，或甚至触感丧失等痛苦，从统计数据来看尤其是糖尿病患者通常会在发病后五年左右并发周边神经病变，其中有百分之五十的患者会有截肢的危险，因此連续追踪分析生理讯号，随时提醒使用者自身的生理状态，在身体有异状时能让使用者及早排除生理不适，维持身心健康，以达到预防及保健之目的十分重要；或是老人居家看护、幼儿生理现象侦测，对于家中无法自我照顾的族群提供远端视，在遇到危险状况时能适时的提供适当的救援措施。可穿戴设备不仅帮助提供更多医疗支持，提升慢性病、残疾人和老年人的生活质量，

图 3 智能可穿戴设备沿路发展历程

時間	過去	現在	將來
特點	小型化／便攜性	智慧化／互聯性	服務加值／數據分析和判斷
服務主軸	1. 擴充、延伸手機功能（如：來電／來訊／電話...） 2. 改善或補強手機人機使用介面（如：遙控、聲控操作智慧手機） 3. 其他：利用APP與穿戴整合，發揮手機前無之新功能（如：瀏覽資訊狀態、尋找手機、環境偵測、門卡、NFC應用等）	1. 運動健身紀錄與管理（計步計距計卡路里等） 2. 瘦身塑身計劃與激勵（專家建議與社群比較及鼓勵） 3. 其他：生活起居紀錄與提示（與下方照護會交集，如：起床喚醒、睡眠紀錄等）	1. 生理紀錄分析與專家建議（如：睡眠分析與改善） 2. 健康養生監督與專家建議（如：飲食監督、服藥提醒） 3. 生命跡象監視與醫療照護（如：居家照護、急救看護、用藥警示或調整） 4. 其他階段醫療行為之輔助，或其他新特殊加值服務（如：遠距離醫療、遠距離防作弊等）
類別形式	手機周邊／手機輔助 –輔助手機功能為主	運動健身／健康管理 –紀錄管理、服務為主	健康照護／醫療照護 –專業加值服務為主

Internet of things makes it more suitable for the old to “live their lives in retirement at home.” However, the emergence of this kind of technology for wearable medical textiles is no longer as a brand new product, and it has a history of developing for nearly 20 years. As shown in Table 3 below, its development is characterized by the change from being small in the past to being intelligent and interconnected at present, and in the future, it will develop towards service value and data analysis and conclusion.

As textile materials are modified at micro levels of fiber and yarn for serving multiple purposes, a single fiber, filament or yarn can functions as a sensor, a brake, and even a cell, and these different elements in flexible electricity-conductive textile materials can be further combined and connected with each other in different fabric structures to establish complete functional electric circuits (or connect external functional elements). As compared with previous wearable products, these textiles with complete functional circuits are more flexible and comfortable, feel more like textiles, and can be worn for a long time by infants and the old whose skin is sensitive, recording the characteristics of their lives during a long period of time. Meanwhile, the area in contact with sensors will become large, the signals collected will be more diversified, so that the results of analysis will be more accurate. Therefore, hidden health problems will be discovered earlier. Moreover, the real time monitoring of physical condition can also more effectively prevent many acute health problems, especially, the old falling down, having a stroke, or suffering sudden problems with lung or heart, besides detecting their problems, which will be dealt with on a timely manner. For example, such diseases as diabetes, alcoholism, uremia, immune deficiency or malnutrition are the common causes of peripheral neuropathy. The patients with this will experience the sufferings such as pain, numbness, sharp pain, burn or even loss of the sense of touch in limbs. Statistically speaking, especially diabetic patients will suffer peripheral neuropathy usually about five years after the disease strikes, and 50% of them are in danger of being amputated. Therefore, it is very important to continuously track and analyze the signals for physical condition, remind users at any time of their physical condition, and enable users to solve health problems at the time the occurrence of abnormality and remain in healthy condition, so that the goal of prevention and being healthy can be achieved. Furthermore, they can be used for taking care of the old at home, and monitoring the physical condition of infants. Videos of those who stay at home but have no ability of self-care can be remotely accessed, and in the case of emergency, appropriate rescue measures can be provided. Wearable equipment not only helps to provide more medical supports, and improve the living standard for the patients with chronic diseases, and for the disabled and the old, but also reduces the number of inpatients, saves medical spending, prevents diseases, enhances the safety and quality of lives for the old by providing appropriate help, enables the old to be more independent, and has the potential to become the integral part of modern health care system.

还可减少住院，节省医疗开支，预防疾病或者通过提供适当帮助，提高老年人的空间安全感和生存质量，增加老年人生活的独立性，有潜力成为现代健康护理系统中不可或缺的组成部分。此外，如何透过纺织品传输讯号也是关键的因素。所以导电纤维技术变得非常重要，它是以金属材料制成纤维或纱线做为传输讯号的导线。为避免传递时短路，需要包覆绝缘材质，来达到电子电路纤维化并可用以连结电子元件的目的，且具有可水洗、高传导性、柔曲性、抗氧化等性能。借着巧妙地整合纺织与电子科技，就可轻易地在穿戴载体上进行线路布局设计及制作应用，再透过智慧型无线传输模组，就能自动把资料传至云端分析。受测者穿上服装后，可在无线通讯存取范围内做各种活动而不影响资料的撷取与传输。因此，以智慧型纺织品为基础的穿戴式装置在居家照护、医疗保健及户外意外防止方面将会有很大的实用性。

4. 展望

目前，全球医卫用纺织品市场呈现出三种技术发展趋势：一，多种工艺技术进一步复合；二，交叉学科领域进一步融合；三，产业链上下游技术集成创新。同时，结合中国医卫纺织品市场自身的短板—科技技术附加值低、外科植入性纺织品和体外过滤用纺织品大部分依赖进口，仍需增强新产品开发的能力，重点发展特殊的生物医用纤维，建立具有自主知识产权的产品替代进口，尤其是在 1) 大聚合物纳米纤维在药液控释、组织支架、软组织修补、矫形植入以及创伤处理等方面开发与应用；2) 各种智能医疗用品，实现医用纺织品智能化。在这个发展过程中，不同专业医疗产品的运用场景差别大，各自的病理原理复杂，每项医疗纺织品的开发和试验，需要同时融合纺织、生物、医学、材料，甚至电子工程等方面的专业高端人才。因此，针对特定的产品，专业跨界人才需要被精准地发掘。

此外，除了企业技术还须提升，在国家政策法规引导和保障机制，市场准入与临床实验方面也都需要继续改进。从原纤开发到纤维产品，通过纺纱技术、生产、销售的灵活运作，通过国家政策的支持，市场规范化的操作保证，继而稳步扩宽全球医疗卫生用纺织品的市场。

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Additionally, how to transmit signals through textiles is also a key factor. Therefore, the technology for electricity-conductive fiber becomes very important, featuring the fiber or yarn that is made of metal material to serve as a conductive wire for transmitting signals. In order to avoid short circuit at the time of transmission, it needs to be coated with insulating materials, so that the electric circuit is fiber-like, and can be used to connect electronic element, and has the qualities of being able to be water-washed, highly conductive, flexible, and oxidation-resistant. Through the ingenious integration between textiles and electronic science and technology, a circuit can be easily arranged, designed, made and applied in a wearable equipment, and with intelligent wireless transmission modules, information can be automatically transmitted to the cloud for analysis. After users put on the clothes, they can do all kinds of activities within the scope of access to wireless communication without affecting the collection and transmission. Therefore, the wearable equipment based on intelligent textiles will be highly practicable in terms of domestic care, medical care and outdoor accident prevention.

