Recent Developments in High Performance Fibers

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Glass Fiber: Types, Properties, Manufacturing Process and Uses 玻璃纤维：类型、特性、制造工艺和用途

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Introduction of Glass Fiber:玻璃纤维介绍： Glass is a non-metallic fiber, widely used as industrial material these days. The art of spinning glass yarns to make fabrics is very old, dating back to 1713. In 1893, a glass dress made for the Broadway actress, Georgia Cayvan, which was exhibited at the World's Columbian Exposition in Chicago, was made from bundles of spun glass fiber held together by silk threads. However, the fabric was too cumbersome to be worn because it was too stiff to drape. The base ingredients of glass fibers are forms of silica, mainly sand, limestone, stone ash and borax.玻璃是一种非金属纤维，如今被广泛用作工业材料。纺玻璃纱制作织物的艺术非常古老，可以追溯到 1713 年。1893 年，为百老汇女演员乔治亚·凯万 （Georgia Cayvan） 制作的玻璃裙子在芝加哥世界哥伦比亚博览会上展出，该裙子是由丝线固定在一起的玻璃纤维束制成的。然而，这种面料太笨重了，不能穿，因为它太硬了，无法悬垂。玻璃纤维的基本成分是二氧化硅的形式，主要是沙子、石灰石、石灰和硼砂。

Fig: Glass fiber (chopped strands)图：玻璃纤维（短切的股线）

Glass fiber also called fiberglass. It is material made from extremely fine fibers of glass. Fiberglass is a lightweight, extremely strong, and robust material. Although strength properties are somewhat lower than **carbon fiber** and it is less stiff, the material is typically far less brittle, and the raw materials are much less expensive. Its bulk strength and weight properties are also very favorable when compared to metals,

and it can be easily formed using molding processes. Glass is the oldest, and most familiar, performance fiber. Fibers have been manufactured from glass since the 1930s. Glass fiber products are categorized into four major groups; chopped strands, direct draw rovings, assembled rovings, and mat products 玻璃纤维也称为玻璃纤维。它由极细的玻璃纤维制成。玻璃纤维是一种重量轻、非常坚固且坚固的材料。尽管强度特性略低于碳纤维并且刚度较低，但该材料通常要轻得多，而且原材料也便宜得多。与金属相比，它的体积强度和重量特性也非常有利，并且可以使用成型工艺轻松成型。玻璃是最古老、最熟悉的高性能纤维。自 1930 年代以来，纤维一直由玻璃制成。玻璃纤维产品分为四大类;短切股线、直接拉伸粗纱、组装粗纱和垫子产品

Types of Glass Fiber: 玻璃纤维的种类：As to the raw material glass used to make glass fibers or nonwovens of glass fibers, the following classification is known: 至于用于制造玻璃纤维或玻璃纤维无纺布的原材料玻璃，已知以下分类：

1. A-glass: With regard to its composition, it is close to window glass. In the Federal Republic of Germany it is mainly used in the manufacture of process equipment.**1. A 玻璃：**就其成分而言，它与窗户玻璃接近。在德意志联邦共和国，它主要用于制造工艺设备。

2. C-glass: This kind of glass shows better resistance to chemical impact.**2. C 型玻璃：**这种玻璃表现出更好的耐化学冲击性。

3.D- Glass: An important type of glass fiber is D-type glass fiber. Boron contains the trioxide compound intensively. Boron trioxide is used as a starting material for the synthesis of other boron compounds such as boron carbide in the production of fluids for glass and enamels, and in the production of heat resistance and thermal shock resistance borosilicate glasses.**3.D- 玻璃：** 一种重要的玻璃纤维类型是 D 型玻璃纤维。硼含有大量的三氧化物化合物。三氧化二硼用作合成其他硼化合物（如碳化硼）的起始原料，用于生产玻璃和搪瓷流体，以及生产耐热性和抗热震性硼硅酸盐玻璃。

4. E-glass: This kind of glass combines the characteristics of C-glass with very good insulation to electricity. E-glass is basically a calcium alumino-borosilicate glass containing less than 1% alkali calculated as Na_2O.**4. 无碱玻璃：**这种玻璃结合了 C 玻璃的特性，具有非常好的电绝缘性。无碱玻璃基本上是一种铝硼硅酸钙玻璃，碱含量低于 1%，计算为 Na_2O。

5. AE-glass: Alkali resistant glass.**5. AE 玻璃：**耐碱玻璃。

6. ECR-glass: It is also called electronic glass fiber. It has a good waterproofing ratio, high mechanical strength, electrical acidic and alkali corrosion resistance. It shows better properties than E-Type glass fiber. The biggest advantage is a more environmentally friendly glass fiber.**6. ECR-玻璃：**也称为电子玻璃纤维。具有良好的防水比、高机械强度、耐电酸碱腐蚀性能。它显示出比 E 型玻璃纤维更好的性能。最大的优点是更环保的玻璃纤维。

7. AR-glass: Alkali Resistant (AR: Alkali Resistant) Glass Fibers are specially designed for concrete construction. They contain alkaline zirconium silicates. They are effective to prevent concrete cracking. This adds strength and flexibility to concrete. They are also used for asbestos changes. They have alkali strength and strength. It is very difficult to dissolve in water. Not affected by pH changes. They are

easily added to stainless steel and concrete mixtures. Intensive Magnesium and Calcium added fibers. Ideal for applications with high acidic strength and mechanical strength.**7. AR 玻璃：**耐碱（AR：耐碱）玻璃纤维专为混凝土施工而设计。它们含有碱性硅酸锆。它们可有效防止混凝土开裂。这增加了混凝土的强度和柔韧性。它们也用于石棉更换。它们具有碱性强度和强度。很难溶于水。不受 pH 值变化的影响。它们很容易添加到不锈钢和混凝土混合物中。强化镁和钙添加纤维。非常适合具有高酸性强度和机械强度的应用。

R-glass, S-glass or T-glass fibers are trade names of equivalent fibers having better tensile strength and modulus than E-type glass fibers. Higher acidic strength and wetting properties are obtained with a smaller filament diameter.R-玻璃、S 玻璃或 T 型玻璃纤维是等效纤维的商品名，具有比 E 型玻璃纤维更好的拉伸强度和模量。较小的细丝直径可获得更高的酸强度和润湿性能。

You may also like: Glass Fiber Composites: Properties, Manufacturing and Applications 您可能还喜欢： 玻璃纤维复合材料：性能、制造和应用

Generally, glass consists of quartz sand, soda, sodium sulphate, potash, feldspar and a number of refining and dying additives. The characteristics, with them the classification of the glass fibers to be made, are defined by the combination of raw materials and their proportions. Textile glass fibers mostly show a circular.通常，玻璃由石英砂、苏打、硫酸钠、钾肥、长石和一些精炼和染色添加剂组成。特性，以及要制造的玻璃纤维的分类，由原材料的组合及其比例定义。纺织玻璃纤维大多呈圆形。

Physical and Mechanical Properties of Glass Fiber:玻璃纤维的物理和机械性能：Glass fibers are useful because of their high ratio of surface area to weight. However, the increased surface area makes them much more susceptible to chemical attack. By trapping air within them, blocks of glass fiber make good thermal insulation, with a thermal conductivity of the order of 0.05 W/(mK).玻璃纤维很有用，因为它们的表面积与重量之比很高。然而，增加的表面积使它们更容易受到化学攻击。通过将空气困在其中，玻璃纤维块具有良好的隔热效果，导热系数约为 0.05 W/（mK）。

Glass fibers have outstanding mechanical properties, such as less fragility, extreme strength, less stiffness, and lightweight. Some physical and mechanical properties of glass fibers are listed below table.玻璃纤维具有出色的机械性能，例如较小的脆性、极高的强度、较低的刚度和重量轻。下表列出了玻璃纤维的一些物理和机械性能。

Table: Different types of glass fibers and physical and mechanical properties
表：不同类型的玻璃纤维及其物理机械性能

Glass fiber type	Silicon dioxides (SiO_2) (%)	Density (g/cm^3)	Tensile strength (MPa)	Modulus (GPa)	Elongation at break (%)
A-type	63–72	2.44	3300	72	4.8
C-type	64–68	2.56	3300	69	4.8
D-type	72–75	2.11	2500	55	4.5
E-type	52–56	2.54	3448	72	4.7
R-type	56–60	2.52	4400	86	5.1
S-type	64–66	2.53	4600	89	5.2
ECR-type	54–62	2.72	3400	80	4.3
AR-type	55–75	2.7	1700	72	2.3

The strength of glass is usually tested and reported for "virgin" or pristine fibers those which have just been manufactured. The freshest, thinnest fibers are the strongest because the thinner fibers are more ductile. The more the surface is scratched, the less the resulting tenacity. Because glass has an amorphous structure, its properties are the same along the fiber and across the fiber. Humidity is an important factor in the tensile strength. Moisture is easily adsorbed, and can worsen microscopic cracks and surface defects, and lessen tenacity.玻璃的强度通常针对"原始"或原始纤维进行测试和报告，即刚刚制造的纤维。最新鲜、最细的纤维是最坚固的，因为较细的纤维更具延展性。表面被划伤的越多，产生的韧性就越小。由于玻璃具有无定形结构，因此其沿光纤和跨光纤的特性相同。湿度是抗拉强度的一个重要因素。水分很容易被吸附，会加剧微观裂纹和表面缺陷，并降低韧性。

In contrast to carbon fiber, glass can undergo more elongation before it breaks. There is a correlation between bending diameter of the filament and the filament diameter. The viscosity of the molten glass is very important for manufacturing success. During drawing (pulling of the glass to reduce fiber circumference), the viscosity should be relatively low. If it is too high, the fiber will break during drawing. However, if it is too low, the glass will form droplets rather than drawing out into fiber.与碳纤维相比，玻璃在断裂之前可以经历更多的伸长。细丝的弯曲直径与细丝直径之间存在相关性。熔融玻璃的粘度对于制造成功非常重要。在拉丝过程中（拉扯玻璃以减少纤维周长），粘度应相对较低。如果太高，纤维会在拉丝过程中断裂。但是，如果温度过低，玻璃会形成液滴，而不是吸出纤维。

Manufacturing Processes of Glass Fiber 玻璃纤维的制造工艺 Idea of manufacturing glass fiber and yarn is centuries old. The raw materials for glass are primarily silica sand and limestone, with small amount of other compounds such as aluminium hydroxide, sodium carbonate and borax. After the initial process of melting glass and passing it through spinnerets, continuous filaments or staple fibers of glass are manufactured by two different methods.制造玻璃纤维和纱线的想法已有数百年的历史。玻璃的原材料主要是硅砂和石灰石，还有少量其他化合物，如氢氧化铝、碳酸钠和硼砂。在熔化玻璃并通过喷丝头的初始过程之后，玻璃的连续细丝或短纤维通过两种不同的方法制造。

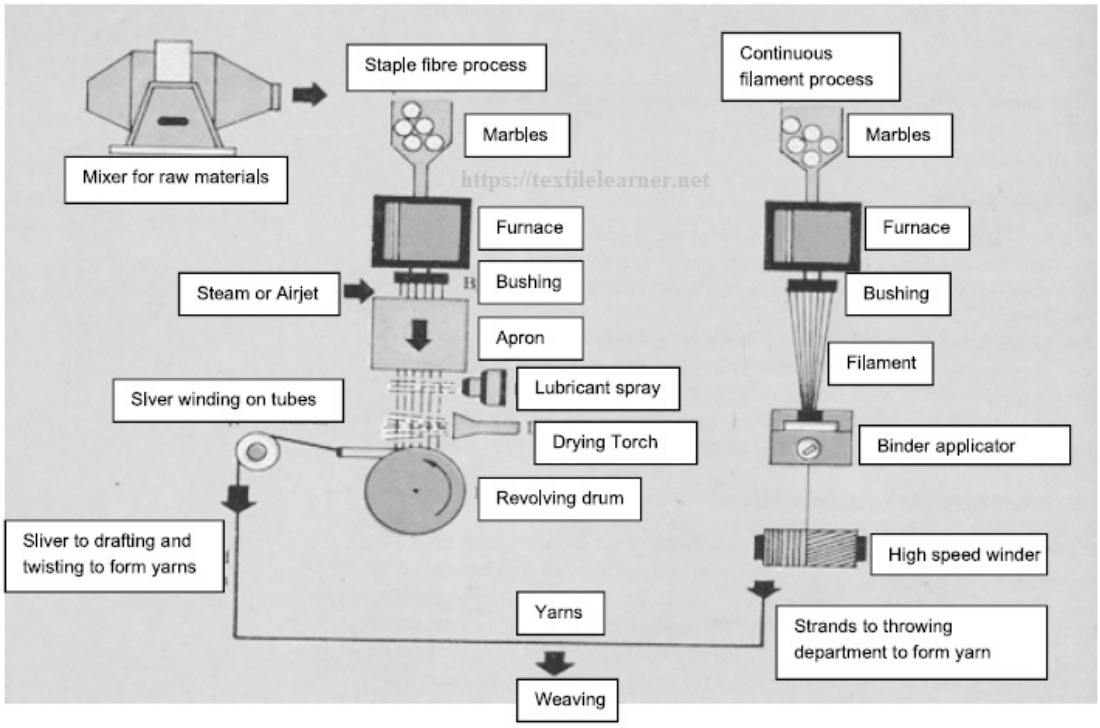

Fig: Flow diagram showing glass fiber manufacture

图：玻璃纤维制造的流程图

Continuous Filament Process 连续长丝工艺 In this process, continuous filaments of indefinite length is produced. The molten glass passes through spinnerets having hundreds of small openings. These strands of multiple filaments are carried to winder revolving at very high speed of more than 2 miles per km. This process draws out the fibers in parallel filaments of the diameter of the openings. A sizing or a binder is applied to facilitate the twisting and winding process and to prevent breakage during yarn formation. After winding, filaments are further twisted and plied to make yarns by methods similar to those for making other continuous filament yarns. The sizing is removed through volatizing in an oven. These yarns are used for making such items as curtains and drapes.在这个过程中，产生无限长的连续细丝。熔融玻璃穿过具有数百个小开口的喷丝头。这些多根细丝以每公里超过 2 英里的非常高的速度被带到卷绕机上。这个过程将纤维拉出与开口直径相同的平行细丝。施用上浆剂或粘合剂以促进加捻和卷绕过程，并防止纱线形成过程中断裂。卷绕后，长丝进一步加捻和捻合，以类似于制造其他连续长丝的方法制成纱线。通过在烘箱中挥发来去除浆料。这些纱线用于制作窗帘和窗帘等物品。

Staple Fiber Process 短纤维工艺 Fibers with long-staple qualities are manufactured through staple fiber process. There are many methods for producing such fibers.具有长绒品质的纤维是通过短纤维工艺制造的。生产这种纤维的方法有很多。

In one of such methods, the molten glass flows through the small holes of bushing, where jets of compressed air shake the thin streams of molten glass into fine fibers. These fibers vary in length ranging from 8 to 15 inches. The fibers fall through a spray of lubricant and a drying flame onto e revolving drum where they form into a

thin web. These fibers in the form of web are gathered from the drum into a sliver. Yarn is then made from this sliver by similar methods that are adopted for making cotton or wool yarns. These yarns are used for fabrics for industrial purposes where insulation is required.在其中一种方法中，熔融玻璃流经衬套的小孔，压缩空气射流将熔融玻璃的细流摇成细纤维。这些纤维的长度从 8 英寸到 15 英寸不等。纤维通过润滑剂喷雾和干燥火焰落到旋转的滚筒上，在那里它们形成薄网。这些网状的纤维从滚筒中聚集成条子。然后通过与制造棉纱或羊毛纱类似的方法用这种条子制成纱线。这些纱线用于需要绝缘的工业用途织物。