4. Outlook

At present, global markets for medical textiles show three trends in technological development: one, further combination of multiple technologies; two, further interdisciplinary integration; three, technical integration and innovation upstream and downstream of industry chain. Meanwhile, in the light of the shortcomings in China's markets for medical textiles that are low additional scientific value and dependence on exports for most of surgical implanted textiles and in vitro filtration textiles, it is still necessary to enhance the ability for developing new products, intensively develop special medical textiles, create the products with dependant intellectual property rights to substitute for import, and especially, 1) develop and apply large polymer nano fibers in such aspects as drug solution control and release, tissue bracket, soft tissue repair, orthopedic implants and wound treatment; and 2) apply intelligent medical textiles in a variety of intelligent medical products. During this course of development, there is a huge difference between the applications of medical products in different fields, where, their respective pathological theories are complicated, and the development and testing of each medical textile need the talented people from such fields as textiles, biology, medical science, materials, and even electronic engineering to work together at the time. Therefore, for particular products, talented professionals changing from one field to other ones need to be accurately discovered.

In addition, not only is it necessary for enterprises to enhance technologies, continuous improvement also needs to be made on the guidance of state policies and laws, security mechanism, market access, and clinic experiment. Through the flexible organization of spinning technology, production and sale in every aspect from filament development to fiber product, with the support of state policies, and under the guarantee that market activities will comply with regulations, global market for medical textiles will be developed steadily.

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智能可穿戴能源纤维
Smart wearable energy fiber

人类从来没有遇到过这种情况，在中国东部密集出现了 200 多个百万以上人口级别的大城市，超过 5 亿人从农村来到了城市。“齐之临淄三百闾，张袂成帷，挥汗成雨，比肩继踵而在。”，寒冬的供暖、出行的交通，城市人美好生活的背后是能源消耗的支撑。在化石能源驱动的时代，雾霾、光化学烟雾，燃油发动机排放的废气给人类生活带来很多问题，已经到了不得不解决的时候。如今，新能源技术越来越受到社会的重视，用新能源汽车驱动城市交通从而解决交通污染问题是人们的愿望，新能源技术产生的影响不仅仅在出行交通方面，与柔性可穿戴技术的结合是智能服装发展的一个重要支撑。

智能穿戴作为一个新兴的领域，需要美学设计、纺织、能源化学、材料学、计算机通信等各学科跨领域的密切合作。本文将从能源的角度从能源收集、能源储存、纤维能源的应用和能源与其他模块的连接四个方面来介绍智能纤维能源的研究和应用。

1. 光能、机械能收集纤维—复合能源衣

我们生存的环境中存在光、风、人体运动等各种能量，如何收集这些能量并转化为电能给随身穿戴的电子设备提供持续电能是人们向往已久的梦想。图 1 为一种新型全固态智能可穿戴织物，通过飞梭织布技术，可以在一张 320 微米厚的单层织物中，将太阳能织物模块和纳米发电机模块按照不同的电气输出要求进行编织，并根据需求集成到人体衣物的不同部位。该织物不仅可以采集太阳光能，还可以同时将人体运动导致的织物内部纤维机械摩擦转化成电能，从而驱动随身电子设备不间断地工作。只要有光，只要人在运动，纤维织物便可以源源不断地收集能量。

图 1 复合能源纤维产生的电能可以为手表供电（注：源自《Nature Energy》）

Figure 1. Electric powergenerated by composite energy fiber can support power for the watch (Note:source from Nature Energy).

Human beings have never met with such a situation:there appear metropolises with a population of more than 2 million people in eastern China and more than 500 million people have come from the countryside to the urban areas, just as what was described in the Spring and AutumnAnnals of Viscount Yan, “Linzi has three hundred gates of alleys with so many people that the sun can be curtained to darken the sky when they open up sleeves, the rain can fall when they wipe off sweat, and the street will be overcrowded with people shoulder-to-shoulder and tiptoe-to-heel”.Behind the heat supply in the cold winter, transportation in trips and the city dwellers’ beautiful life is the support of energy consumption. In thefossil energy driven era, haze, photochemical smog and emissions from fuel engines broughtproblems to human life. Now comesthe time when we have to solve them. Today, new energy technology is paid more and more attention.It is the aspiration of people to fuel the urban transportation driven by new-energy vehicles to solve traffic pollution. New energy technology not only exerts impact on traffic and transportation, but also significantly supports the development of smart clothes through its combination with flexible wearable technology.

As an emerging field, Smart wear requires the close cooperation between various fields, such as aesthetics design, textile, energy chemistry, material science and computer communication. This article will introduce the research and application of smart fiber energy from the four aspects of energy collection, energy storage, fiber energy application and energy integrated with other modules.

1. Fiber collecting light& mechanical energy in composite energy coat

There are various kinds of energy in the environment where we live,such as light, wind and human motion. How to collect these kinds of energy and transform them into electric powerto provide continuous power for wearable electronic devices is a dream that human beings have been longing for a long time. The Figure 1 shows a new type of whole-solid-state smart wearable fabric. By means of shuttle weaving technology,we can weavea piece of 320-micrometer thick single-layered fabric in the solar module and Nanogenerator module based on different requirements for electric output, and integrate it into the different parts of clothing for the human body according to specific needs. Such fabric can not only collect solar energy, but also transform the mechanical friction caused by human motions between the internal fibers of fabrics into electric power, so as to driveportable electronic devices to continuously work. As long as there is light, as long as people are moving, the fiber fabric can continuously collect energy.

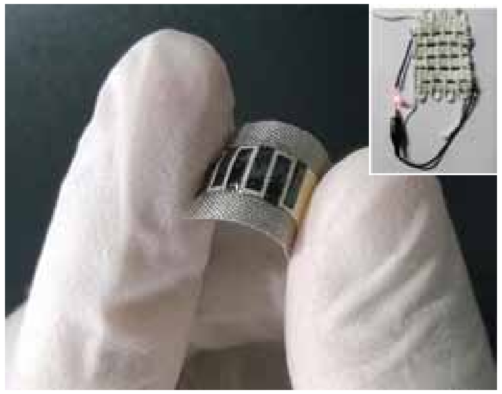


图 2 纤维平面、线状超级电容器（注：源自《Advanced Energy Materials》《Advanced Materials》）
Figure 2. Fiber plane linear supercapacitor (Note: source from Advanced Energy Materials andAdvanced Materials)

2. 储能纤维—衣服做成的电池？—基于纺织物的可穿戴微型超级电容器

智能服装多功能的实现需要电池、电容器等能源存储器件来供能。传统的刚性锂电池等已被广泛应用于各种智能纺织物中，然而其非柔性的特点极大地限制了它们的应用。理想的智能纺织物的能源器件也应该是以纺织纤维的形式存在，并能直接编入衣服中与供能器件连接起来使用，并对织物的舒适度与柔软度没有大的影响。同时，环境中的能量收集后需要及时将这些能量储存起来，为可穿戴器件供电。图 2 为纤维基二维平面状和一维线状超级电容器，将氧化还原石墨烯等材料以自组装的方与导电纤维编制一起发挥储能作用。轻薄和柔性的纤维作为基底，可以直接编织到布料中。布料由微米级别的纤维纺成，每一根纤维、每一束纤维之间有足够的空隙，提供了大量的比表面积，天然地承载了加载到纤维空间中的石墨烯等电池活性物质。

3. 纤维基能源的应用—纤维触觉

储存的能源的应用之一是为功能模块供电，在这些功能器件中，可以感受或响应外界刺激的压力、应力传感器是电子织品的重要组成部分。智能服装的飞速发展对这些传感器提出了更高的要求，希望其具有和柔性纤维可比的轻质量、舒适、柔性。然而，大多数压力传感器是由传统光刻等方法制备的硅基压力传感器，其高硬度、低灵敏性、有限的传感范围很难满足智能服装未来发展需求。图 3 为在织物基底上的附着在人造手的不同手指上的压力传感器阵列，输出信号可以实时地随着应力大小的变化而变化，从而使纤维带有“触觉”。

Google 与 Levi's 合作的 Project Jacquard 于去年上市了一款带有触控功能的 jacket，利用我们所熟知的纺织原料，包括棉、麻等纤维与导电纤维编成纱线进而在纱线织进布料中实现触控功能。将纤维编制在牛仔夹克的袖子上，使得骑行 (自行车) 者可以在骑车过程中通过拍击、摩擦、滑动袖子等方式来控制随身携带的手机等智能设备，比如切换音乐、获得导航等。

2. Battery-like energy-storage fiber: textile-based wearable micro-supercapacitor

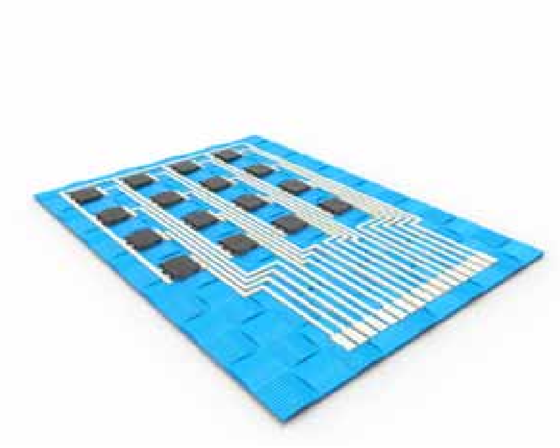
The realization of multi-functional intelligent clothes requires the power supply of energy storage devices, such as batteries and capacitors. Traditional rigid lithium batteries have been widely used in all kinds of smart textiles. However, their non-flexible characteristics have greatly restricted their applications. The ideal power devices for smart textiles should also exist in the form of textile fibers, can be directly woven into clothes to connect with energy supply devices, and have no great influence on comfort and softnessof fabrics. At the same time, after energy collection in the environment, the energy needs storing in time to supply power for wearable devices. What areshown in Figure 2 arethe two-dimensioned plane and one-dimensioned linear supercapacitor of fiber matrix. Theyknit redox graphene and other materials in self-assembly form into conductive fibers to jointly display the role of energy storage.Light, thin and flexible fibers, used as the substrate, can be directly woven intothe cloth, which are made of micron-leveled fibers. Thereareenough gapsbetween each fiber and each bundle of fibers, which provides great specific surface area, and naturally carries graphene and other battery active substances loaded into the fiber space.

3. Fiber touch: application of fiber matrix energy:

One of the applications of stored energy is to supply power for functional modules. In these functional devices, pressure and stress sensors that can feel or respond to external stimuli are important components of electronic fabrics. The rapid development of smart clothes has put forward higher requirements forthese sensorsto have light quality, comfort and flexibility comparable to flexible fibers. However, most of pressure sensors are silicon-based ones fabricated through traditional lithographic methods. Their high hardness, low sensitivity and limited sensing range are difficult to meet the demands for the future development smart clothes. What is displayed in Figure 3 is the pressure sensor array attached to different fingers of artificial hands on fabric substrate. Its output signal can change in real time along with the change of stress intensity, so as to provide fibers with "touch".

Google cooperated with Levi's in Project Jacquard, which releasedthe jacket with the touch-control function last year. The jacket is made by the textile raw materials we are familiar with, including cotton,linen and other fibers. These fibers are knitted with conductive fiber into yarn. When the yarn is woven into the cloth, the touch-control function will work. The fiber can beknitted into the sleeves ofcowboy jackets, so that the riders can control the cellphoneand other portable smart devices in bicycling by rapping, rubbing and sliding sleeves, so as to switch music and obtainGPS.

图 3. 纤维压力传感器阵列（注：源自《Advanced Materials》）
Figure 3. Fiber pressure sensor array (Note: source from Advanced Materials)



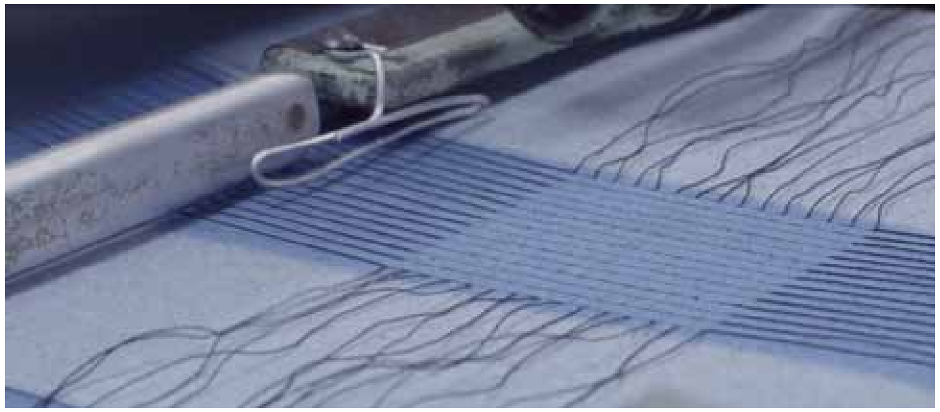


图 4.Project Jacquard
Figure 4.Project Jacquard

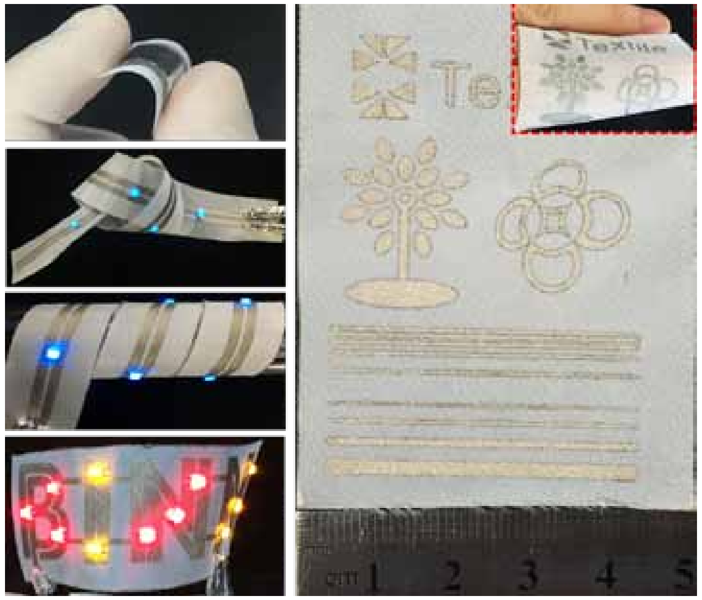


图 5. 纤维基底的柔性导电图案和柔性电路
Figure 5. Fiber-matrix flexible conductive pattern & flexible circuit