In yet another method, the ends of the glass rods are melted from which drops of glass fall away drawing off glass filaments after them onto a speedily revolving cylinder where they are wound parallel to each other. A web of sliver is formed if the cylinder moves sideways. Sometimes, the staple may be thrown off the cylinder onto a stationary sieve where it forms a sliver. In either conditions, the sliver is then converted into spun yarn.在另一种方法中，玻璃棒的末端被熔化，玻璃滴从中落下，随后从玻璃丝上吸出，落到一个快速旋转的圆柱体上，在那里它们彼此平行地缠绕。如果圆柱体侧向移动，则会形成一条条子腹板。有时，订书钉可能会从圆筒上甩到固定筛子上，在那里形成一条条子。在任何一种情况下，棉条都会转化为短纤纱。

The staple fiber, if subjected to oven, is compressed to the desired thickness and the binder which was earlier applied, is cured. This permanently binds the fibers.短纤维如果经过烘箱加热，则被压缩成所需的厚度，并且先前应用的粘合剂被固化。这会永久结合纤维。

Glass Fiber Production: 玻璃纤维生产：The subsequent manufacture of glass fibers may be executed to the direct melting process. However, in most cases glass rods or balls are made first which then may undergo a variety of further processes.玻璃纤维的后续制造可以执行直接熔化过程。然而，在大多数情况下，玻璃棒或玻璃球是先制造的，然后可能会经过各种进一步的加工。

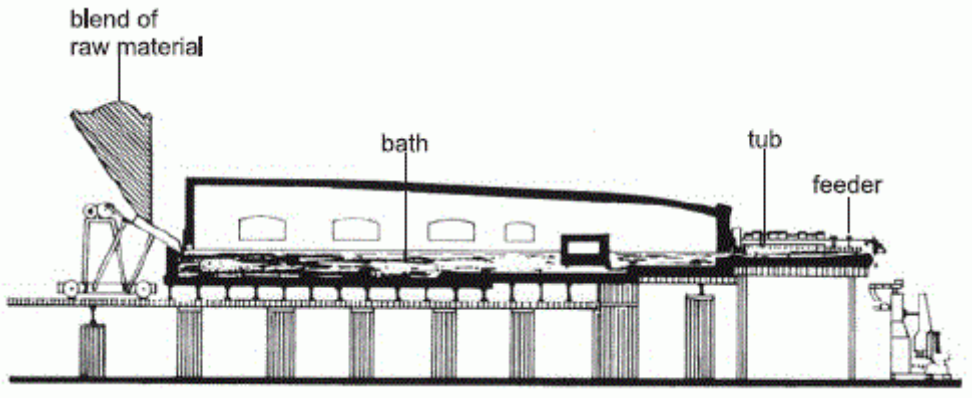

Fig: Manufacture of glass melt 图：玻璃熔体的制造

Nozzle-Drawing: 喷嘴拉拔：As can be seen in below Fig, the glass fed in is melted in a heated melt tub at 1250–1400ºC. Then, it emerges at the bottom of the melt tub from nozzle holes of 1–25 mm diameter and it is taken off and drawn. The filaments solidify and are finished and wound. One can find them in the shops as various kinds of “glass silk”. To make them into webs, the filaments are cut to length (mostly, between 6 and 25 mm).如下图所示，进料的玻璃在 1250-1400ºC 的加热

熔化桶中熔化。然后，它从直径为 1-25 mm 的喷嘴孔中从熔体桶底部出现，并被取出并拉出。细丝凝固并完成和缠绕。人们可以在商店里找到它们作为各种“玻璃丝”。为了将它们制成网，将细丝切成一定长度（通常在 6 到 25 毫米之间）。

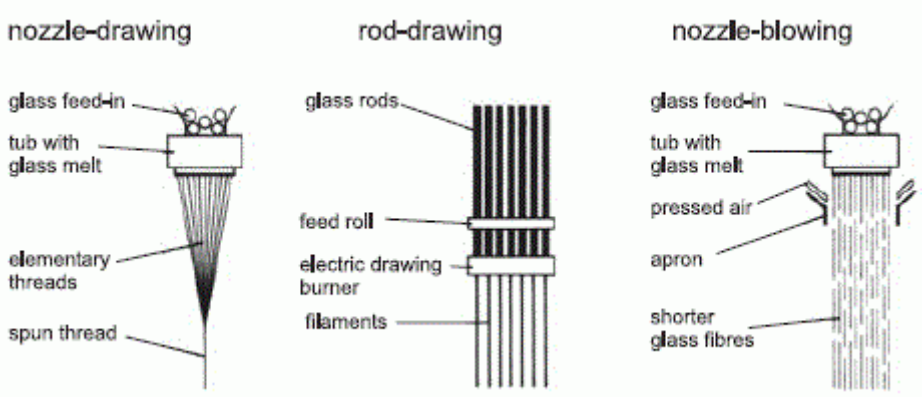

Fig: Processes to make glass fibers 图：制造玻璃纤维的工艺

Nozzle-Blowing: 喷嘴吹气：The same as with nozzle-drawing, glass balls are melted in the tub. The melt emerging from the nozzle holes is then taken by pressed air, which draws the liquid glass so as to make fibers of 6–10 um diameter. A fluttering effect is caused by the flow of pressed air, which results in fibers of lengths from 50 to 300 mm. A lubricant is put on and the fibers are laid down on a sieve drum which sucks them in. The dry web received is held together by the long fibers, the short ones lying in between them as a filling material. Then, the slivers of glass fiber material are cut.与喷嘴拉制相同，玻璃球在桶中熔化。然后从喷嘴孔中流出的熔体被压缩空气带走，压缩空气吸入液态玻璃，从而制成直径为 6-10 微米的纤维。颤振效应是由压缩空气的流动引起的，这导致纤维长度为 50 至 300 毫米。涂上润滑剂，将纤维放在筛筒上，筛筒将它们吸入。接收到的干网由长纤维固定在一起，短纤维作为填充材料位于它们之间。然后，切割玻璃纤维材料的条子。

Rod-Drawing: 拉杆：By means of a burner, bundles of glass rods are melted at their bottom ends. This results in drops which, as they fall down, draw filaments after them. The filaments are taken by a rotating drum, a squeegee laying them down onto a perforated belt. Thus, a dry web is received which can be wound as glass fiber slivers. – Machine performance being limited by the number of glass rods fed in, the rotating drum may be combined with nozzle-drawing, which results in drum-drawing. This multiplies machine performance. The dry web is again laid down onto a perforated belt and solidified or, after winding it so as to receive slivers, cut for further processing on machines producing **wetlaid nonwovens**. Using and processing glass fibers is not without any problems. For example, fine pieces of broken fibers may disturb if the work place is not well prepared for the purpose. Using the nonwovens to manufacture glass-fiber reinforced plastics, it is important the surface of the plastic material is fully even. Ends of fiber looking out may be pulled out or loosened by outward stress (temperature, gases, liquids), which may influence material characteristics. In some cases, it is advisable to cover up such layers of glass fiber with suitable chemical fibers.通过燃烧器，成束的玻璃棒在其底端熔化。这导致液滴落下时，会在它们后面拉出细丝。细丝由旋转的滚筒带走，刮刀将它

们放在多孔带上。因此，可以接收到可以缠绕为玻璃纤维条的干网。– 机器性能受进料玻璃棒数量的限制，旋转滚筒可能与喷嘴拉拔相结合，从而导致滚筒拉出。这将使机器性能成倍增加。干纤网再次铺设在多孔带上并凝固，或者在缠绕后接受条子，切割以便在生产湿法无纺布的机器上进行进一步加工。使用和加工玻璃纤维并非没有问题。例如，如果工作场所没有为此目的做好充分准备，细小的断裂纤维可能会造成干扰。使用无纺布制造玻璃纤维增强塑料时，塑料材料的表面必须完全均匀。向外的纤维末端可能会因向外应力（温度、气体、液体）而拉出或松动，这可能会影响材料特性。在某些情况下，建议用合适的化学纤维覆盖这些玻璃纤维层。

Application / End Uses of Glass Fiber and Yarn:玻璃纤维和纱线的应用/最终用途：Glass fibers are used in a number of applications which can be divided into four basic categories: (a) insulations, (b) filtration media, (c) reinforcements, and (d) optical fibers.玻璃纤维用于多种应用，可分为四个基本类别：（a） 绝缘，（b） 过滤介质，（c） 增强材料和 （d） 光纤。

Glass fiber is manufactured in a wide range of fine diameters. Some of them are so fine that they can be seen only through a microscope. This quality of fineness contributes greatly to the flexibility of glass fibers. Various manufacturers produce different types of glass fibers for different end uses. Glass fibers them are used for various purpose.玻璃纤维的制造范围很广。其中一些非常精细，只能通过显微镜看到。这种细度质量对玻璃纤维的柔韧性有很大帮助。不同的制造商为不同的最终用途生产不同类型的玻璃纤维。玻璃纤维 它们用于各种目的。

- For making home furnishings fabrics;用于制作家居用品面料;
- For making apparels and garments; and 用于制作服装和服装;和
- For the purpose tires and reinforced plastics.用于轮胎和增强塑料。

There are certain glass fibers that can resist heat upto 7200ºC and can withstand forces having speed of 15,000 miles per hour. These types of glass fibers are used as: 有些玻璃纤维可以抵抗高达 7200ºC 的热量，并且可以承受每小时 15,000 英里的速度。这些类型的玻璃纤维用作：

- Filament windings around rocket cases;火箭外壳周围的细丝缠绕;
- Nose cones; 鼻锥;
- Exhaust nozzles; and 排气喷嘴;和
- Heat shields for aeronautical equipment 航空设备用隔热板

Some other types of glass fibers are embedded into various plastics for strength. These are used in:一些其他类型的玻璃纤维被嵌入各种塑料中以提高强度。这些用于：

- Boat hulls and seats; 船体和座椅;
- Fishing rods; and 钓鱼竿;和
- Wall paneling 墙板

Some other types of glass fibers are used for reinforcing electrical insulation. Yet other types are used as batting for heat insulation in refrigerators and stoves. Glass fiber is also used in furnishings (such as upholstery and curtains); insulation, conveyor belts, circuit boards, protective clothing for military troops, ropes and meshes in shipbuilding and aircraft construction.一些其他类型的玻璃纤维用于增强电绝缘。还有其他类型的用作冰箱和炉灶隔热的棉絮。玻璃纤维也用于家具

（如室内装潢和窗帘）;绝缘材料、传送带、电路板、军队的防护服、造船和飞机制造中的绳索和网。

Conclusion: 结论：Using glass fiber as a reinforcing agent in the composite industry shows a big trend since the price of the glass fiber is low in comparison to carbon fiber or **Kevlar**. For general-purpose application E-glass is seen to be a best choice and also for high technology applications various types of glass fiber like S glass or ECR glasses were introduced to the market. Glass fiber products have the advantages that it can be used either in the traditional composite manufacturing processes (hand layup) or it can be used in high technology composite manufacturing techniques like RTM.在复合材料工业中使用玻璃纤维作为增强剂是一个很大的趋势，因为与碳纤维或凯夫拉纤维相比，玻璃纤维的价格较低。对于通用应用，无碱玻璃被视为最佳选择，对于高科技应用，各种类型的玻璃纤维（如 S 玻璃或 ECR 玻璃）被引入市场。玻璃纤维产品的优点是，它既可以用于传统的复合材料制造工艺（手糊），也可以用于 RTM 等高科技复合材料制造技术。

In the transportation and automotive industries the idea of lightweight vehicles is the driving force for **glass fiber composite** manufacturers and according to the demand of customers glass fiber is widely used since it fulfills the composite market needs by considering low cost and availability in the glass fiber market. By looking at the growth of light vehicle sales to about 50% from 2010 to 2015, increasing the glass fiber production can also be considered.在运输和汽车行业，轻量化汽车的理念是玻璃纤维复合材料制造商的驱动力，根据客户的需求，玻璃纤维被广泛使用，因为它通过考虑玻璃纤维市场的低成本和可用性来满足复合材料市场需求。从 2010 年到 2015 年轻型车销量增长到 50% 左右，也可以考虑增加玻璃纤维产量。

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2. 碳纤维：性能、分类、制造和用途

Carbon Fiber: Properties, Classification, Manufacturing and Uses

Carbon Fiber: Properties, Classification, Manufacturing and Uses 碳纤维：性能、分类、制造和用途

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Manufacturing Process of Carbon Fiber 碳纤维的制造工艺

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What is Carbon Fiber?A carbon fiber is a long, thin strand about 5–10 μm in diameter and composed mostly of carbon atoms. It is also called graphite fiber or carbon graphite, carbon fiber consists of very thin strands of the element carbon. It is a **high performance fiber**. Carbon fibers are manufactured from two pre cursors known as PAN (poly acrylonitrile) and pitch or any other organic base fibers. The carbon atoms are bonded together in microscopic crystals that are more or less aligned parallel to the axis of the fiber. This crystal alignment makes the fiber incredibly strong. Several thousand carbon fibers are joined together to form a yarn.**什么是碳纤维？** 碳纤维是直径约 5-10 μm 的细长股，主要由碳原子组成。它也被称为石墨纤维或碳石墨，碳纤维由非常细的碳元素链组成。它是一种高性能纤维。碳纤维由两种前驱体制成，称为 PAN（聚丙烯腈）和沥青或任何其他有机基础纤维。碳原子在微观晶体中键合在一起，这些晶体或多或少平行于纤维的轴线排列。这种晶体排列使纤维非常坚固。数千根碳纤维连接在一起形成纱线。

Fig: Carbon fiber 图：碳纤维

Properties of Carbon Fiber: Carbon fibers properties rely on the process utilized for its production, the raw material, and the specific production process. Carbon fibers are popular as the most efficient lightweight material to use as alternative to conventional metals for numerous structural uses. It is a lightweight, strong, and durable material that is made from carbon atoms. Here are some of its key properties:**碳纤维的特性：**碳纤维的性能取决于用于其生产的过程、原材料和特定的生产过程。碳纤维作为最有效的轻质材料而广受欢迎，可用作传统金属的替代品，用于多种结构用途。它是一种由碳原子制成的轻质、坚固且耐用的材料。以下是它的一些关键属性：

- Carbon fibre plates are thin, strong and flexible, they can be designed and installed to provide a cost effective solution which does not detract visually from the original design of the structure.碳纤维板薄、结实且灵活，它们的设计和安装可以提供具有成本效益的解决方案，而不会在视觉上减损结构的原始设计。
- It has high stiffness, high tensile strength, low weight, high chemical resistance, high temperature tolerance and one of the most popular materials in civil engineering.它具有高刚度、高抗拉强度、低重量、高耐化学性、耐高温性，是土木工程中最受欢迎的材料之一。

Here is a table summarizing some of the key properties of carbon fibre:下表总结了碳纤维的一些关键特性：