4. 能源与其他模块的连接—柔性纤维导电图案

智能服装中有传感器、蓝牙、能源等很多模块，如何将这些模块集成起来？实现方法之一是将导电纤维编织到布料中，另一种方法是以布料为基底直接在上面进行柔性图案的设计，使其导电的同时，又不损失纤维的形貌 (图 5)。这种设计的优点在于它拥有导电功能，同时又可以随心所欲地设计想要的图形展示个性。

集成到衣服上的电子元器件引起了人们的广泛兴趣。如植入纤维不同柔性传感器可实现各种生理指标实时监测的服装、可以对周围电子产品如手机及其他电子设备进行操作和控制的服装、可以对手机等智能设备进行充电的服装等。与新能源技术和互联网思维相结合，是智能服装研究的思路之一，同时消费者对智能可穿戴服装舒适性、时尚美观等提出了更高的要求。程序员和设计师仿佛是处于两个不同的次元的生物，但是在智能服装的发展中两者缺一不可，因为智能和时尚这两者人们都需要，而这在纤维能源方面也不例外。

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4. Flexible fiber conductive pattern: connection of energy withother modules

There are many modules in smart clothes, such as sensors, Bluetooth, energy and so on. How to integrate these modules? One of the ways is to weave conductive fibers into the cloth, and the other one is to directly design flexible patterns on cloth substrate, so as to make them conductive without losing the appearance of fiber, as shown in Figure 5. The advantage of such a design is that it hasconductive functions and the personality of the desired graphical display can be designed at will.

The electronic components integrated into the clothes have aroused wide interest. For example, the fibers implanted in different flexible sensors can achieve real-time monitoring of various physiological indicators of clothing, the clothes that can operate and control the peripheral electronic products, such as cell phones and other electronic devices, as well as the clothes that can chargecell phones and other smart devices. The combination of new energy technology and Internet thinking is one of the ways of smart clothing research. Meanwhile, consumers put forward higher requirements for the comfort, fashion and beauty in smart wearable clothes. The programmer and the designer seem to betwo living things dwelling in two different dimensions.However, in the development of smart clothes, neither of them can be dispensed with, because both intelligence and fashion are needed by people, which is true of fiber energy.

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非织造材料在医卫领域的发展与应用
Development & application of nonwoven materials in medical services

随着科技进步、社会需求以及疾病谱的改变，一种全局的大健康理念进入人们的生活，继而使人们对健康生活的追求和自我保护意识增强，对医卫用纺织品的需求也保持高增长。据产业用纺织品行业协会的报道，我国医卫纺织品消费的需求量在2019年预计可达42.46万吨。这其中，非织造材料因其制备流程简单、原材料来源丰富、制备成本低等优点，使其在产业用纺织品行业，尤其是医疗卫生领域脱颖而出。

1. 医卫材料

自2003年“非典”的SARS病毒传播以来，我国的医用防护材料在市场上层出不穷，其按功能可分为即弃型和重复实用型; 按用途则可分为普通医用 (如伤口敷料、消毒湿巾、止血贴等) 及高性能医用 (如口罩、医疗防辐射服等)[1]。

作为医卫材料，首先应符合医疗防护标准要求的对微生物、病毒等有隔离作用，还要具备“三抗”功能 (抗酒精、抗血、抗油)；其次是可穿着或可佩戴防护用品应具有舒适性；对于可植入体内的材料应具有生物相容性；此外，还应满足一定的物理机械性能，使材料在使用或穿着期间不易被磨破而导致防护功能下降。

2. 非织造材料在医卫领域的优势

传统的医卫纺织品多数以棉、麻等天然纤维或者涤纶、丙纶等合成纤维或者混纺材料为原料，经机织、涂层或层压而成的机织物、高密织物、涂层织物等，其舒适性好，且涂层处理可赋予材料多种防护功能，但是纱线交织形成的织物孔隙大，且其功能整理过程复杂，经洗涤后再达防护要求的过程费用高，反复洗涤后织物表面绒毛或涂层脱落、织物结构松散，致使材料防护性能降低。

非织造医卫材料是单纤维经互相摩擦、抱合、粘结等制成的三维立体结构，首先，此种结构孔径小而曲折，增加了对病菌的阻隔效率；其次，非织造材料的孔隙率高，因此可在适度过滤阻力下实现高效过滤或阻菌；此外，相比传统的重复性医卫纺织品，一次性材料防止细菌

With the progress of science and technology and the changes of social demands and disease spectrum, a concept for overall health enters people's life. It not only enhances people’s pursuit of healthy life and awareness of self-protection, but also makes the demand for medical and sanitary textile maintain high growth. According to the report by industrial textile products association, China's demand for consumption of medical and sanitary textile products in 2019 is expected to reach 424.6 thousand tons. Among them, nonwoven materials are outstanding in the industrial textile products, especially in the medical and sanitary fields due to their simple preparation process, abundant raw materials and low preparation cost.

1. Medical and sanitary materials

Since the transmission of SARS virus in 2003, China’s medical protective materials have emerged in an endless stream. They can be categorizedinto disposable one and repeated practical one according to function, or ordinary medical one, such as wound dressings, disinfecting wipes and hemostasis, andhigh-performance medical one, such as breathing masks and radiation-proof medical clothes [1], according to usage.

Medical and sanitary materialsare required to meet medical protection standards for isolation of microbes and viruses, with the functions of "three antis", anti-alcohol, anti-blood and anti-oil.In addition, wearable protective equipment is expected to be comfortable. Moreover, the implantable materials should be biocompatible. Last but not least,the materials are supposed to fulfill certain physical and mechanical properties to avoid being easily worn to cause the declination of protective functions in usage or dressing.

2. Advantages of nonwoven materials in medical services

Most of the traditional medical textiles are made by cotton, linen and other natural fiber, or synthetic fibers ofteryleneor polypropylene, or woven fabric, high density fabric and coating fabric byweaving, coating or laminatingblended materials. Such a kind of medical textilesis comfortable, with its coatingprocess providing materials with multiple protection functions. However, the textiles formed by interlacing the yarns have big pores between each other. Besides, theyneed complicated functional trimming.Upon washing-up, the process of fulfilling again the protection requirements requires high cost. After repeated washing, the surface fluff or coating of the textiles often shed, which makes the textile structure loose and thus reducing the protective performance of materials.

Nonwoven medical and sanitary materials arethethree-dimensional structure created by the mutual friction, cohesion and adhesion between sing fibers with the features as follows: First of all, such a structure is with small and tortuousaperture, which increases barrier efficiency againstbacteria; secondly, nonwoven materials are with high porosity, which makes them achieve efficient filtration or bacteria-resistance in certain filtration resistance; in addition, compared with traditional repetitive medical and sanitary textiles, disposable materials can prevent bacterial infection and cross infection, which makes the latter more healthy and safe. Therefore, nonwoven materials have great potential in application in disposable medical and sanitary field, such as wound dressings, surgical clothes and diapers.

感染和交叉感染，更卫生安全。因此，非织造材料在即弃型医卫领域(如手术服、伤口敷料、纸尿裤等)具有较大应用潜力。

3 . 非织造医卫材料的发展

3.1 原料方面

早期用于制备非织造医卫材料的纤维原料主要包括聚酯、聚丙烯、聚酰胺、聚四氟乙烯等，而这些合成材料因亲水性差而致舒适性不好。近年来出现了很多生物降解性好、相容性好、亲水性较高的材料以及对传统材料的改性材料，包括海藻纤维、海藻酸盐纤维、甲壳素纤维、聚乳酸纤维、改性 Lyocell 纤维、亲水改性聚丙烯等，此外还有高性能材料包括温敏材料、热变色材料、可逆水溶性材料等。生物基纤维和高性能纤维技术的不断进步，更加拓宽了非织造材料在医卫领域的应用范围。

3.2 技术方面

随着人们对医卫材料的要求日益严苛，新的制备技术在传统非织造工艺的基础上不断发展。

(1) 双组份纺粘水刺技术。该技术是德国 Freudenberg 公司发明的，目前国内的江南大学非织造技术中心等研究机构取得了重要进展，江西吉安三江化纤有条正式生产线。该技术是将普通圆形纤维开纤制备契形纤维，后经水刺加固。其产品舒适柔软，且在阻隔、抑菌、导液速度等方面均优于纺粘和水刺无纺布，是医用防护服的理想材料。

(2) 插层熔喷技术(图 1)。该技术创于 3M 公司，最初是在传统熔喷技术的纤维流中喷吹入中空弹性短纤。目前国内的江苏环宇集团等攻克了插层技术，并将更多功能性纤维插入以实现熔喷材料的功能化、高性能化。此外，PP 熔喷非织造材料的驻极技术，在不改变材料透气透湿性的同时提高了其阻隔微小颗粒的性能。

图 1 插层熔喷示意图及其材料

Figure 1. Sketch map and materials of intercalation meltblown

(3)SMS 复合功能化技术。传统的 SMS 技术以 PP 为主要原料，是纺粘非织造产品与熔喷产品复合。近几年又发展了如 SMMS、SMMMS、SSMMMSS 等复合技术，并与涂层技术和 PP 改性工艺结合，使材料功能化，在改善产品质量的同时提高其性能。

(4) 闪蒸技术。目前该技术被美 DuPont 公司垄断，国内很多高校和企业正研究将该技术产业化以降低其使用成本。该技术所制防护服兼具防护性、耐用性和舒适性，可保护医卫人员免受微米级颗粒的伤害，因此也是医用防护服的理想材料。

4 . 结论

作为与生命健康密切相关的医卫用材料，其市场需求较大，且随着医学的快速发展和人们对健康生活的追求，非织造材料在医卫领域有不可动摇的地位，具有较大的发展空间。未来，非织造医卫材料会朝着研发并应用高性能、差别化、生物基纤维，提高技术水平，开发功能化、高性能医卫材料的方向发展，我国的非织造材料在医卫领域正进入蓬勃发展的阶段。

江南大学非织造技术中心 申莹，邓炳耀

3. Development of nonwovenmedical and sanitarymaterials

3.1 Raw materials

Primarily, the raw materials to prepare nonwoven medical and sanitary materials included polyester, polypropylene, polyamide and polytetrafluoroethylene. These synthetic materials are poor in comfort due to poor hydrophilicity. A lot of materials with high biodegradability, compatibility and hydrophilicity and modified traditional materials have emerged in recent years, including seaweed fiber, alginate fiber, chitin fiber, polylactic acid fiber, modified Lyocell fiber, hydrophilic modified polypropylene and so on. In addition, there appear high-performance materials, including temperature sensitive materials, thermochromism materials, and reversiblewater soluble materials. The continuous progress of bio-based fiber and high-performance fiber broadens the application of nonwoven materials in medical and sanitary field.

3.2 Technology

As people's demand for medical and sanitary materials grows increasingly stringent, new preparation technology continuously develops based on traditional technology of nonwoven materials.

(1) Bicomponent spun-bonded water-repellent technology was invented by Freudenberg from Germany. At present, the Nonwoven Technology Center of Jiangnan University and other research institutes have made great progress.Jiangxi Ji'an Sanjiang Chemical Fibers has a formal production line, with the technology of preparing common circular fibers intowedge-shaped fibers and reinforcing them via spunlacing progress. Its products are ideals materialsfor medical protective clothes as they are soft, comfortable and superior to spunbonded and spunnonwoven fabrics in terms of blocking, bacteriostasis and drainage speed.

(2) Intercalation meltblown technology (as shown in Figure 1)was created by 3M, It originatedfrom spraying hollow elastic short fiber into the fiber flow in the traditional meltblown process. At present, Jiangsu Huanyu Group has conquered the difficulties in intercalation technology and inserted more functional fibers to realize the functionalization and high performance of meltblown materials. In addition, the electret technology of PP meltblown nonwovenmaterials has improved its performance of blocking small particles without changing the permeability of air and water vapor of the materials.

(3) SMS composite functionalization technology. Traditional SMS technology, with PP as the main raw material, was the combination of spunbonded nonwovens and meltblown products. In recent years, composite technologies such as SMMS, SMMMS and SSMMMSS have been developed in combination with coating technology and PP modification technique, so as to functionalize materials and improving product quality and performance.

(4) Flash distillationtechnology. At present, such technology is monopolized by DuPont from the United States. Many universities and enterprises in China are making research on the industrialization of such technology to reduce its application cost. The technology is used to produce protective clothes. With great performance in protection, durability and comfort, the clothes can protect medical and sanitary people from micron particle damage, and thus becoming the best material for medical protective wear.

4. Conclusion

Medical and sanitary materials, closely related to life and health, are greatly demanded in themarket. With the rapid development of medicine and people's pursuit of a healthy lifestyle, nonwoven materials have established an unshakable position in medical and sanitary field with large space for development. The future nonwoven materials will evolve toward the development and application of high performance, differentiation and bio-based fiber, the improvement of technology,as well as the development of functional and high-performance medical and sanitary materials. Thedevelopment of nonwoven materials in medical and sanitary field in China has entered the thriving stage.

Shen Ying, Deng Bingyao

Nonwoven technology center of Jiangnan University

功能性纤维“让人们享受健康、舒适、美的家居生活”

Functional fiber "makes people enjoyhome life of health, comfort and beauty"

功能性纤维在近几年得到了突飞猛进的发展，纤维以其独特的功能性在家纺产品领域得以推广应用；纤维的抗菌性、抗静电性、凉感性能、保暖性能、吸湿发热性、高弹性、慢回弹性、全降解绿色环保性等功能赋予了家纺产品功能化。

随着人们生活方式的改变，人们越来越重视家居环境的健康、安全、绿色、环保，对家纺产品的功能性要求也随之日益增强。目前，家纺行业产品已由数量扩张进入品质提升时期，由花型、颜色、款式设计创新向健康环保、科技创新转变，产品的功能性和品质得到不断地提升，家纺品牌的信誉度也不断地得到市场和消费者的认可。功能性的家纺产品研发，已逐步成为当前市场竞争中家纺行业发展的靓点、战略重点及发展趋势。

家纺产品作为一种表达个性思想和生活情趣的载体，已形成独特的纺织文化。新型纤维的发展，使得功能性面料的市场拓展了一个又一个新的空间领域，各种类型的功能性面料被陆续推上市场，纺织面料产品的内涵得到了创新和丰富。首先，新型高分子材料的发展，引入了新型材料，赋予了新性能。功能性组分物质采用接枝共聚、共混、复合纺丝等技术工艺方法赋予功能性纤维更完美的使用效果和新的特性。如：牛奶蛋白纤维，该纤维面料手感滑糯、光泽亮丽、吸湿透气，体现出真丝般的品质，蛋白氨基酸的成分使得产品具有亲肤护肤功能，目前已开发应用于家纺套件、被芯面料等；薄荷纤维，该纤维面料柔软舒适，吸湿性好，有一定的凉感性，薄荷酮有效成分具有持久抗菌功能，主要用于夏季家纺产品等;吸湿发热纤维，该纤维产品具有吸湿、透气、保暖的特点，主要用于冬季毯类、被芯类产品等；太极石纤维，该纤维产品具有远红外、抗菌、改善微循环的功能，主要用于被芯、枕头、套件及家居服等。

Functional fiber has been on a rapid growth in recent years and widely used in home textiles with its unique performances of anti-bacteria, antistatic property, cool-feeling, thermal insulation, moisture absorption, heat emission, high elasticity, slow rebound resilience, as well as degradation environmental protection.