Property 财产	Description 描述
Density 密度	1.75 – 1.95 g/cm³ 1.75 – 1.95 克/立方厘米

Property 财产	Description 描述
Tensile strength 抗张强度	600 – 7000 MPa 600 – 7000 兆帕
Young's modulus 杨氏模量	230 – 850 GPa 230 – 850 加仑
Stiffness 刚度	Very stiff 非常僵硬
Thermal expansion 热膨胀	Low coefficient of thermal expansion 低热膨胀系数
Corrosion resistance 耐腐蚀性	Highly resistant to corrosion 高度耐腐蚀
Electrical conductivity 电导率	Good conductor of electricity 良好的电导体
Fatigue resistance 抗疲劳性	Good resistance to repeated loading cycles 良好的抗重复加载循环能力
Aesthetic appeal 美学吸引力	Unique look and texture that many people find appealing 独特的外观和质地，许多人觉得很吸引人

Classification of Carbon Fiber: At present, carbon fiber has the rapid development, and there are many types of carbon fiber production at home and abroad. Generally, they can be classified by the type of fiber precursor, carbon fibre property and purpose.**碳纤维的分类：**目前，碳纤维发展迅速，国内外碳纤维生产种类众多。通常，它们可以按纤维前驱体的类型、碳纤维特性和用途进行分类。

a) Classification according to the type of precursor fiber materialsa） 按原丝纤维材料的类型分类

1. PAN-based carbon fibre; 基于 PAN 的碳纤维;
2. Pitch-based carbon fibre;基于沥青的碳纤维;
3. Rayon-based carbon fibre;人造丝基碳纤维;
4. Vapor-grown carbon fibre.气相生长的碳纤维。

b) Classification of carbon fiber according to different manufacture methodsb）根据不同的制造方法对碳纤维进行分类

1. Carbon fiber (800~1600°C),碳纤维 （800~1600°C），
2. Graphite fibers (2000~3000°C),石墨纤维 （2000~3000°C），
3. Oxidative fibers (preoxidation fiber at 200~300°C), 氧化纤维（200~300°C 的预氧化纤维），
4. Activated carbon fibre and 活性碳纤维和
5. Vaporgrown carbon fibre. 气相碳纤维。

c) Classification of carbon fibre according to mechanical propertiesc） 根据机械性能对碳纤维进行分类

1. General grade carbon fibre (GP) and 通用级碳纤维 （GP） 和

2. High performance carbon fibre (HP)高性能碳纤维 （HP）

d) Classification of carbon fibre according to the functiond） 根据功能对碳纤维进行分类 It includes: 它包括：

1. Load structure using carbon fibre;使用碳纤维的负载结构;
2. Flame resistant (fire) carbon fibre 阻燃（Fire）碳纤维
3. Activated carbon fibre (adsorption activity);活性炭纤维（吸附活性）;
4. Conductive carbon fibre; 导电碳纤维;
5. Carbon fiber used for lubrication;用于润滑的碳纤维;
6. Wear-resistant carbon fibre;耐磨碳纤维;
7. Corrosion resistant carbon fibre.耐腐蚀碳纤维。

e) Classification of carbon fibre according to application fielde） 按应用领域分类碳纤维

Manufacturing Process of Carbon Fiber 碳纤维的制造工艺 Carbon fiber can be manufactured from PAN and PITCH. These processes are described below.碳纤维可以由 PAN 和 PITCH 制造。这些过程如下所述。

FROM PAN: 来自 PAN： A typical process used to manufacturing of carbon fiber from PAN includes spinning, stabilization, carbonizing, surface treating, and sizing.用于从 PAN 制造碳纤维的典型工艺包括纺丝、稳定、碳化、表面处理和上浆。

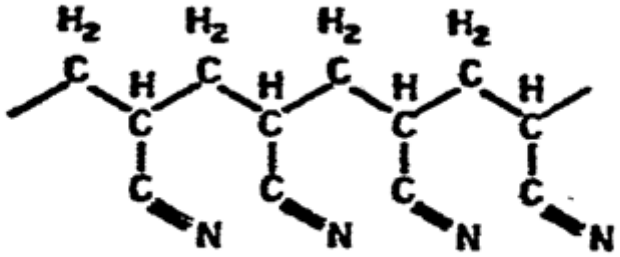

Fig: Structure of carbon fiber 图：碳纤维的结构

1. PAN contains highly polar C-N groups that are randomly arranged on either side of the chain.1. PAN 包含随机排列在链两侧的高极性 C-N 基团。

2. Carbon filaments are wet spun from a solution of PAN and stretched at an elevated temperature during which the polymer chains are aligned in the filament direction. Then the filament are heated at 200 to 300^0C for a few hours.2. 碳丝是从 PAN 溶液中湿纺并在高温下拉伸的，在此期间聚合物链沿长丝方向排列。然后将细丝在 200 至 300^0C 下加热几个小时。

3. At this stage the C-N groups located on the same side combine to form a more stable and rigid ladder like structure and some of the CH_2 groups are oxidized.3. 在这个阶段，位于同一侧的 C-N 基团结合形成更稳定和刚性的梯状结构，并且一些 CH_2 基团被氧化。

4. In the next stage the PAN filaments are carbonized by heating at a controlled rate between 1000 to 2000^0C in an inert atmosphere.4. 在下一阶段，通过在惰性气氛中以 1000 至 2000^0C 之间的受控速率加热，使 PAN 细丝碳化。

5. Tension is maintained on the filament to prevent shrinkage and to improve molecular orientation.5. 保持细丝的张力，以防止收缩并改善分子取向。

6. Subsequently the carbonized filaments are heated above 2000^0C, where their structures becomes more oriented and turns towards a true graphite form with increasing heat treatment temperature.6. 随后，碳化细丝被加热到 2000^0C 以上，随着热处理温度的升高，它们的结构变得更加定向并转向真正的石墨形式。

7. At this stage the graphitized filaments attain a high tensile modulus, but their tensile strength may be relatively low.7. 在这个阶段，石墨化细丝达到高拉伸模量，但它们的拉伸强度可能相对较低。

8. Tensile strength can be increased by hot stretching above 2000^0C.8. 2000^0C 以上的热拉伸可以提高拉伸强度。

FROM PITCH: 来自 PITCH：

1. Pitch is a byproduct of petroleum refining, and is a lower cost raw material than PAN.1. 沥青是石油精炼的副产品，是比 PAN 成本更低的原料。

2. The carbon atoms in pitch are arranged in low molecular weight aromatic ring patterns.2. 沥青中的碳原子排列成低分子量芳香环图案。

3. Heating to temperature above 300°C polymerizes these molecules into long two dimensional sheet like structure.3. 加热到 300°C 以上的温度将这些分子聚合成长二维片状结构。

4. The highly viscose state of pitch at this stage is called mesophase.4. 这个阶段沥青的高粘胶状态称为中间期。

5. Pitch filaments are produced by melt spinning the mesophase pitch through a spinneret.5. 沥青丝是通过喷丝头熔融纺丝将中间相沥青制成的。

6. The filaments are cooled to freeze the molecular orientation and then heated between 200 to 300°C in oxygen atmosphere to stabilize them and make them infusible.6. 将细丝冷却以冻结分子取向，然后在氧气气氛中加热 200 至 300°C 以稳定它们并使它们不熔。

7. In the next step the filaments are carbonized at 2000°C.7. 下一步，细丝在 2000°C 下碳化。

8. Rest of process of transferring the structure to graphitic form is similar to that followed for PAN precautions.8. 将结构转化为石墨形式的其余过程类似于 PAN 预防措施所遵循的过程。

	US Units	SI Units
Tensile Strength	600 Ksi	4137 MPa
Tensile Modulus	35 Msi	242 GPa
Elongation	1.5%	
Density	0.065 lb/in^3	1.81 g/cc
Fiber Diameter	0.283 mils	7.2 microns
Carbon Content	95%	
Yield	400 ft/lb	270 m/kg

Fig: Standard Carbon Fiber Properties 图：标准碳纤维特性

Uses of Carbon Fiber: 碳纤维的用途：The carbon fibers are an important part of many products, and new applications are being developed every year. Carbon fibre-reinforced composite materials are used in the automotive and aerospace industry, sports and many other components where light weight and high strength are needed. Carbon fibers have high electric conductivity (volumetric impedance) and at the same time have excellent EMI shielding property. This successfully brings CFRP (Carbon fiber reinforced plastics) to the field of EMI shielding. Carbon fibers have low heat expansion ratio and high dimensional stability, and sustains its mechanical performances even under high temperature region. CFRP is superior to steel or glass fiber reinforced plastics (GFRP) in its specific tensile strength and specific elastic modulus (specific rigidity). Fatigue resistance of Carbon fiber surpasses that of other structural material. Carbon fibers are used in the following fields: Aerospace industry, sporting goods, **automobiles**, wind turbine blades, military, medical applications and many more fields.碳纤维是许多产品的重要组成部分，每年都有新的应用被开发出来。碳纤维增强复合材料用于汽车和航空航天工业、运动和许多其他需要轻量化和高强度的部件。碳纤维具有高导电性（体积阻抗），同时具有优异的 EMI 屏蔽性能。这成功地将 CFRP（碳纤维增强塑料）带入了 EMI 屏蔽领域。碳纤维具有低热膨胀率和高尺寸稳定性，即使在高温区域也能保持其机械性能。CFRP 在比拉伸强度和比弹性模量（比刚度）方面优于钢或玻璃纤维增强塑料（GFRP）。碳纤维的抗疲劳性优于其他结构材料。碳纤维用于以下领域：航空航天工业、体育用品、汽车、风力涡轮机叶片、军事、医疗应用等等。

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3. 矿物纤维的特性、类型和用途

Mineral Fiber Properties, Types and Uses 矿物纤维的特性、类型和用途

October 31, 2022 by Mazharul Islam Kiron 十月 31， 2022by Mazharul Islam Kiron

What is Mineral Fiber? 什么是矿物纤维？Mineral fiber is a generic term for all non-metallic inorganic fibers. Mineral fibers are derived from inorganic natural sources. Mineral fibers are of less importance in the textile trade. Glass and asbestos are the most commonly used mineral natural fibers. But the most important and useful fiber material among the mineral fibers is asbestos (AS). Asbestos occurs naturally as fiber. A synthetic mineral fiber known as rock wool or slag wool is produced by blowing air or steam through molten rock or slag. It is soft and flexible and good insulator of electricity, heat, and corrosion. Mineral fibers are used as fillers in fireproofing and thermal insulation materials.矿物纤维是所有非金属无机纤维的总称。矿物纤维来自无机天然来源。矿物纤维在纺织品贸易中的重要性较低。玻璃和石棉是最常用的矿物天然纤维。但矿物纤维中最重要和最有用的纤维材料是石棉 （AS）。石棉天然以纤维形式存在。一种称为岩棉或矿渣棉的合成矿物纤维是通过吹空气或蒸汽穿过熔融岩石或矿渣而制成的。它柔软有弹性，具有良好的电、热和腐蚀绝缘体。矿物纤维用作防火和隔热材料的填料。

Properties of Mineral Fibers:矿物纤维的特性：Mineral fibers generally have a high thermal performance, are combustible and are relatively impermeable. The primary useful physical properties of mineral fibers are its outstanding thermal stability and very high tensile strength. It can melt, but only at 1450°-1500°C (2580°-

2670°F), the temperature of lava in a volcano. Its tensile strength surpasses that of steel. Properties / Characteristics of mineral fibers are point out below.矿物纤维通常具有较高的热性能，可燃且相对不透水。矿物纤维的主要有用物理特性是其出色的热稳定性和非常高的拉伸强度。它可以融化，但只能在 1450°-1500°C（2580°-2670°F） 的温度下熔化，这是火山中熔岩的温度。其抗拉强度超过钢。矿物纤维的特性/特性如下。

1. Mineral fiber has good insulations properties 矿物纤维具有良好的绝缘性能
2. It has good fireproofing properties used in clothing, conveyor belts. 具有良好的防火性能，用于服装、输送带。
3. It has good soundproofing properties.它具有良好的隔音性能。
4. It is also acid-proof, and rust-proof.它还具有防酸和防锈功能。
5. It has low electrical and thermal conductivity.它具有低导电性和导热性。
6. It does not deteriorate in normal usage,它在正常使用中不会变质，
7. It is not attacked by insects or microorganisms,它不受昆虫或微生物的攻击，
8. It is used in brake linings, gaskets, industrial packing, electrical windings,它用于制动衬片、垫片、工业包装、电气绕组、
9. It is a fibrous form of silicate of magnesium and calcium-containing iron and aluminum and other minerals 它是硅酸盐的纤维状，由镁和含钙的铁和铝以及其他矿物组成
10. It has been a serious health hazard and removed from the textiles market.它已经严重危害了健康，并被从纺织品市场上撤下。

Types / Classification of Mineral Fiber:矿物纤维的种类/分类： Natural fibers are mainly classified as **vegetable fibers**, animal fibers, and mineral fibers depending on the origin. According to the International Mineralogical Association and the French Agency for Environmental and Occupational Health Safety (AFSSET), mineral fiber is obtained by melting and then fibrating various minerals. There are two types of mineral fiber:天然纤维根据来源主要分为植物纤维、动物纤维和矿物纤维。根据国际矿物学协会和法国环境和职业健康安全局 （AFSSET） 的说法，矿物纤维是通过熔化然后分解各种矿物获得的。矿物纤维有两种类型：

The ones that come directly from rocks in the form of fiber. Asbestos is the only mineral fiber that is natural. Asbestos, wollastonite, and sepiolite are natural mineral fibers.那些以纤维形式直接来自岩石的物质。石棉是唯一天然的矿物纤维。石棉、硅灰石和海泡石是天然矿物纤维。

Other ones are artificially produced from minerals. These fibers are classified into three categories: vitreous fibers (**glass fiber**, glass wool, rock and basalt fiber, slag wool, refractory ceramic fibers), crystalline fibers (alumina fiber, potassium titanate fiber, and **carbon fiber**), and metallic fibers (steel wool, stainless wool, copper wool).其他的是由矿物人工生产的。这些纤维分为玻璃纤维（玻璃纤维、玻璃棉、岩石和玄武岩纤维、渣棉、耐火陶瓷纤维）、结晶纤维（氧化铝纤维、钛酸钾纤维和碳纤维）和金属纤维（钢丝绒、不锈钢丝绒、铜棉）。

In this article I will discuss important types of mineral fibers.在本文中，我将讨

论矿物纤维的重要类型。

Asbestos Fiber: 石棉纤维：Asbestos fiber is the only naturally occurring mineral fiber-like serpentine, amphiboles, and anthophyllite. Asbestos is recovered from the rocks which have crystallized in the fibrous form. Asbestos fiber had been used as early as 2500 years ago. Asbestos was renowned for its resistance to fire and used in buildings for fire protection. It also limits electrical and chemical damage.石棉纤维是唯一天然存在的矿物纤维状蛇纹石、角闪石和直闪石。石棉是从结晶为纤维状的岩石中回收的。石棉纤维早在 2500 年前就已使用。石棉以其耐火性而闻名，并用于建筑物的防火。它还限制了电气和化学损伤。

Traditionally, the hard mats on ironing boards were made from asbestos, but today, they are made from a man-made material. The largest mining areas can be found in Russia (46% market share), China and Kazakhstan (16% each), Brazil (10%), and Canada (8%). The fibers are extracted from rocks and can be spun into yarns. The yarns can then be processed into wovens, knits, and other textile fabrics. The fibers can also be added to other materials such as concrete and are very suitable for insulation. The outstanding property of asbestos fiber is its resistance to heat and burning. They are also highly resistant to acids, alkalis, and other chemicals. These fibers are used to make special fire-proof and industrial fabrics.传统上，熨衣板上的硬垫是由石棉制成的，但今天，它们是由人造材料制成的。最大的矿区位于俄罗斯（46% 的市场份额）、中国和哈萨克斯坦（各 16%）、巴西 （10%） 和加拿大 （8%）。纤维是从岩石中提取的，可以纺成纱线。然后可以将纱线加工成机织、针织和其他纺织面料。纤维还可以添加到混凝土等其他材料中，非常适合绝缘。石棉纤维的突出特性是耐热和耐燃烧。它们还对酸、碱和其他化学品具有很强的抵抗力。这些纤维用于制造特殊的防火和工业织物。

Compared to natural and chemical fibers, asbestos fibres are extremely fine. The diameter of the elementary fibers varies between 0.02 and 0.2 µm. Further advantages of asbestos are its high-temperature stability and low cost. For these reasons, large amounts of asbestos have been mined and processed worldwide. In 1987, the world production was approximately 4 million tons, but this amount has declined in recent years.与天然纤维和化学纤维相比，石棉纤维非常细。基本纤维的直径在 0.02 到 0.2 µm 之间变化。石棉的其他优点是其高温稳定性和低成本。由于这些原因，全世界已经开采和加工了大量的石棉。1987 年，世界产量约为 400 万吨，但近年来这一数量有所下降。

The use of asbestos has been known since ancient times when it was used as wicks in lamps. There has been extensive research to replace asbestos with other natural and chemical fibers in various fields of application, such as work and fire protection, with heat and electrical insulation, as seals, in filtration, in friction linings, and technical products for construction (asbestos concrete) as well as with chemical products.石棉的用途自古以来就广为人知，当时它被用作灯的灯芯。已经进行了广泛的研究，以用其他天然和化学纤维代替石棉，用于各种应用领域，例如工作和消防、隔热和电绝缘、密封件、过滤、摩擦衬片、建筑技术产品（石棉混凝土）以及化学产品。

Asbestos is used in all types of protective equipment for fire fighting, fire screens, insulation for steam and hot pipes, brake lining insulative building materials, tapes

and braids for electrical uses and items wherein non-combustibility is essential. Many times asbestos fiber is used with glass in making decorative fabric for curtains and draperies and for heat insulation.石棉用于所有类型的消防防护设备、防火幕、蒸汽和热管绝缘、制动衬里绝缘建筑材料、电气用途的胶带和编织物以及不可燃性必不可少的物品。石棉纤维经常与玻璃一起用于制造窗帘和窗帘以及隔热的装饰织物。

Fine asbestos dust and fine dust containing asbestos are considered to be carcinogenic. In this case, the size of the dust corns and the fibers and not the asbestos material itself poses the problem. For this reason, the use of asbestos in Germany has been reduced significantly. However, health concerns have diminished their use, especially asbestos, which is banned in many countries.细石棉粉尘和含石棉的细粉尘被认为是致癌物。在这种情况下，灰尘玉米和纤维的大小，而不是石棉材料本身的大小，都会造成问题。因此，德国的石棉使用量已显着减少。然而，对健康的担忧减少了它们的使用，尤其是石棉，这在许多国家都是被禁止的。

Ceramic Fiber: 陶瓷纤维：Ceramic fibers are inorganic materials that include glass, silicon carbide, boron carbide and aluminium oxide. Generally ceramic fibers are differentiated from glass. In ceramics, the structure of the main constituent, namely silicon dioxide tetrahedra, is crystalline or partly crystalline and opaque. In glass, the tetrahedra (SiO4) arrangement is random and amorphous. Glass is a transparent amorphous solid. Glass as an inorganic substance in a condition that is continuous with and analogous to the liquid state of that substance, but which, due to changes in viscosity during cooling, has attained a high degree of viscosity rendering it rigid. Glass is typically 50% silica and consists of boron oxide, aluminium and several other minerals.陶瓷纤维是无机材料，包括玻璃、碳化硅、碳化硼和氧化铝。通常，陶瓷纤维与玻璃不同。在陶瓷中，主要成分（即二氧化硅四面体）的结构是结晶或部分结晶且不透明。在玻璃中，四面体 （SiO4） 排列是随机且无定形的。玻璃是一种透明的无定形固体。玻璃作为一种无机物质，其状态与该物质的液态连续并相似，但由于冷却过程中粘度的变化，它已经达到了高度的粘度，使其变得坚硬。玻璃通常含有 50% 的二氧化硅，由氧化硼、铝和其他几种矿物组成。

Examples from the ceramic fiber are glass fibers, aluminum oxide, silicon carbide, and boron carbide. Glass wood and quartz can be categorized into the glass fiber group.陶瓷纤维的例子有玻璃纤维、氧化铝、碳化硅和碳化硼。玻璃、木材和石英可归为玻璃纤维组。

Basalt Fiber: 玄武岩纤维：Basalt is naturally available worldwide. It is eco-friendly in nature; its fibers are produced by the process of drawing and winding fibers from the melt. It has good fire resistance, is chemically inert and can tolerate impact load.玄武岩在世界范围内天然可用。它本质上是环保的;它的纤维是通过从熔体中拉出和缠绕纤维的过程生产的。它具有良好的耐火性，具有化学惰性，可以承受冲击载荷。

Basalt is a natural mineral from the rock lava and can be used to produce high temperature-resistant and chemically inactive products. When extracted from volcanic rocks, basalt fibers are practically amorphous, and at high temperatures, the fiber crystallizes partially depending on the quenching temperature. Basalt largely consists

of plagiocene and pyroxene, which are SiO_2 and Al_2O_3 compounds, respectively, and is chemically highly stable in strong alkalis. In strong acids, basalt has a relatively low stability. Basalt is a non-polymeric fiber; hence, it has a low elongation to fracture property of 3.15%. Other properties include a tensile strength of 2.8 GPa and a density of 2.8 g/cm^3.玄武岩是来自岩石熔岩的天然矿物，可用于生产耐高温和化学惰性产品。当从火山岩中提取时，玄武岩纤维几乎是无定形的，在高温下，玄武岩纤维会部分结晶，具体取决于淬火温度。玄武岩主要由斜长石和辉石组成，它们分别是 SiO_2 和 Al_2O_3 化合物，在强碱中化学高度稳定。在强酸中，玄武岩的稳定性相对较低。玄武岩是一种非聚合物纤维;因此，它具有 3.15% 的低断裂伸长率。其他特性包括 2.8 GPa 的拉伸强度和 2.8 g/cm^3 的密度。

Brucite Fiber: 水镁石纤维： Brucite is the mineral form of magnesium hydroxide; it has good anti alkaline properties. It is more stable in an alkaline medium than glass fiber. The moderate strength of this fiber can reach up to 900 MPa.水镁石是氢氧化镁的矿物形式;具有良好的抗碱性。它在碱性介质中比玻璃纤维更稳定。这种纤维的中等强度可达 900 MPa。

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4. 高性能聚乙烯纤维

High Performance Polyethylene Fibers – An Overview 高性能聚乙烯纤维 – 概述

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High Performance Polyethylene Fibers – An Overview 高性能聚乙烯纤维 – 概述

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Introduction 介绍 Gel-spun polyethylene fibers are ultra-strong, high-modulus **fibers** that are based on the simple and flexible polyethylene molecule. They are called high-performance polyethylene (HPPE) fibers, high-modulus polyethylene (HMPE) fibers or sometimes extended chain polyethylene (ECPE) fibers. The gel-spinning process uses physical processes to make available the high potential mechanical properties of the molecule. This has been quite successful but there is still ample room for improvement.凝胶纺聚乙烯纤维是基于简单而灵活的聚乙烯分子的超强、高模量纤维。它们被称为高性能聚乙烯 （HPPE） 纤维、高模量聚乙烯 （HMPE） 纤维，有时也称为延长链聚乙烯 （ECPE） 纤维。凝胶纺丝过程使用物理过程来提供分子的高潜在机械特性。这已经相当成功，但仍有很大的改进空间。

Fig: Polyethylene Fibers 图：聚乙烯纤维

Basic Structure of Polyethylene Fibers 聚乙烯纤维的基本结构 The polyethylene is a long chain aliphatic hydrocarbon and it is thermoplastic. The Tg is approximately -120ºC. Tm depends upon the structure which ranges from 108-132ºC. It has high molecular weight alkane and has a good resistance to chemical attack.

Because it is a crystalline material and does not interact with any liquids, there is no solvent at room temperature.聚乙烯是一种长链脂肪烃，具有热塑性。Tg 约为 -120ºC。Tm 取决于结构，范围为 108-132ºC。它具有高分子量烷烃，具有良好的耐化学侵蚀性。因为它是一种结晶材料，不与任何液体相互作用，所以在室温下没有溶剂。

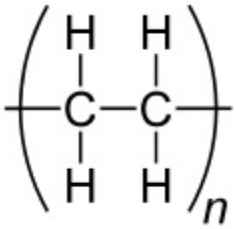

Fig: Structure of polyethylene fiber 图：聚乙烯纤维的结构

Manufacturing of Polyethylene Fibers 聚乙烯纤维的制造 Gel-spun high-performance polyethylene fibers are produced from polyethylene with a very high molecular weight (UHMW-PE). This material is chemically identical to normal high-density polyethylene (HDPE), but the molecular weight is higher than the commonly used PE grades. It is in the range that is used in abrasion-resistant engineering plastics. Different from all other high-performance fibers, the molecules in high performance polyethylene fibers are not 'preformed' to form high tenacity and modulus fibres. In **aramids** and comparable fibres, the molecules tend to form rod-like structures and these need only be oriented in one direction to form a strong fibre. Polyethylene has much longer and flexible molecules and only by physical treatments can the molecules be forced to assume the straight (extended) conformation and orientation in the direction of the fibre. All the physical and chemical properties of polyethylene remain in the fibers. The differences result from the high chain extension (stretching), the high orientation and the high crystallinity. The gel-spun fibres have properties that are superior to those made by solid-state processes.凝胶纺高性能聚乙烯纤维由具有极高分子量 （UHMW-PE） 的聚乙烯制成。这种材料在化学上与普通高密度聚乙烯 （HDPE） 相同，但分子量高于常用的 PE 等级。它属于用于耐磨工程塑料的范围内。与所有其他高性能纤维不同，高性能聚乙烯纤维中的分子不是经过"预成型"以形成高韧性和模量纤维的。在芳纶和类似的纤维中，分子倾向于形成棒状结构，这些分子只需要朝一个方向定向即可形成坚固的纤维。聚乙烯具有更长、更灵活的分子，只有通过物理处理才能迫使分子在纤维方向上呈现笔直（延伸）的构象和方向。聚乙烯的所有物理和化学特性都保留在纤维中。差异源于高链延伸（拉伸）、高取向和高结晶度。凝胶纺纤维具有优于固态工艺制成的纤维的性能。

Gel Spinning 凝胶纺丝 High performance polyethylene fibers are commercially produced under the trade names Dyneemaby DSM High Performance Fibers in the Netherlands and by the Toyobo/DSM joint venture in Japan, and Spectra by Honeywell (formerly Allied Signal or Allied Fibers) in the USA. The basic theory about what a super-strong polyethylene fibers should look like was already available in the 1930s from the ideas of Carothers, but it took almost half a century to produce HPPE fibres. The basic theory of how to produce a super-strong fibre from a polymer such as polyethylene is easy to understand. In normal polyethylene the molecules are

not orientated and are easily torn apart. To make strong fibres, the molecular chains must be stretched, oriented and crystallised in the direction of the fibre. Furthermore, the molecular chains must be long to have sufficient interaction and for this reason polyethylene with an ultra-high molecular weight (UHMW-PE) is used as the starting material. Usually extension and orientation are realised by drawing. The problem is that spinning these fibres from the melt is almost impossible due to the extremely high melt viscosity. Furthermore, the drawing of a melt processed UHMW-PE is only possible to a very limited extent owing to the very high degree of entanglement of the molecular chains. In the gel spinning process these two problems are solved: the molecules are dissolved in a solvent and spun through a spinneret. In the solution the molecules become disentangled and remain in that state after the solution is spun and cooled to give filaments. Because of its low degree of entanglement, the gel spun material can be drawn to a very high extent. The main steps in the process are the continuous extrusion of a solution of ultra high-molecular weight polyethylene (UHMW-PE) Spinning of the solution, gelation and crystallization of the UHMW-PE. This can be done either by cooling and extraction or by evaporation of the solvent. Super drawing and removal of the remaining solvent gives the fibre its final properties but the other steps are essential in the production of a fibre with good characteristics. In the gel-spinning process, not only do all the starting parameters have an influence on the final properties of the fibre, the different process steps also influence all the following stages in the production of the fibre. So, starting from the same principles, Dyneema and Spectra may use very different equipment to produce comparable fibres. 高性能聚乙烯纤维在荷兰以 Dyneemaby DSM High Performance Fibers 的商品名和日本的 Toyobo/DSM 合资企业以及美国的 Honeywell（前身为 Allied Signal 或 Allied Fibers）的 Spectra 进行商业生产。关于 超强聚乙烯纤维应该是什么样子的基本理论在 1930 年代就已经从 Carothers 的思想中获得了，但生产 HPPE 纤维花了近半个世纪的时间。如何从聚乙烯等聚合物生产超强纤维的基本理论很容易理解。在普通聚乙烯中，分子没有定向，很容易撕裂。为了制造坚固的纤维，分子链必须沿纤维的方向拉伸、定向和结晶。此外，分子链必须很长才能产生足够的相互作用，因此使用超高分子量聚乙烯 （UHMW-PE） 作为起始材料。通常，延伸和方向是通过绘图来实现的。问题是，由于熔体粘度极高，从熔体中纺丝这些纤维几乎是不可能的。此外，由于分子链的缠结程度非常高，熔融加工的 UHMW-PE 的拉丝只能在非常有限的范围内进行。在凝胶纺丝过程中，解决了这两个问题：分子溶解在溶剂中并通过喷丝头旋转。在溶液中，分子解开并在溶液旋转和冷却后保持该状态，得到细丝。由于其缠结程度低，凝胶纺丝材料可以被拉伸到非常高的程度。 该过程的主要步骤是超高分子量聚乙烯 （UHMW-PE） 溶液的连续挤出、溶液的纺丝、UHMW-PE 的凝胶化和结晶。这可以通过冷却和萃取或通过蒸发溶剂来完成。超级拉伸和去除剩余溶剂使纤维具有最终性能，但其他步骤对于生产具有良好特性的纤维至关重要。在凝胶纺丝工艺中，不仅所有起始参数都会影响纤维的最终性能，不同的工艺步骤也会影响纤维生产的所有后续阶段。因此，从相同的原则出发，Dyneema 和 Spectra 可能会使用非常不同的设备来生产类似的纤维。