With the change of life styles, people are paying more and more attention to the health, safety and environmental protection of household environment; meanwhile, the functional requirements for home textile products are also increasing. At present, home textile industrial products have evolved from quantity expansion to quality enhancement, as well as from innovation in design of pattern, color and style toinnovation of health, environmental protection and technology. The reputation of home textile brands is also continuously recognized by the markets and consumers. The research and development of functional home textile products have gradually become a highlight, strategic focus and development trend of home textile industry in the current market competition.

As a carrier for expression of personal ideas, life and tastes, home textile products have formed a unique textile culture. With the development of new fibers, the market of functional fabrics has been expanded into new spheres one after another. All kinds of functional fabrics have been released in the market, with the innovation and enrichment in the connotation of textile fabrics. First of all, the development of new high polymer materials has led to the introduction of new materials and new properties. Functional components adopt the technical processes and methods of graft copolymerization, alloying and composite spinning to endow functional fibers with more marvelous effects of usage and new properties. For example, milk protein fiber fabric touchessleek, smooth, shiny andglossy, with the quality of real silk, which is good at absorbing moisture and ventilating. The component of protein amino acid makes the products feel smooth and protects skins and has been developed and applied to home textile suite, and quilt core lining.Besides, mint fiber fabric is soft and comfortable with good hygroscopicity and certain cool sense. Witha lasting antibacterial function, the effective component of menthone whereinis mainly used in summer textile products. Furthermore, moisture-absorption heath-emission fiberproducts are featured with moisture absorptive, breathable and warmth keeping, and mainly used in winter blankets and quilt core products. Besides, Tai-Chi stone fiber performs far infrared, anti-bacteria and microcirculation improvement, which makes it mainly used in quilt core, pillows, suites and homewear.

序号	纤维名称	纤维特点	检测指标
1	牛奶纤维	柔软滑爽，亲肤护肤	含 18 种氨基酸
2	薄荷纤维	持久抗菌	抑菌率 99%
3	吸湿发热纤维	吸湿、发热、保暖	最高升温值 8.4°C 30min 平均升温值 5.7°C
4	太极石纤维	远红外	远红外发射率 92%

其次，细旦化、异形化纤维使得新材料具有了特殊的表面状态、光学效应和相应的特殊性能，如 CoolMax 纤维，该纤维具有沟槽型结构，利用毛细效应实现吸湿速干功能，主要用于夏被面料、家居服等；再次，生产工艺的提高和发展使功能性纤维得到了有效研发和生产。如：从结构方面设计的美雅碧纤维，中空纤维等;从绿色环保生产技术方面研发的聚乳酸（玉米纤维），植物多酚等。总之，功能性纤维的开发和应用，在引导家纺产品市场流行趋势、推动家纺产品发展发挥了重要的作用。

功能性纤维的应用拓展了家纺用面料的开发空间，使面料具有功能性的同时在手感、舒适性、色泽、吸湿性等方面也得到进一步的发展和改善。如:超细纤维改善了面料的吸湿、透气、柔软、悬垂等性能；石墨烯纤维的出现，使得尖端科技为民所用；聚乳酸纤维提高了农作物的利用率，实现全降解环保绿色生态。

目前市场上的功能性产品鱼目混珠现象并不少见，很多功能性纺织品的安全性堪忧，没有权威检测机构的检测认定，对人体健康可能会造成潜在威胁，消费者无法辨其真伪，自身权益很难得到保障。所以，功能性纺织品国内市场、有待进一步得到规范，这样更有利于其健康发展。

通过几年的努力，罗莱”研发了一系列功能性家纺新产品，从纺织新材料、新技术、新工艺、新产品方面研发创新，收获颇丰。新材料等功能性面料，如薄荷纤维面料、牛奶纤维面料、芳香系列等产品已成功应用于“罗莱”、“罗莱 Kids”、“LOVO”、“欧恋娜”等品牌的套件、芯被产品之中，深受好评，其中负离子产品技术已应用于电商品牌的被芯、床垫、枕头等产品之上，并形成了“爆款”，新材料的应用形成了公司利润的一个重要的增长点。

所以未来纺织材料必然向着新型环保、可循环、高性能方向发展，家纺行业也不列外，只有更好地利用功能纤维、不断地创新研发功能性家纺产品才能给行业发展提供了源源不断的动力和潜力，才能更好地“让人们享受健康、舒适、美的家居生活”。

罗莱生活科技股份有限公司 宫怀瑞

No.	Name of fiber	Feature of fiber	Indicator of detection
1	Milk fiber	Soft, sleek, comfortable and protective for skin	Including 18 kinds of amino acids
2	Mint fiber	Long-last anti-bateria	Bacteriostasis rate of 99%
3	Moisture-absorption heat-emission fiber	Moisture absorption, heat emission, warmth preservation	Maximum warming value at 8.4 , with average warming value at 5.7
4	Tai-Chi stone fiber	Far IR	Emissivity of far IR at 92%

Secondly, fine denier and profiled fiber make new materials with unique surface states, optical effects and corresponding special properties. For example, CoolMax fiber has a groove-type structure. It can avail the capillary effect to achieve quick absorbing and drying, which is mainly used in summer quilt fabrics and home wear. Thirdly, the improvement and development of production processes promotes the effective research, development and production of functional fibers, such as MIYABI fiber and hollow fiber that focuses on structure design, as well as thepolylactic acid fiber, also called corn fiber, and plant polyphenol that make R&D in environment-protective production technology. In a word, the development and application of functional fibers play an important role in guiding the trend of home textile products market and promoting the development of home textile products.

The application of functional fibers has expanded the development room of home textile fabrics. In addition to functional features, the properties of hand feel, comfort, color and moisture absorption has been further developed and improved. For example, the superfine fiber has improved the performance of moisture absorption, breathability, softness and draping. The emergence of graphene fiber has made cutting-edge technology service common people. The polylactic acid fiber has changed corncob from waste into treasure, and thusraising the utilization rate of crops and realizing the full degradation environmental protection ecosystem.

Currently, it is commonly found that the fictitious is mixed with the genuine.The problem on safety of many functional textiles is worth serious consideration. Those without accreditation of detection by authoritative testing organizations might cause potential threats against people’s health. Consumers cannot distinguish the authenticity of those products, which make them hard to guarantee their own interests. Therefore, domestic market of functional textiles needs to be further standardized, which is conducive to its healthy development.