Spinning Solution 旋转解决方案 With long-chain, flexible polymers the high orientation required can be obtained by drawing up to a very high draw ratio (50–100

times). Melt processed UHMW-PE can be drawn up to five times only, as the interaction between the molecular chains is too high because of the molecular entanglements. In solution, the molecules disentangle but there remain a number of cross-overs determined by the concentration and the length of the molecules. The flexible molecules assume a roughly spherical shape with a diameter proportional to the cubic root of the molecular weight. For the UHMW-PE chains the diameter of such a ball is about 1% of the total chain length. As soon as strain is applied when the solution is pressed through the spinneret, the molecules are forced into more elongated form For maximum fibre strength, the polyethylene molecules should be as long as possible. From an economic point of view the concentration of the solution should be as high as possible. However, these two factors together result in a solution that has a viscosity that is far too high to spin. Careful optimisation of these parameters is an essential part of the process.对于长链柔性聚合物，可以通过拉深到非常高的拉伸比（50-100 倍）来获得所需的高取向性。熔融加工的 UHMW-PE 最多只能拉伸五次，因为分子缠结导致分子链之间的相互作用太高。在溶液中，分子解开，但仍有许多由分子的浓度和长度决定的交叉。柔性分子呈大致球形，直径与分子量的立方根成正比。对于 UHMW-PE 链条，这种球的直径约为链条总长度的 1%。当溶液被压过喷丝头时，一旦施加应变，分子就会被迫变成更细长的形式。为了获得最大的纤维强度，聚乙烯分子应尽可能长。从经济角度来看，溶液的浓度应尽可能高。然而，这两个因素共同导致溶液的粘度太高而无法旋转。仔细优化这些参数是该过程的重要组成部分。

Gelation and Crystallization 凝胶化和结晶 The solvent used in the polyethylene gel-spinning process should be a good solvent at high temperatures (>100°C) but at lower temperatures (<80°C) the polymer should easily crystallize from the solution. After the spinneret, the solution is cooled in the quench, the solvent is removed and a gel fibre is formed. This can be done by evaporation or by extraction of the solvent.聚乙烯凝胶纺丝过程中使用的溶剂在高温下应为良好溶剂（>100°C），但在低温下 （<80°C） 聚合物应容易从溶液中结晶。喷丝头后，溶液在淬火中冷却，去除溶剂并形成凝胶纤维。这可以通过蒸发或萃取溶剂来完成。

Drawing 绘图 The final properties of the fibre in the gel-spinning process are achieved in the super drawing stage. All the preceding steps are needed to make this possible. The strength and modulus are directly related to the draw ratio. The maximum attainable draw ratio appears to be related to the molecular weight and the concentration. The attainable draw ratio increases with decreasing concentration, but for each molecular weight there is a minimum concentration below which drawing is not possible, due to insufficient molecular overlap.纤维在凝胶纺丝过程中的最终性能是在超级拉伸阶段实现的。要实现这一点，需要执行上述所有步骤。强度和模量与拉伸率直接相关。可达到的最大拉伸比似乎与分子量和浓度有关。可达到的拉丝比随着浓度的降低而增加，但对于每个分子量，都有一个最小浓度，由于分子重叠不足，低于该浓度是不可能的。

Properties of Polyethylene Fiber 聚乙烯纤维的特性

1. Tensile properties: The primary properties of the Dyneemaand Spectra fibres are high strength and high modulus in combination with the low density. HPPE fibres

have a density slightly less than one, so the fibre floats on water. Whereas the strength and modulus are already very high. The tenacity is 10 to 15 times that of good quality steel and the modulus is second only to that of special carbon. Elongation at break is relatively low, as for other high-performance fibres, but owing to the high tenacity, the energy to break is high.**1. 拉伸性能：**Dyneemaand Spectra 纤维的主要特性是高强度和高模量以及低密度。HPPE 纤维的密度略小于 1，因此纤维漂浮在水面上。而强度和模量已经非常高。韧性是优质钢的 10 到 15 倍，模量仅次于特殊碳。与其他高性能纤维一样，断裂伸长率相对较低，但由于高韧性，断裂能量很高。

2. Energy absorption: Dyneema and Spectra fibres can absorb extremely high amounts of energy. This property is utilized in products for ballistic protection. But it makes the fibre equally suited for products such as cut-resistant gloves and motor helmets. The fibres can also be used to improve the impact strength of carbon or glass fibre-based composites. In these applications, not only the high tenacity is used but also the high energy absorption.**2. 能量吸收：**Dyneema 和 Spectra 纤维可以吸收极大量的能量。此特性用于防弹产品。但它使这种纤维同样适用于防割手套和汽车头盔等产品。这些纤维还可用于提高碳纤维或玻璃纤维基复合材料的冲击强度。在这些应用中，不仅使用了高韧性，还使用了高能量吸收。

3. Fatigue Fatigue: Is very important in, for example, rope applications. HPPE fibres are the first high-performance fibers that not only have a high tenacity but that also have tension and bending fatigue properties comparable with the commonly used polyamide and polyester grades in ropes.**3. 疲劳 疲劳：**例如，在绳索应用中非常重要。HPPE 纤维是第一种高性能纤维，不仅具有高韧性，而且具有可与绳索中常用的聚酰胺和聚酯等级相媲美的拉伸和弯曲疲劳性能。

4. Abrasion resistance: Abrasion resistance is very important in ropes, also in gloves. In many of applications it is at least one of the factors that determines wear and tear and so the service life. The high molecular weight polyethylene used for HPPE fibres is also a well-known engineering plastic.**4. 耐磨性：**耐磨性在绳索中非常重要，在手套中也是如此。在许多应用中，它至少是决定磨损和使用寿命的因素之一。用于 HPPE 纤维的高分子量聚乙烯也是一种众所周知的工程塑料。

5. Effects of water: Polyethylene fibers are not hygroscopic and does not absorb water. The fibres have a very low porosity, therefore water absorption in the fibre is negligible.**5. 水的影响：**聚乙烯纤维不吸湿，不吸水。纤维的孔隙率非常低，因此纤维中的吸水率可以忽略不计。

6. Chemical resistance: HPPE fibres are produced from polyethylene and do not contain any aromatic rings or any amide, hydroxylic or other chemical groups that are susceptible to attack by aggressive agents.The result is that polyethylene and especially highly crystalline, high molecular weight polyethylene is very resistant against chemicals.**6. 耐化学性：** HPPE 纤维由聚乙烯制成，不含任何芳香环或任何易受侵蚀性试剂攻击的酰胺、羟基或其他化学基团。结果是聚乙烯，尤其是高结晶、高分子量聚乙烯具有很强的耐化学性。

Applications of Polyethylene Fibers:聚乙烯纤维的应用：

1. Medical implants 医疗植入物
2. Cable and marine ropes 电缆和船用绳索
3. Sail cloth 帆布

4. Composites like Pressure vessel boat hulls, sports equipment, impact shields 复合材料，如压力容器船体、运动器材、冲击盾

5. Fish netting 鱼网

6. Concrete reinforcement 混凝土加固

7. Protective clothing 防护服

8. Can be used in radar protective cover because of its low dielectric constant 由于其低介电常数，可用于雷达保护罩

9. Can be used as a lining material of a pond which collects evaporation of water and containment from industrial plants.可用作池塘的衬里材料，收集工业厂房的蒸发和密封。

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5. 芳纶纤维

Aramid Fibers: Types, Properties, Manufacturing Process and Applications
芳纶纤维：类型、性能、制造工艺和应用

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Aramid Fibers-An Overview 芳纶纤维 - 概述

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Introduction 介绍 All fibers used in polymer engineering composites can be divided into two categories, namely synthetic fibers and natural fibers. Synthetic fibers are the most common. Although there are many types of synthetic fibers, glass, carbon and aramid fibers represent the most important. Kevlar is an aromatic polyamide or aramid fiber introduced in early 1970s by DuPont. It was the first organic fiber with sufficient tensile strength and modulus to be used in advanced composites. It has approximately five times the tensile strength of steel with a corresponding tensile modulus. Originally developed as a replacement for steel in radial tires, aramid is now used in a wide range of applications. It is a trade name of aramid fiber. (vigotsky, 2002)高分子工程复合材料中使用的所有纤维可分为两大类，即合成纤维和天然纤维。合成纤维是最常见的。尽管合成纤维的种类很多，但玻璃、碳和芳纶纤维是最重要的。Kevlar 是杜邦于 1970 年代初期推出的一种芳香族聚酰胺或芳纶纤维。它是第一种具有足够拉伸强度和模量的有机纤维，可用于高级复合材料。它的抗拉强度大约是钢的五倍，具有相应的拉伸模量。芳纶最初是作为子午线轮胎中钢的替代品而开发的，现在用于广泛的应用。它是芳纶纤维的商品名。（维戈茨基，2002 年）

Definition 定义 The U.S. Federal Trade Commission gives a good definition of an aramid fiber as “a manufactured fiber in which the fiber forming substance is a long chain synthetic polyamide in which at least 85% of the amide linkages are attached directly to two aromatic rings. (comparison of aramid fibers, 2003)美国联邦贸易委员会对芳纶纤维给出了很好的定义，即“一种人造纤维，其中纤维形成物质是长链合成聚酰胺，其中至少 85% 的酰胺键直接连接到两个芳香环上。（芳纶纤维的比较，2003 年）

History 历史 First time aramid fibers commercially introduced by an American company DuPont in 1960 with trade name of Nomex. These Nomex fibers was well known due to their good thermal and electrical insulations properties. In 1971 DuPont introduced a much higher tenacity and modules fiber with trade name of Kevlar. Scientists in the fields of liquid crystals, polymers, rheology and fibre processing, as

well as process and system engineers, spent several years prior and during the early stage of its market introduction establishing the basics and fundamental understanding necessary to take full advantage of this new class of high-performance materials. (Hearle, 2001)1960 年，美国杜邦公司首次推出芳纶纤维，商品名为 Nomex。这些 Nomex 纤维因其良好的热绝缘和电绝缘性能而广为人知。1971 年，杜邦推出了一种强度更高的模数纤维，商品名为 Kevlar。液晶、聚合物、流变学和纤维加工领域的科学家以及工艺和系统工程师在产品上市前和上市初期花了几年时间，为充分利用这一类新型高性能材料奠定了必要的基础和基本知识。（赫尔，2001 年）

Basic Structure and chemical composition of aramid fibers 芳纶纤维的基本结构和化学成分 Tho monomers of aramid fibers are consist of 1,4-phenyl-diamine (para-phenylenediamine) and terephthaloyl chloride. The result is polymeric aromatic amide with altering benzene ring and amide groups. When they produced these polymer strand aligned randomly. Technically, aramid fibers are long-chain synthetic polyamides. Aramid fibers have extremely high tensile strength, which is why they are commonly used in armor and ballistic protection applications. With a distinctive yellow color, aramid fibers are frequently used in advanced composite products which require high-strength and light-weight properties.芳纶纤维的单体由 1,4-苯基二胺（对苯二胺）和对苯二酰氯组成。结果是聚合物芳香酰胺具有改变苯环和酰胺基团。当他们产生这些聚合物链时，这些聚合物链随机排列。从技术上讲，芳纶纤维是长链合成聚酰胺。芳纶纤维具有极高的抗拉强度，这就是它们通常用于装甲和防弹保护应用的原因。芳纶纤维具有独特的黄色，经常用于需要高强度和轻质特性的先进复合产品。

The chemical composition of aramid is poly para-phenyleneterephthalamide (PPD-T) and it is more properly known as a para-aramid. It is oriented para-substituted aromatic units. Aramids belong to the family of nylons. Common nylons, such as nylon 6,6 do not have very good structural properties, so the para-aramid distinction is important. Aramid fibers like Nomex or Kevlar, however, are ring compounds based on the structure of benzene as opposed to linear compounds used to make nylon. The aramid ring gives thermal aramid stability, while the para structure gives it high strength and modulus. Like nylons, aramid filaments are made by extruding the precursor through a spinneret. The rod form of the para-aramid molecules and the extrusion process make Kevlar fibers anisotropic–they are stronger and stiffer in the axial direction than in the transverse direction. In comparison, graphite fibers are also anisotropic, but glass fibers are isotropic.芳纶的化学成分是聚对苯二甲酰胺 （PPD-T），它更恰当地称为对位芳纶。它是定向对位取代芳烃单元。芳纶属于尼龙家族。常见的尼龙，如尼龙 6,6 不具有非常好的结构性能，因此对位芳纶的区别很重要。然而，像 Nomex 或 Kevlar 这样的芳纶纤维是基于苯结构的环化合物，而不是用于制造尼龙的线性化合物。芳纶环提供热芳纶稳定性，而 para 结构使其具有高强度和模量。与尼龙一样，芳纶丝是通过喷丝头挤出前驱体制成的。对位芳纶分子的棒状和挤出工艺使凯夫拉纤维具有各向异性——它们在轴向比横向更坚固、更坚硬。相比之下，石墨纤维也是各向异性的，但玻璃纤维是各向同性的。

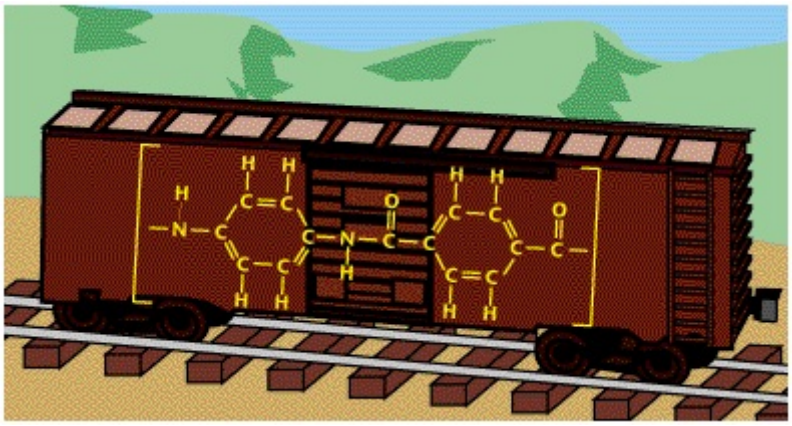

Fig: Chemical composition of Kevlar 图：Kevlar 的化学成分

It is made from a condensation reaction of para-phenylene diamine and terephthaloyl (PPD-T) chloride. The resultant aromatic polyamide contains aromatic and amide groups which makes them rigid rod like polymers. The rigid rod like structure results in a high glass transition temperature and poor solubility, which makes fabrication of these polymers, by conventional drawing techniques, difficult Instead, they are melt spun from liquid crystalline polymer solutions as described later. The Kevlar fiber is an array of molecules oriented parallel to each other like a package of uncooked spaghetti. This orderly, untangled arrangement of molecules is described as a crystalline structure. Crystallinity is obtained by a manufacturing process known as spinning, which involves extruding the molten polymer solution through small holes.它由对苯二胺和对苯二酰 （PPD-T） 氯化物的缩合反应制成。所得的芳香族聚酰胺含有芳香族和酰胺基团，这使它们成为刚性棒状聚合物。刚性棒状结构导致玻璃化转变温度高且溶解度差，这使得通过常规拉丝技术制造这些聚合物变得困难，相反，它们是从液晶聚合物溶液熔融纺丝而成的，如下所述。凯夫拉纤维是一组相互平行的分子，就像一包生意大利面。这种有序、解开的分子排列被描述为晶体结构。结晶度是通过一种称为纺丝的制造工艺获得的，该工艺涉及通过小孔挤出熔融聚合物溶液。

When PPD-T solutions are extruded through a spinneret and drawn through an air gap during fiber manufacture, the liquid crystalline domains can orient and align in the flow direction. Kevlar can acquire a high degree of alignment of long, straight polymer chains parallel to the fiber axis. The structure exhibits anisotropic properties, with higher strength and modulus in the fiber longitudinal direction than in the axial direction. The extruded material also possesses a febrile structure. This structure results in poor shear and compression properties for aramid composites. Hydrogen bonds form between the polar amide groups on adjacent chains and they hold the individual Kevlar polymer chains together [8]. It is shown as in the following figure: 在纤维制造过程中，当 PPD-T 溶液通过喷丝头挤出并通过气隙时，液晶域可以沿流动方向定向和对齐。Kevlar 可以获得平行于纤维轴的长而直的聚合物链的高度对齐。该结构表现出各向异性特性，纤维纵向的强度和模量高于轴向。挤压材料还具有发热结构。这种结构导致芳纶复合材料的剪切和压缩性能较差。氢键在相邻链上的极性酰胺基团之间形成，它们将单个凯夫拉聚合物链固定在一起 [8]。如下图所示：

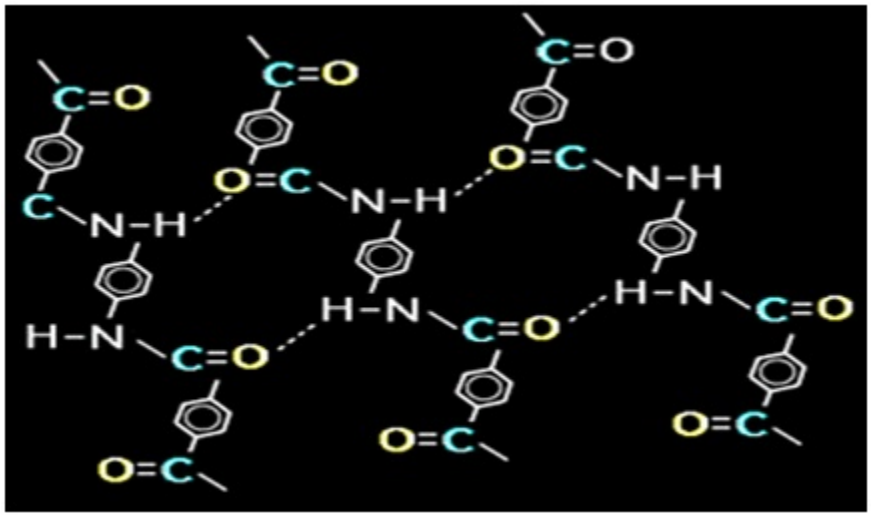

Fig: Hydrogen bonds form between the polar amide groups 图：极性酰胺基团之间形成氢键

Types of aramid fibers 芳纶纤维的类型 There are two main types of aramid fibers.芳纶纤维有两种主要类型。

1. Meta- aramid 间位芳纶
2. Para- aramid 对位芳纶

The term meta and para refers to the location of chemical bonds in the structure of aramid fibers. The chemical bonds of a para-aramid fibers are more aligned in the long direction of the fibers. The meta-aramid fibers are not aligned they are in zigzag pattern there for they are not developed the higher tensile strength of the para-aramid bonds.术语 meta 和 para 是指芳纶纤维结构中化学键的位置。对位芳纶纤维的化学键在纤维的长方向上更加对齐。间位芳纶纤维没有对齐，它们在那里呈锯齿形，因为它们没有形成对位芳纶键的更高拉伸强度。

1. Meta-aramid 1. 间位芳纶 Fibers made from the meta aramid have the excellent thermal, chemical and radiation resistance and are make the fire retardant textiles such as outer wear for fire fighters and racing car drivers. Nomex and teijiconex are examples of meta aramids.由间位芳纶制成的纤维具有出色的耐热性、耐化学性和耐辐射性，可用于制造阻燃纺织品，例如消防员和赛车手的外衣。Nomex 和 teijiconex 是间位芳纶的例子。

2. Para-aramids 2. 对位芳纶 Fibers which are made from the para-aramid have higher strength. These are more commonly used in fibers reinforcement plactics for civil engineering structures, Stress skin panels, and other highly tensile strength applications. Kevlar and technora are example of para-aramid fibers. (Hearle, 2001) (Properties of Aramid Fibers, 2015)由对位芳纶制成的纤维具有更高的强度。这些更常用于土木工程结构的纤维增强板、应力表皮板和其他高抗拉强度应用。Kevlar 和 technora 是对位芳纶纤维的例子。（赫尔，2001 年）（芳纶纤维的特性，2015 年）

Different trade name of aramid fibers 芳纶纤维的不同商品名 Aramid fibers are available with different trade names. There properties are determine by the manufacturing process, conditions in which fibers are prepared and end uses. Different trade names of aramid fibers are Kevlar, Technora, Tawron, Nomex etc. (Aramid Fibers, trade names)芳纶纤维有不同的商品名称。这些特性由制造工艺、

纤维制备条件和最终用途决定。芳纶纤维的不同商品名称是 Kevlar、Technora、Tawron、Nomex 等（芳纶纤维，商品名称）

Manufacturing process of aramid fibers 芳纶纤维的制造工艺 The polymer poly-metaphenylene isophthalamide is used to make meta- aramids and the polymer p-phenylene terephthalamide to make para-aramids. Because the aramids decompose before they melt they are produced by wet and dry spinning methods. Sulphuric acid is the normal solvent used in the spinning processes. In wet spinning a strong solution of the polymer, which also contains inorganic salts, is spun through a spinneret into weak acid or water. In this bath the salts leach out. In the dry spinning process the salts are more difficult to remove and this process is only used to produce the weaker meta-aramid fibres. In both processes post treatment of the fibres by additional drawing is used to optimise fibre properties. Aramid products are available as filament yarn, staple fibre or pulp. (Aramid fibers manufacturing method)聚合物聚偏苯基间苯二苯酰胺用于制造间位芳纶，聚合物对苯对苯二甲酰胺用于制造对位芳纶。因为芳纶在熔化之前会分解，所以它们是通过湿法和干法纺丝法生产的。硫酸是纺纱过程中使用的正常溶剂。在湿法纺丝中，聚合物的强溶液（也含有无机盐）通过喷丝头纺成弱酸或水。在这个浴中，盐分会渗出。在干纺工艺中，盐更难去除，该工艺仅用于生产较弱的间位芳纶纤维。在这两个过程中，通过附加拉伸对纤维进行后处理以优化纤维性能。芳纶产品有长丝、短纤维或纸浆等形式。（芳纶纤维制造方法）

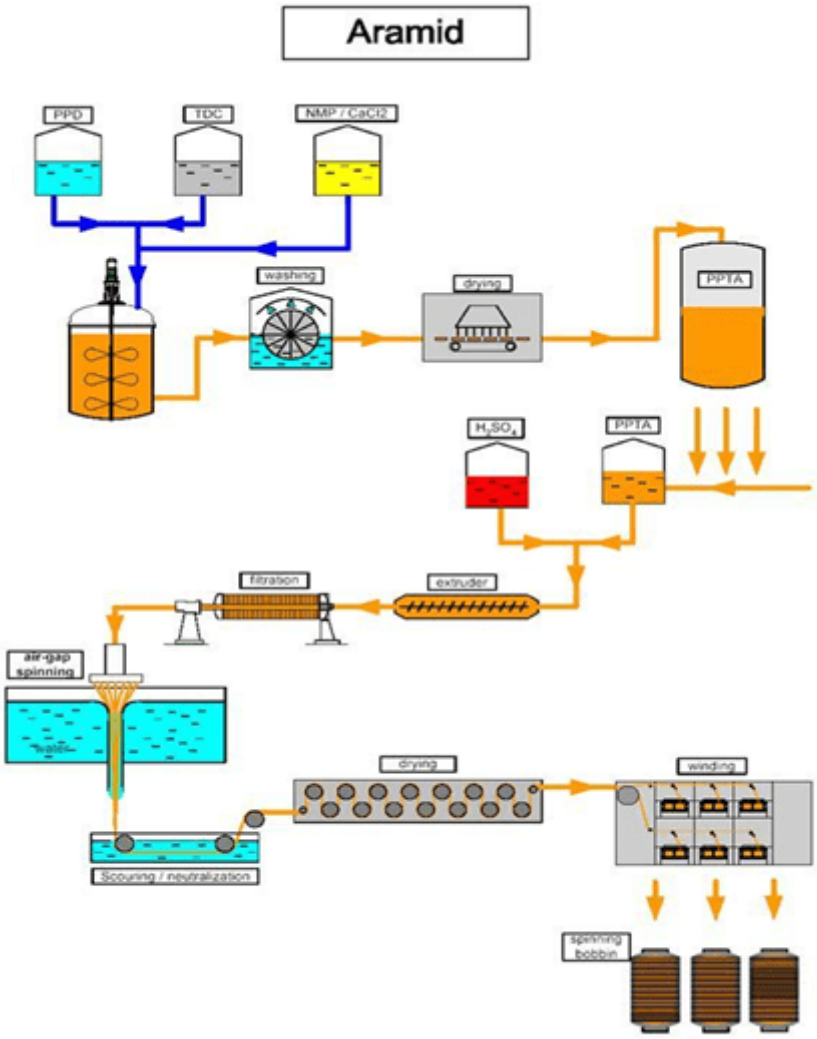

Fig: Manufacturing Process of aramid fibers 图：芳纶纤维的制造工艺

Characteristics of Aramid Fibers 芳纶纤维的特性

1. Fiber Structure 1. 纤维结构 In aramid fibers a series of synthetic polymers in which repeating units have large phenyl rings are linked together by amide groups. Amide groups (CO-NH) form strong bonds that are resistant to solvets and heat. Phenyl rings are bulky six-sided groups of carbon and hydrogen atoms that prevent polymer chains from rotating and twisting around their chemical bonds.在芳纶纤维中，一系列合成聚合物，其中重复单元具有大苯基环，通过酰胺基团连接在一起。酰胺基团 （CO-NH） 形成耐溶剂和耐热的强键。苯基环是笨重的碳和氢原子六边形基团，可防止聚合物链在其化学键周围旋转和扭曲。

2. Fiber Properties 2. 纤维特性 Aramid fibers have medium to ultra-high strength, medium to low elongation and moderately high to ultra-high modulus with the densities ranging from 1.38g/cm3. Heat-resistant and flame-retardant fibers contain high proportion or meta-oriented phenylene rings, whereas ultra-high strength high-modulus fibers contain mainly para-oriented phenylene rings.芳纶纤维具有中至超高强度、中低伸长率和中高至超高模量，密度范围为 1.38g/cm3。耐热阻燃纤维包含高比例或偏向的苯环，而超高强度高模量纤维主要包含对位取向的苯

环。

3. Chemical Properties 3. 化学性质 All aramids contain amide links that are hydrophilic. However, not all aramid products absorb the same moisture. The PPD-T (poly-phenylene terephathalamide) fiber has very good resistance to many organic solvents and salt, but strong acids can cause substantial loss of strength. Aramid fibers are difficult to dye due to their high Tg. Also, the aromatic nature of para-aramid is responsible for oxidative reactions when exposed to UV light, that leads to a change in color and loss of some strength.所有芳纶都含有亲水性酰胺键。然而，并非所有芳纶产品都能吸收相同的水分。PPD-T（聚苯对苯对苯胺）纤维对许多有机溶剂和盐具有非常好的抵抗力，但强酸会导致强度的大幅损失。芳纶纤维由于其高 Tg 而难以染色。此外，对位芳纶的芳香族性质在暴露于紫外线时会导致氧化反应，从而导致颜色变化和一些强度的损失。

4. Themal Properties 4. 主题属性 Aramid fibers do not melt inn the conbentional sense but decompose simultaneously. They burn only with difficulty because of limited oxygen Index values. It should be mentioned that at 300 degrees celcius some aramid types can still retain about 50% of their strength. Aramid fibers show high crystallinity which results in negligible shrinkage at high temperature.芳纶纤维不会在结构意义上熔化，而是同时分解。由于氧指数值有限，它们只能困难地燃烧。值得一提的是，在 300 摄氏度时，一些芳纶类型仍然可以保持其大约 50% 的强度。芳纶纤维具有高结晶度，因此在高温下的收缩可以忽略不计。

5. Mechanical Properties 5. 机械性能 Aramid yarn have breaking tenacity of 3045 MPa, in other words more than 5 times than this steel (under water, aramid is 4 times stronger) and twice than this of glass fiber or nylon. High strength is result of its aromatic and amide group and high crystallinity. Aramid retains strength and modulus at temperatures as high as 300 degrees celcius. It behaves elastically under tension. When it comes to severe bending, it shows non-linear plastic deformation. With tension fatigue, no failure is observed even at impressively high loads and cycle times. Creep strain for aramid is only 0.3%.芳纶纱线的断裂强度为 3045 MPa，换句话说，是这种钢的 5 倍多（在水下，芳纶的强度是玻璃纤维或尼龙的 4 倍），是玻璃纤维或尼龙的两倍。高强度是其芳香族和酰胺基团以及高结晶度的结果。芳纶在高达 300 摄氏度的温度下保持强度和模量。它在张力下表现为弹性。当涉及到严重弯曲时，它表现出非线性塑性变形。在拉伸疲劳下，即使在令人印象深刻的高负载和循环时间下也不会观察到故障。芳纶的蠕变应变仅为 0.3%。

You may also like: Application of High Performance Fibers for Special Purposes 您可能还喜欢： 高性能纤维在特殊用途中的应用

To sum up, aramid general characteristics are:综上所述，芳纶的一般特性是：

1. High strength 高强度
2. Resistance to absorption 抗吸收性
3. Resistance to organic solvent 耐有机溶剂
4. Good chemical resistance 良好的耐化学性
5. No conductivity 无导电性
6. No melting point low flammability 无熔点，低可燃性
7. Excellent heat, and cut resistane 优异的耐热性，并切割抵抗烷

8. Sensitive to acids and ultraviolet radiation (ARAMID FIBER CHARACTERISTICS, 2015)对酸和紫外线辐射敏感（ARAMID FIBER CHARACTERISTICS，2015 年）

Advantages of aramid fibers 芳纶纤维的优点 Aramid main advantages are high strength and low weight. Like graphite, it has slightly negative axial coefficient of thermal expansion, which means aramid laminates can be made thermally table in dimensions. Unlike graphite, it is very resistant to impact and abrasion damage. It can be made waterproof when combined with other materials like epoxy. It can be used as a composite with rubber retaining its flexibility. High tensile modulus and low breakage elongation combined with very good resistance to chemicals make it the right choice for different composite structural parts inn various applications.芳纶的主要优点是强度高、重量轻。与石墨一样，它具有略负的轴向热膨胀系数，这意味着芳纶层压板的尺寸可以制成热工作台。与石墨不同，它非常耐冲击和磨损。当与环氧树脂等其他材料结合使用时，它可以变得防水。它可以用作复合材料，橡胶保持其柔韧性。高拉伸模量和低断裂伸长率，加上非常好的耐化学性，使其成为各种应用中不同复合材料结构件的正确选择。

You may also like: Anti Ballistic Fabric: Materials, Protection, Properties and Application 您可能还喜欢：防弹织物：材料、保护、性能和应用