After several years of efforts, Luolaideveloped a series of new functional textile products, with great gains out of its R&Dand innovation in new materials, technology, technique and products of textile.Functional fabrics of new materials, such as mint fiber fabrics, milk fiber fabrics and aromatic series, become successfully applied to the suites and quilt core products with the brands ofLuolai, Luolai Kids, LOVO and Yolanna, with great praise.Among them, the negative ion technology is applied to quilt cores, mattresses, pillows and other products of e-commerce brands, and becomes“hot articles”. The application of new materials becomesa vital growth point of profits for companies.

Therefore, the future textile materials are bound to develop towardnew environmental-protection, recycling and high performance, and this is true of textile industry. Only by better use of functional fibers and continuous innovation and R&D of functional textile products, can the industrial development be provided with constant power and potential, so as to "make people enjoy home life of health, comfort and beauty".

Gong Huairui

Luolai Life Technology Co., Ltd.

发布纤维	具体品种	企业	品牌
纤·生态律动			
生物基纤维	新溶剂法再生纤维素纤维	保定天鹅新型纤维制造有限公司 中纺院绿色纤维股份公司 山东英利实业有限公司	元丝 希赛尔 瑛赛尔
	生物基聚酰胺 56 纤维	凯赛生物产业有限公司	泰纶
循环再生无染聚酯纤维	化学法循环再生无染聚酯纤维	浙江绿宇环保股份有限公司 浙江佳人新材料有限公司	绿宇环保 佳人
纤·科技跃升			
新型生态催化聚酯纤维	钛系聚酯纤维	盛虹集团江苏国望高科纤维有限公司 浙江恒逸石化有限公司 中国石化仪征化纤股份有限责任公司	盛虹 逸钛康 怡然
	皮芯复合钛系聚酯纤维	江苏江南高纤股份有限公司	牛头牌
石墨烯改性功能纤维	石墨烯（生物质）改性聚乳酸纤维	济南圣泉集团股份有限公司	内暖
	石墨烯改性聚酰胺 6 纤维	南通强生石墨烯科技有限公司 常州恒利宝纳米新材料科技有限公司	凯瑞纳 希纳斯
纤·匠心品牌			
抗形变纤维	阳涤高弹复合聚酯纤维	盛虹集团江苏国望高科纤维有限公司	舞虹弹
	细旦多孔蓬松聚酯纤维	桐昆集团浙江恒腾差别化纤维有限公司	桐昆
	高弹性模量聚丙烯腈纤维	吉林奇峰化纤股份有限公司	华绒
差别化再生纤维素纤维	易纺再生纤维素纤维	赛得利	BV 系列再生纤维素纤维
	异形超短再生纤维素纤维	唐山三友集团兴达化纤有限公司 山东银鹰化纤有限公司	三友 云鹰
纤·智创工程			
高性能碳纤维	碳纤维 GQ4522(高强)	中复神鹰碳纤维有限责任公司 威海拓展纤维有限公司 江苏恒神股份有限公司	SYT49 拓展 恒神
	碳纤维 QZ5526(高强中模)		
高性能对位芳纶	高强高模对位芳纶	烟台泰和新材料股份有限公司	泰普龙
高性能超高分子量聚乙烯纤维	耐热抗蠕变原液着色超高分子量聚乙烯纤维	江苏神鹤科技发展有限公司	神鹤
高性能聚酰亚胺纤维	纳米级聚酰亚胺纤维	长春高琦聚酰亚胺材料有限公司 江西先材纳米纤维科技有限公司	轶纶 先材

Fiber name	Specific product	Company	Brand
Fiber·Ecological Rhythm			
Biologically Based Fiber	New Solvent Regenerated Cellulose Fiber	Baoding Swan Fiber Co., Ltd. China Textile Academy Green Fibre Co., Ltd. Shandong Yingli Industrial Co., Ltd.	ORICELL THINCELL Incell
	Bio-Based Polyamide56 Fiber	Cathay Industrial Biotech Ltd.	TERRYL
Recycled Spun-dyed Polyester Fiber	Chemical Method Recycled Spun-dyed Polyester Fiber	Zhejiang Grerial Co., Ltd. Zhejiang Jiaren New Materials Co., Ltd.	GRERIAL Jiaren
Fiber·Technological Upgrade			
New Eco-Catalytic Polyester Fiber	Titanium-Based Polyester Fiber	Shenghong Group · Jiangsu Guowang High-technique Fiber Co., Ltd. Zhejiang Hengyi Petrochemicals Co., Ltd. Sinopec Yizheng Chemical Fibre Co., Ltd.	SHENGHONG Eticont -
	Sheath-Core Titanium Polyester Composite Fiber	Jiangsu Jiangnan High Polymer Fiber Co., Ltd.	NIU TOU
Graphene Modified Functional Fiber	Graphene (biomass) Modified Polylactic Acid Fiber	Jinan Shengquan Group Share-holding Co., Ltd.	Healfiber
	Graphene Modified Polyamide 6 Fiber	Nantong Qiangsheng Graphene Science and Technology Co., Ltd. Highbery New Nano Materials Technology Co., Ltd.	KYORENE PHENAX
Fiber·Elaborate Brand			
Deformation Resistance Fiber	High Elastic Composite Polyester Fiber	Shenghong Group·Jiangsu Guowang High-technique Fiber Co., Ltd.	COSHINNG TAN
	Fine Denier Porou Fluffy Polyester Fiber	Tongkun Group Zhejiang Hengteng Differential Chemical Fiber Co., Ltd.	TONGKUN_
	High Elastic Modulus Polyacrylonitrile Fiber	Jilin Qifeng Chemical Fiber Co., Ltd.	WALON
Differential Regenerated Cellulose Fiber	Easy Spinning Regenerated Cellulose Fiber	Sateri	Sateri BV Series Fibres
	Special-shaped Ultrashort Regenerated Cellulose Fiber	Tangshan Sanyou Xingda Chemical Fiber Co.,Ltd. Shandong Silver Hawk Chemical Fibre Co., Ltd.	Sanyou YUN YING
Fiber·Intelligent Engineering			
High Performance Carbon Fiber	Carbon Fiber GQ4522 (High Strength)	Zhongfu Shenying Carbon Fiber Co., Ltd. Weihai Tuozhan Fiber Co., Ltd. Jiangsu Hengshen Co., Ltd.	SYT49 TuoZhan HS
	Carbon Fiber QZ5526 (High Strength Middle Modulus)		
High Performance Para-aramid	High Strength High Modulus Para-aramid	Yantai Tayho Advanced Materials Co., Ltd.	Taparan
High Performance Ultra-high Molecular Weight Polyethylene Fiber	Heat-resistant and Creep Resistance Dope Dyed Ultra-high Molecular Weight Polyethylene Fiber	Jiangsu Holy Crane Technology Development Co., Ltd.	HolyCrane
High Performance Polyimide Fiber	Nano-scale Polyimide Fiber	Changchun Hipolyking Co., Ltd. Jiangxi Advanced Nanofiber S&T Co., Ltd.	Yilun H!Nanofiber_