Disadvantages of aramid fibers 芳纶纤维的缺点 On the other hand, aramid fiber has a few disadvantages. The fibers assorb moisture, so aramid composites are more sensitive to the environment than glass or graphite composites. For this reason, it must be combined with moisture resistance materials like epoxy systems. Compressive properties are ralativly poor too. Consequently, aramid fiber is not used in bridge building or whenever this king of resistance in needed. Also, aramid fibers are difficult to cut and to grind without special equipments (e.g special scissors for cutting, special drill bits). Finally, aramid suffer some corrosion and are degradated by UV light. For this reason they must be properly coated. (ADVANTAGES – DISADVANTAGES, 2015)另一方面，芳纶纤维也有一些缺点。纤维会吸收水分，因此芳纶复合材料比玻璃或石墨复合材料对环境更敏感。因此，它必须与环氧树脂系统等防潮材料结合使用。压缩性能也非常差。因此，芳纶纤维不用于桥梁建设或需要这种阻力之王的时候。此外，芳纶纤维在没有特殊设备（例如用于切割的特殊剪刀、特殊钻头）的情况下难以切割和研磨。最后，芳纶会受到一些腐蚀并被紫外线降解。因此，它们必须进行适当的涂层。（优点 - 缺点，2015 年）

Key Applications of Aramid Fiber 芳纶纤维的主要应用 Some applications for aramid fibres are listed below.下面列出了芳纶纤维的一些应用。

1. It is usually used as fibre reinforcement for polymer matrix composites.它通常用作聚合物基复合材料的纤维增强材料。
2. Ballistic protective applications such as bullet proof vests 防弹保护应用，如防弹背心
3. Protective apparel such as gloves, motorcycle protective clothing and hunting gaitors, chaps and pants.防护服，如手套、摩托车防护服和狩猎绑腿、裤子和裤子。
4. Sails for sailboats, yachts etc 帆船、游艇等的帆

5. Belts and hosing for industrial and automotive applications 用于工业和汽车应用的皮带和软管

6. Aircraft body parts 飞机机身零件

7. Boat hulls 船体

8. Fibre optic and electromechanical cables 光纤和机电电缆

9. Friction linings such as clutch plates and brake pads 离合器片和刹车片等摩擦片

10. Gaskets for high temperature and pressure applications 用于高温和高压应用的垫片

11. Adhesives and sealants (Aramid Fibre (Kevlar / Twaron) – Properties and Applications, 2015)胶粘剂和密封剂（芳纶纤维 （ Kevlar / Twaron ） – 特性和应用，2015 年）

Comparison of aramid fiber with other high performance fibers 芳纶纤维与其他高性能纤维的比较

***** Aramid fibers have High Strength to Weight Ratio 芳纶纤维具有高强度重量比** Force per unit area at failure / Density = is the Strength to Weight ratio of this material. Kevlar is very strong and is slightly stronger than Carbon Fiber per unit weight.失效时每单位面积的力 / 密度 = 是该材料的强度重量比。凯夫拉尔非常坚固，每单位重量比碳纤维略强。

MATERIAL	Strength to weight 强度重量比 KN.m/kg. KN.m/千克。	Ultimate Strength MPa 极限强度 MPa	Density g/cm3 密度 g/cm3
Spectra fiber (UHMWPE) 光谱光纤（UHMWPE）	3619	2300-3500	.97
Kevlar (ARAMID) 凯夫拉（ARAMID）	2514	2757	1.44
Carbon Fibre 碳纤维	2457	4137	1.75
Carbon laminate 碳层压板	785	1600	1.5
E Glass Fibre E 玻璃纤维	1307	3450	2.57
E Glass laminate E 玻璃层压板	775	1500	1.97
Polypropylene 聚丙烯	89	19.7-80	.91
S Glass Fibre S 玻璃纤维	1906	4710	2.47
Spider Silk 蜘蛛丝	1069	1000	1.3
Balsa axial load 轻木轴向载荷	521	83	.16

Steel alloy ASTM A36 钢合金 ASTM A36	254	400	7.8
Aluminium alloy 铝合金	222	248-483	2.63-2.8
Oak 橡 木	87	65	.75
Epoxy 环氧的	26	12-30	1.23
Nylon 尼龙	69	75	1.15

***** Kevlar (ARAMID) is Much Stiffer than Glass but Not as Stiff as Carbon Fiber.凯夫拉尔 （ARAMID） 比玻璃硬得多，但不如碳纤维硬。**

The Rigidity of a material is measured by its Youngs' Modulus.材料的刚度由其杨氏模量来衡量。

Kevlar is quite stiff and has low stretching at break.凯夫拉非常坚硬，断裂时拉伸率低。

Material 材料	Young's Modulus GPa 杨氏模量 GPa
PTFE (Teflon) PTFE（特氟龙）	0.5
Rubber (small strain) 橡胶（小应变）	0.01-0.1
PTFE (Teflon) PTFE（特氟龙）	0.5
Low density polyethylene 低密度聚乙烯	0.2
UHMWPE (such as Dyneena or Spectra)UHMWPE（例如 Dyneena 或 Spectra）	.7
Polypropylene 聚丙烯	1.5-2
Nylon 尼龙	2-4
Pine wood (along grain) 松木（沿纹理）	8.963
Oak wood (along grain) 橡木（沿纹理）	11
Aluminium 铝	69
Aramid (such as Kevlar and Twaron)芳纶（如 Kevlar 和 Twaron）	70.5-112.4
Brass and bronze 黄铜和青铜	100-125
Glass-reinforced plastic (70/30 by weight fibre/matrix, unidirectional, along grain)玻璃纤维增强塑料（纤维/基体重量的 70/30，单向，沿纹理）	40-45

Carbon fiber (depends on direction and type)碳纤维（取决于方向和类型）	300-400
Carbon fiber reinforced plastic (70/30 fibre/matrix, unidirectional, along grain)碳纤维增强塑料（70/30 纤维/基体，单向，沿纹理）	181
Steel 钢	200
Single-walled carbon nanotube 单壁碳纳米管	1,000+

***** Tensile Strength of Kevlar is lower than E GlassKevlar 的拉伸强度低于 E 玻璃** This table is offered as a comparison only since there are a great number of variables.此表仅作为比较提供，因为存在大量变量。

Material 材料	MPa units MPa 单位
Carbon steel 1090 碳钢 1090	650
High density polyethylene (HDPE)高密度聚乙烯 （HDPE）	37
Polypropylene 聚丙烯	19.7-80
High density polyethylene 高密度聚乙烯	37
Stainless steel AISI 302 不锈钢 AISI 302	860
Aluminium alloy 2014-T6 铝合金 2014-T6	483
Aluminium alloy 6063-T6 铝合金 6063-T6	248
E-Glass alone 单独使用 E-Glass	3450
E-Glass in a laminate 层压板中的无电玻璃	1500
Carbon fiber alone 单独碳纤维	4127
Carbon fiber in a laminate 层压板中的碳纤维	1600
Kevlar 凯夫拉	2757
Pine wood (parallel to grain)松木（平行于纹理）	40

(Aramid fibers, 2015) （芳纶纤维，2015 年）

Conclusion 结论 The current production of continuous aramid fibres (both low and high modulus) worldwide is estimated at about 60,000 metric tons (MT)/year, only 4% of which goes into composite applications. This represents 2,400 MT/year, compared to 40,000 MT/year of carbon and five million MT/year of glass fibre.目前全球连续芳纶纤维（低模量和高模量）的产量估计约为 60,000 公吨 （MT）/年，

其中只有 4% 用于复合材料应用。这意味着 2,400 公吨/年，而碳和 500 万吨/玻璃纤维。

You may also like: High Performance Polyethylene Fibers – An Overview 您可能还喜欢：高性能聚乙烯纤维 – 概述

The development of para-aramid fibres (especially high-modulus) has been slowed down by certain disadvantages that have turned up gradually with their use. These disadvantages include poor compression strength, microcracking due to the high thermal expansion coefficient in the width direction, high moisture regain, and problems with processing (cutting, machining, finishing, surface aspect).对位芳纶纤维（尤其是高模量纤维）的发展因某些缺点而减慢，这些缺点随着它们的使用而逐渐显现出来。这些缺点包括压缩强度差、由于宽度方向的高热膨胀系数而导致的微裂纹、高回潮以及加工问题（切割、加工、精加工、表面方面）。

In addition, these fibres face stiff competition from carbon, which has much better mechanical properties and is available at lower cost. As a result, there is currently little to report in the way of major developments for composites applications. 此外，这些纤维还面临着来自碳的激烈竞争，而碳具有更好的机械性能并且成本更低。因此，目前几乎没有关于复合材料应用重大发展的报道。

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6. 凯夫拉纤维

Kevlar Fiber: Types, Properties, Manufacturing Process and Applications 凯夫拉纤维：类型、特性、制造工艺和应用

December 29, 2014 by Mazharul Islam Kiron 十二月 29， 2014by Mazharul Islam Kiron

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An Overview of Kevlar Fiber 凯夫拉纤维概述

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INTRODUCTION 介绍 Kevlar is the trade name of Dupont's para-aramide fiber. The discovery of Kevlar Aramid fiber begins in1965. a DuPont research scientist synthesized a series of paraoriented aromatic polyamides.Kevlar 是 Dupont 对位芳纶纤维的商品名称。凯夫拉芳纶纤维的发现始于 1965 年。杜邦的一位研究科学家合成了一系列对位拉伸芳香族聚酰胺。

Kevlar Aramid fiber was commercialized by DuPont in 1972. The word 'Aramid' is a generic term for a manufactured fibre in which the fibre forming substance is a long chain synthetic polyamide in which at least 85% of the amide linkages are attached directly to the two aromatic rings as defined by the U.S. federal trade commission. Kevlar fibre is based on poly (P-phenylene terephthalamide)Kevlar 芳纶纤维于 1972 年由杜邦公司商业化。"芳纶"一词是人造纤维的通用术语，其中纤维形成物质是长链合成聚酰胺，其中至少 85% 的酰胺键直接连接到美国联邦贸易委员会定义的两个芳香环上。凯夫拉纤维基于聚（对苯二甲酰胺）

 Fig:

kevlar 无花果： kevlar

Aramid fibers are being considered for use in many structural engineering applications. Many of these would require knowledge of the long-term creep behaviour under constant loads. Creep tests at ambient conditions are considered to be the most reliable way of predicting the creep behaviour of 芳纶纤维正在考虑用于许多结构工程应用。其中许多需要了解恒定载荷下的长期蠕变行为。环境条件下的蠕变测试被认为是预测

Aramid at the same time useful conclusions about the viscoelastic properties of the material can be made.同时，可以得出关于材料粘弹性的有用结论。

DuPont Kevlar Aramid fibre is used to make a variety of clothing, accessories, and equipment safe and cut resistant. It's lightweight and extraordinarily strong, with five times the strength of steel on an equal-weight basis. Best known for its use in ballistic and stab-resistant body armor, Kevlar® brand Aramid fibre has shown its own heroism in helping to save the lives of thousands of people around the world.杜邦凯夫拉芳纶纤维用于制造各种服装、配饰和设备，确保其安全且耐切割。它重量轻且非常坚固，在同等重量的基础上，其强度是钢的五倍。Kevlar® 品牌芳纶纤维以其用于防弹和防刺防弹衣而闻名，在帮助挽救全球数千人的生命方面展示了自己的英雄主义。

The result Kevlar Aramid fibre is now successfully used in everything from vehicles and industrial clothing to fibre optics and city roads 结果凯夫拉芳纶纤维现在已成功用于从汽车和工业服装到光纤和城市道路的方方面面

What is Kevlar? 什么是凯夫拉尔？

- Kevlar is an organic fiber in the aromatic polyamide family.Kevlar 是芳香族聚酰胺家族中的一种有机纤维。
- Kevlar has unique combination of high strength, high modulus, toughness and thermal stability.Kevlar 具有高强度、高模量、韧性和热稳定性的独特组合。
- It was developed for demanding industrial and advanced-technology applications.它是为要求苛刻的工业和先进技术应用而开发的。
- Currently, many types of Kevlar are produced to meet a broad range of end uses 目前，生产多种类型的 Kevlar 以满足广泛的最终用途

ADVANTAGES 优势

- Higher tensile modulus than steel wire 比钢丝更高的拉伸模量
- High breaking tenacity 高断裂强度
- Very high kinetic energy absorption 极高的动能吸收
- 4-5-time strength than steel 强度是钢的 4-5 倍
- It has a much higher tensile modulus than steel wire 它具有比钢丝高得多的拉伸模量

DISADVANTAGES 弊

- Low elongation to brake 制动伸长率低
- Low electric conductivity 低导电性
- Low thermal shrinkage 低热收缩率

PROCESS OF KEVLAR MANUFACTURING 凯夫拉制造过程

P-phenylene diamine + terepthaloyl chloride 对苯二胺 + 对苯酰氯

↓ (Condensation polymerization with lithium chloride with low temp)↓ （低温氯化锂缩合聚合）

Poly (p-phenylene terephthalamide) + HCL 聚（对苯二苯二甲酰胺）+ HCL↓Liquid crystal polymer (LCP)液晶聚合物 （LCP）↓Dry-Jet wet spinning2 干喷湿纺 2↓Drawing at more than 300 ° c at 15-20 draw ratio 在 300 °C 以上和 15-20 拉伸比下拉伸↓FDY or staple fibre of KevlarFDY 或 Kevlar 的短纤维

The two raw materials, p-phenylene diamine and terephthaloyl chloride will

undergo low temperature polycondensation in alkyl amide solvent like dimethyl acetamide. The polymer from this reaction system is isolated by precipitation with water, neutralized and subsequently washed and dried.对苯二胺和对苯二醇氯这两种原料将在二甲基乙酰胺等烷基酰胺溶剂中发生低温缩聚反应。通过用水沉淀分离来自该反应体系的聚合物，中和，然后洗涤和干燥。

The polymer and sulphuric acid solution will be subjected to dry-jet wet spinning for producing Kevlar fibre or filament yarns, the Kevlar polymer decomposes in heat before reaching melt temperature, so melt spinning is not used.聚合物和硫酸溶液将经过干射湿纺以生产凯夫拉纤维或长丝，凯夫拉聚合物在达到熔融温度之前受热分解，因此不使用熔融纺丝。

CHARACTERISTICS OF ARAMID FIBRES 芳纶纤维的特性 Aramid fibres have unique properties that set them apart from other fibres. Aramid fibre tensile strength and modulus are significantly higher than those of earlier organic fibres and fibre elongation are lower. Aramid fibres can be woven on fabric looms more easily than brittle fibres such as glass, Carbon or ceramic. They also exhibit inherent resistance to organic solvents, Fuels, lubricants and exposure to flame.芳纶纤维具有独特的特性，使其有别于其他纤维。芳纶纤维的拉伸强度和模量明显高于早期有机纤维，纤维伸长率较低。芳纶纤维比玻璃、碳纤维或陶瓷等脆性纤维更容易在织物织机上编织。它们还表现出对有机溶剂、燃料、润滑剂和暴露于火焰的固有抵抗力。