盛虹·中国纤维流行趋势 2018/2019 入围产品

品类	入围纤维	企业名称
产业用纤维	原液着色抗紫外高强聚酰胺 6 纤维	江苏海阳化纤有限公司
	地毯用阻燃聚丙烯纤维	浙江四通化纤股份有限公司
弹性纤维	低温热粘合氨纶	连云港杜钟新奥神氨纶有限公司
	抗紫外氨纶	浙江华峰氨纶股份有限公司
仿真纤维	仿麻聚酯纤维	厦门翔鹭化纤股份有限公司
	竹节可控聚酯纤维	桐昆集团浙江恒盛化纤有限公司 嘉兴胜邦科技有限公司
安全防护纤维	功能性阻燃耐熔滴聚酯纤维	上海德福伦化纤有限公司
	中空阻燃聚酯纤维	中国石化仪征化纤有限责任公司
	皮芯复合导电聚酯纤维	江苏中杰澳新材料有限公司
功能纤维	抗紫外凉感聚酯纤维	浙江银瑜新材料股份有限公司
	凉感聚乙烯复合纤维	凯泰特种纤维科技有限公司
	细旦抑菌聚丙烯纤维	广东蒙泰高新纤维股份有限公司
	光谱蓄热纤维	中国石化仪征化纤有限责任公司 浙江恒逸石化有限公司 恒天中纤纺化无锡有限公司 上海安凸阻燃纤维有限公司
轻柔纤维	细旦高强聚酰胺 6 纤维	福建凯邦锦纶科技有限公司
	细旦（异形）循环再生聚酯纤维	江苏永银化纤有限公司
	细旦循环再生聚酯纤维	苏州如盛化纤有限公司
生物基纤维	凉感聚乳酸纤维	恒天生物基材料工程技术（宁波）有限公司
	原液着色聚乳酸纤维	河南省龙都生物科技有限公司 上海德福伦化纤有限公司
	三维卷曲聚乳酸纤维	恒天长江生物材料有限公司
	牛角瓜纤维	上海魔树生物科技有限公司
原液着色纤维	原液着色竹材再生纤维素纤维	河北吉藁化纤有限责任公司
	抑菌原液着色聚酰胺 6 纤维	广东新会美达锦纶股份有限公司
	细旦原液着色细旦聚酰胺 6 纤维	义乌华鼎锦纶股份有限公司
	凝胶染色聚丙烯腈纤维	吉林奇峰化纤股份有限公司
	细旦凉感原液着色聚酯纤维	浙江金霞新材料科技有限公司
循环再生纤维	原液着色循环再生聚酯纤维	福建省长乐市立峰纺织有限公司
	循环再生聚酰胺 6 纤维	长乐恒申合纤科技有限公司
	蓬松保暖循环再生聚酯纤维	杭州海科纤维有限公司
智能纤维	温感变色再生纤维素纤维	新乡化纤股份有限公司
	相变调温聚丙烯腈纤维	北京宇田相变储能科技有限公司 中国石油大庆石化公司腈纶厂
	相变调温聚丙烯纤维	北京宇田相变储能科技有限公司 湖北博韬化纤有限公司

SHENGHONG · CHINA FIBERS FASHION TRENDS 2018/2019 RECOMMEND PRODUCTS

Cateoory	Product name	Company
Industrial Fiber	Dope Dyed Ultraviolet-Resistant High-strength Polyamide 6 Fiber	Jiangsu Haiyang Chemical Fiber Co., Ltd.
	Flame Resistant Polypropylene Fiber Used for Carpet	Zhejiang Sitong Chemical Fiber Co., Ltd.
Elastic Fiber	Low-temperature Heat-bonded Spandex	LDZ New Aoshen Spandex Co., Ltd.
	Ultraviolet Resistant Spandex	Zhejiang Huafeng Spandex Co., Ltd.
Imitated Fiber	Linen-like Polyester Fiber	Xiamen Xianglu Chemical Fiber Co., Ltd.
	Bamboo Joint Controlled Polyester Fiber	Tongkun Group Zhejiang Hengsheng Chemical Fiber Co, Ltd. Jiaxing Shengbang Technology Co., Ltd.
Safety Protection Fiber	Functional Antiflaming Molten Drop Resistant Polyester Fiber	Shanghai Different Chemical Fiber Co., Ltd.
	Hollow Antiflaming Polyester Fiber	Sinopec Yizheng Chemical Fiber Co., Ltd.
	Core-sheath Conductive Polyester Fiber	Jiangsu ZJA New Materials Co., Ltd.
Functional Fiber	Anti-ultraviolet Cool-feel Polyester Fiber	Zhejiang Yinyu New Materials Co., Ltd.
	Cool-feel Polyethylene Complex Fiber	Kaitai Special Fiber Technology Co., Ltd.
	Fine Denier Anti-bacteria Polypropylene Fiber	Guangdong Modern High-tech Fiber Co., Ltd.
	Spectrum Thermal Storage Fiber	Sinopec Yizheng Chemical Fiber Co., Ltd. Zhejiang Hengyi Petrochemical Co., Ltd. CHTC Sino Fiber Wuxi Co., Ltd. Shanghai Antu Antiflaming Co., Ltd.
Soft Fiber	Fine Denier High-strength Polyamide 6 Fiber	Fujian KaiBang Polyamide Technology Co.,Ltd.
	Fine Denier (shaped) Recycled Polyester Fiber	Jiangsu Yongyin chemical Fiber Co., Ltd.
	Fine Denier Recycled Polyester Fiber	Suzhou Rusheng Chemical Fiber Co., Ltd.
Bio-based Fiber	Cool-feel Polylactic Acid Fiber	Hengtian Bio-based Materials Engineering Technology (Ningbo) Co., Ltd.
	Dope Dyed Polylactic Acid Fiber	Henan Longdu Biotechnology Co., Ltd Shanghai Different Chemical Fiber Co., Ltd.
	Three-dimensional Crimp Polylactic Acid Fiber	Hengtian Changjiang Biomaterial Co., Ltd.
	Mudar Fiber	Shanghai Mushu Biotechnology Co., Ltd.
Dope Dyed Fiber	Dope Dyed Bamboo Cellulose Fiber	Hebei Jigao Chemical Fiber Co., Ltd.
	Anti-bacteria Dope Dyed Polyamide 6 Fiber	Guangdong Xinhui Meida Nylon Co., Ltd.
	Fine Denier Dope Dyed Polyamide 6 Fiber	Yiwu Huading Nylon Co.,Ltd.
	Gel Dyeing Polyacrylonitrile Fiber	Jilin Qifeng Chemical Fiber Co., Ltd.
	Fine Denier Cool-feel Dope Dyed Polyester Fiber	Zhejiang Jinxia New Materials Technology Co., Ltd.
Recycled Fiber	Dope Dyed Recycled Polyester Fiber	Fujian Changle Lifeng Textile Co., Ltd.
	Recycled Polyamide 6 Fiber	Changle Highsun Synthetic Fiber Technologies Co., Ltd.
	Fluffy Heating Recycled Polyester Fiber	Hangzhou Haike Fiber Co., Ltd.
Smart Fiber	Temperature-sense Discoloring Cellulose Fiber	Xinxiang Chemical Fiber Co., Ltd.
	Phase Change Thermoregulation Polyacrylonitrile Fiber	Beijing Yutian Phase Change Energy Storage Technology Co., Ltd. Daqing Acrylic Plant
	Phase Change Thermoregulation Polypropylene Fiber	Beijing Yutian Phase Change Energy Storage Technology Co., Ltd. Hubei Botao Chemical Fiber Co., Ltd.

中国纤维流行趋势
2018 最佳下游合作伙伴

绿色纤维组

三六一度（中国）有限公司

吴江市豫震纺织有限公司

鲁丰织染有限公司

杭州海嘉布艺有限公司

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