Each type of aromatic polymer gives certain characteristic fibre properties. Because of its fibre and intrinsic polymer structure. Rather than going through an encyclopaedic description of the properties of the aromatic Polyamides, we propose in the following section to review some of the predominant studies that we believe are important in order to understand the unique properties of this class of fibre materials. The superimposed structures, such as the crystallites, the fibrils and the skin-core boundaries are definitely unique attributes that can be partially tailored through the fibre process engineering. This is worth examining in more detail. It is equally important to provide more insights into the pleated structure and the formation of the hydrogen bonds acting as zippers between the chains.每种类型的芳香族聚合物都赋予了某些特征性的纤维特性。因为它的纤维和本征聚合物结构。我们建议在下一节中回顾一些我们认为重要的主要研究，以了解这类纤维材料的独特性能，而不是对芳香族聚酰胺的特性进行百科全书式的描述。叠加结构，如微晶、原纤维和表皮核心边界，绝对是独特的属性，可以通过纤维工艺工程进行部分定制。这值得更详细地研究。同样重要的是，要更深入地了解褶皱结构和在链之间充当拉链的氢键的形成。

DIFFERENT TYPES OF KEVLAR 不同类型的凯夫拉尔纤维

- Kevlar – Tire cord yarnKevlar – 轮胎帘子线
- Kevlar 29 – Multipurpose yarnKevlar 29 – 多用途纱线
- Kevlar 49 – High modulus yarnKevlar 49 – 高模量纱线
- Kevlar 68 – Moderate modulus yarnKevlar 68 – 中等模量纱线
- Kevlar 100 – Coloured yarnKevlar 100 – 彩色纱线
- Kevlar 119 – High elongation yarnKevlar 119 – 高伸长率纱线
- Kevlar 129 – High tenacity yarnKevlar 129 – 高韧性纱线

- Kevlar 149 – Ultra high modulus yarnKevlar 149 – 超高模量纱线

Kevlar fibre and filament come in a variety of types, each with its own unique set of properties and performance characteristics for different protection needs.凯夫拉纤维和长丝有多种类型，每一种都有自己独特的特性和性能特征，可满足不同的保护需求。

Kevlar 29 凯夫拉尔 29 The original family of product types of Kevlar having similar tensile properties with many decitex and finishes. These yarns are used in ballistic applications, ropes and cables, protective apparel such as cut-resistant gloves, in life protection uses such as helmets, vehicular armoring and plates, and as rubber reinforcement in tires and automotive hoses.Kevlar 的原始产品系列具有相似的拉伸性能，具有许多 decitex 和饰面。这些纱线用于防弹应用、绳索和电缆、防护服（如防割手套）、生命保护用途（如头盔、车辆装甲和板），以及轮胎和汽车软管中的橡胶增强材料。

Kevlar 49 凯夫拉 49 High modulus type used primarily in fiber optic cable, textile processing, plastic reinforcement, ropes, cables, and composites for marine sporting goods and aerospace applications.高模量类型主要用于光纤电缆、纺织品加工、塑料增强、绳索、电缆和复合材料，用于海洋运动用品和航空航天应用。

Kevlar 100 凯夫拉 100 Producer colored Kevlar yarns, used in ropes and cables, tapes and strappings, gloves and other **protective apparel**, and sporting goods.生产商为凯夫拉纱线着色，用于绳索和电缆、胶带和捆扎带、手套和其他防护服以及体育用品。

Kevlar 119 凯夫拉 119 [Kevlar]Higher elongation, flexible fatigue-resistant yarn types found in mechanical rubber goods, such as tires, automotive belts and hoses.机械橡胶制品（如轮胎、汽车皮带和软管）中发现的高伸长率、柔韧的抗疲劳纱线类型。

Kevlar 129 凯夫拉 129 [Kevlar]Lightweight, high-performance, and high tenacity type of yarns used in motorcycle racing gear, life protection accessories, ropes and cables, and high-pressure hoses used in the oil and gas industry.轻质、高性能、高韧性的纱线，用于摩托车赛车装备、生命保护配件、绳索和电缆，以及用于石油和天然气行业的高压软管。

Kevlar KM2 凯夫拉 KM2 Woven into fabric meeting performance requirements for helmets and vests for military and high-performing UDs for spall liners.编织成织物，满足军用头盔和背心的性能要求，以及剥落衬里的高性能 UD。

Kevlar KM2 plus 凯夫拉 KM2 plus High tenacity, high toughness, finer decitex fiber used in vests and helmet for both military and enforcement officers.高韧性、高韧性、更细的 decitex 纤维，用于军队和执法人员的背心和头盔。

Kevlar AP 凯夫拉 AP Kevlar AP for advanced performance dramatically improves cost-effectiveness and design flexibility to help manufacturers build learner, more robust consumer and industrial products.Kevlar AP 具有先进的性能，可显著提高成本效益和设计灵活性，帮助制造商构建更耐用、更强大的消费类和工业产品。

PROPERTIES OF KEVLAR FIBER 凯夫拉纤维的特性 Kevlar Aramid fibre has a high breaking tenacity, which is several times that of steel wire; it also, has a much higher tensile modulus than steel wire, fibre glass. Kevlar fibre is inherently

stable at relatively at relatively high temperature and has very small shrinkage at elevated temperature, low creep and high glass transition temperature. It is corrosion resistant, non-conductive and resistant to most chemicals except strong acids and bases. The typical properties of Kevlar Aramid fibre yarns are shown in table-4.凯夫拉芳纶纤维具有很高的断裂强度，是钢丝的数倍;它还具有比钢丝、玻璃纤维高得多的拉伸模量。凯夫拉纤维在相对较高的温度下具有固有的稳定性，并且在高温、低蠕变和高玻璃化转变温度下具有非常小的收缩率。它具有耐腐蚀性，不导电，并且耐大多数化学品（强酸和强碱除外）。凯夫拉芳纶纤维纱线的典型特性如表 4 所示。

Yarn properties 纱线特性	Kevlar and Kevlar 29 凯夫拉尔和凯夫拉尔 29	Kevlar 49 凯夫拉 49	Kevlar 68 凯夫拉尔 68	Kevlar 119 凯夫拉 119 [Kevlar]	Kevlar 129 凯夫拉 129 [Kevlar]	Kevlar149 凯夫拉 149
Tensile strength gpd 抗拉强度 gpd	23	23	23	24	26.5	18
Initial modulus gpd 初始模量 gpd	550	950	780	430	750	1100
Elongation % 伸长率 %	3.6	2.8	3.0	4.4	3.3	1.5
Density g/cc 密度 g/cc	1.44	1.45	1.44	1.44	1.45	1.47
Moisture regain% 回潮率%	6	4.3	4.3	–	–	1.5

APPLICATIONS OF KEVLAR FIBER 凯夫拉纤维的应用

Brake pads 刹车片 Brake pads made of Kevlar pulp are better equipped to withstand the wear and tear that friction creates with their enhanced thermal stability and inherent abrasion resistance; reinforced brake pads made of Kevlar are designed for long life and safe, quite braking.由 Kevlar 浆粕制成的刹车片具有增强的热稳定性和固有的耐磨性，可以更好地承受摩擦产生的磨损;由 Kevlar 制成的加固刹车片旨在实现长寿命和安全、相当制动。

Gaskets 垫片 Due to its chemical and thermal stability, reinforced made of Kevlar helps make gaskets strong and durable.由于其化学和热稳定性，由 Kevlar

制成的增强材料有助于使垫圈坚固耐用。

Clutches 离合器 Kevlar is also effective in clutches, which are subject to severe frictional stress. Tests have shown that clutch linings with Kevlar do not require service or replacement as often as standard clutch linings.Kevlar 对受到严重摩擦应力的离合器也很有效。测试表明，带有 Kevlar 的离合器衬片不需要像标准离合器衬片那样频繁地进行维修或更换。

Vehicle armor 车辆装甲 Kevlar provides an effective, lightweight armor solution that helps protect against ballistic attack, allowing cars and light trucks to retain most of their original handling characteristics while stopping multiple rounds. Law enforcement agencies, cash security companies and people who live or work in hostile environments trust Kevlar armor to help increase security in vehicles where weight is a critical factor.Kevlar 提供了一种有效的轻型装甲解决方案，有助于抵御弹道攻击，使汽车和轻型卡车能够在阻止多发子弹的同时保留其大部分原始操控特性。执法机构、现金安全公司以及在恶劣环境中生活或工作的人都相信 Kevlar 装甲可以帮助提高重量是关键因素的车辆的安全性。

Marine Composites 船用复合材料 Kevlar reinforcement helps reduce weight without compromising strength in marine, energy, and maritime vessel composite 凯夫拉增强材料有助于减轻重量，而不会影响船舶、能源和海事船舶复合材料的强度

Armor system 装甲系统 Armor systems of Kevlar Aramid fiber are designed for the protection of human lives and vital equipment against ballistic threats, the ballistic resistance of Kevlar Aramid can be attributed to its excellent thermal properties, high crystalinity, highly oriented fine structure and high tensile properties. The high glass transition temperature and thermal stability of Kevlar fibre ensure the integrity of ballistic structure at relatively high temperature in a ballistic event.凯夫拉尔芳纶纤维的装甲系统旨在保护人类生命和重要设备免受弹道威胁，凯夫拉芳纶的防弹性可归因于其优异的热性能、高结晶度、高度取向的精细结构和高拉伸性能。凯夫拉纤维的高玻璃化转变温度和热稳定性确保了弹道事件中相对高温下弹道结构的完整性。

Aerospace, Marine, & Rail 航空航天、海洋和铁路 DuPont Kevlar helps manufacturers in aerospace, marine, and rail industries to build aircraft, ships, and rail carriages. Le performance characteristics of Kevlar® and can help to increase fuel efficiency and decrease operating and maintenance costs.杜邦 Kevlar 帮助航空航天、船舶和铁路行业的制造商制造飞机、轮船和铁路车厢。Le 性能特点 凯夫拉® 并有助于提高燃油效率并降低运营和维护成本。

Automotive Components Reinforcements 汽车零部件加固 Kevlar fibers help to improve the safety, performance, and durability of automotive components for a wide variety of vehicles, from passenger cars and light trucks to professional race cars. Kevlar help provide inherent strength in automotive components, inside and out.Kevlar 纤维有助于提高从乘用车和轻型卡车到专业赛车的各种车辆的汽车部件的安全性、性能和耐用性。Kevlar 有助于为汽车部件提供内外的内在强度。

Automotive Hoses & Belts Reinforcements 汽车软管和皮带加固 DuPont Kevlar fiber helps improve the safety, performance, and durability of automotive components such as automotive hoses and automotive belts for a wide variety of

vehicles, from passenger cars and trucks to professional race cars 杜邦凯夫拉纤维有助于提高汽车部件的安全性、性能和耐用性，例如从乘用车和卡车到专业赛车等各种车辆的汽车软管和汽车皮带

Fiber Optics 光纤 Kevlar® provides high tensile strength, helping to safeguard fibre optic cables against mechanical stresses to ensure optimal performance. Learn how the inherent dielectric properties, light weight, small diameter, and flexibility of Kevlar® meet requirements for a wide variety of fibre optic cable applications.Kevlar® 提供高抗拉强度，有助于保护光纤电缆免受机械应力，以确保最佳性能。了解 Kevlar® 固有的介电特性、重量轻、直径小和柔韧性如何满足各种光缆应用的要求。

Military Helmets 军用头盔 Kevlar fiber is a very important part of the military's assets. By incorporating its inherent protective technology into military helmets, it has helped to save thousands of lives.凯夫拉纤维是军队资产中非常重要的一部分。通过将其固有的防护技术整合到军用头盔中，它帮助挽救了数千人的生命。

Ropes & Cables 绳索和电缆 Kevlar ropes and cables help deliver performance and value to customers in the fine gauge cable industry by helping to provide excellent robustness, fatigue resistance, shrinkage, and durability. From land to sea to space, learn how Kevlar brand fibre has helped strengthen ropes and cables to stand up to temperature extremes and harsh environments.Kevlar 绳索和电缆通过帮助提供出色的坚固性、抗疲劳性、收缩性和耐用性，帮助为细规格电缆行业的客户提供性能和价值。从陆地到海洋再到太空，了解 Kevlar 品牌纤维如何帮助加固绳索和电缆，使其能够承受极端温度和恶劣环境。

Sporting Goods Apparel & Accessories 体育用品服装和配饰 The quest for lighter, stronger, and safer sporting goods has made Kevlar® a popular choice for both equipment manufacturers and consumers. Learn how the same properties and performance attributes that have proven so effective in industrial and life-protection applications also appeal to athletes, outdoors enthusiasts and anyone else looking for better performance in sports products.对更轻、更坚固、更安全的体育用品的追求使 Kevlar® 成为设备制造商和消费者的热门选择。了解在工业和生命保护应用中被证明如此有效的相同特性和性能属性如何吸引运动员、户外运动爱好者和任何寻求更好运动产品性能的人。

CONCLUSION 结论 This research indicates that you can enjoy the superior protection and long wear life of protective clothing made of KEVLAR without undue concern about the effects of heat and heat stress.这项研究表明，您可以享受由 KEVLAR 制成的防护服的卓越保护和长磨损寿命，而无需过度担心热和热应力的影响。

The lighter weight of KEVLAR fabrics makes them less likely to cause heat stress in hot, humid environments than other heavier fabrics.KEVLAR 面料的重量更轻，因此与其他较重的面料相比，它们在炎热、潮湿的环境中不太可能引起热应激。

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7. 人造纤维

Problems of Man-made Fibers & Methods of Rectification 人造纤维的问题和纠正方法

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Problems Associated of Man-made Fibers and Their Methods of Rectification 人造纤维的相关问题及其校正方法

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Man-made fibers are not a mere alternative to **natural fibers** but are new materials of high functionality and high performance. **Manmade fibers** are produced in factories, which need not be too far from textile manufacturing areas. Specific qualities of fibers can be produced deliberately and quickly in accordance with the demand. The filaments can be produced as fine or as coarse as required, staple lengths can be cut exactly to order. Fibers can be produced with high degree of lustre, with reduced or completely dull lustre, as required. Unlike natural fibers, the final product of man made fibers does not require cleaning.人造纤维不仅仅是天然纤维的替代品，而是具有高功能性和高性能的新型材料。人造纤维是在工厂生产的，这些工厂不需要离纺织品制造区太远。可以根据需求有意识地快速生产特定品质的纤维。长丝可以根据需要生产成细丝或粗丝，短纤长度可以精确按订单切割。纤维可以生产出具有高度光泽的纤维，根据需要减少或完全暗淡的光泽。与天然纤维不同，人造纤维的最终产品不需要清洁。

Fig: Man-made fiber 图：人造纤维

Without above advantages of man-made fibers have many problems. In general, the manmade fibres are generally hydrophobic in nature; this is necessarily a

disadvantage when their products have to be worn next to the skin. These fabrics fail to absorb the perspiration, thus the wearer feels discomfort in hot climate. Manmade fiber fabrics are a little difficult to sew. Seams do not hold tight as in natural fiber fabrics. Without these disadvantages, man-made fiber also problems occur during processing. In this article I have discussed some problems associated with man-made fibers and their methods of rectification.没有上述优点的人造纤维就存在很多问题。一般来说，人造纤维本质上通常是疏水的;当他们的产品必须贴身佩戴时，这必然是一个缺点。这些面料无法吸收汗水，因此穿着者在炎热的气候下会感到不适。人造纤维织物有点难以缝制。接缝不像天然纤维织物那样紧紧。如果没有这些缺点，人造纤维在加工过程中也会出现问题。在本文中，我讨论了与人造纤维相关的一些问题及其校正方法。

Generation of Static Charge:静电荷的产生：Man-made fibers (MMFs) have very high electrical resistance, due to which when they are rubbed against each other during processing in spinning machineries; a very high static charge is generated among fiber fleece which causes leakage of static charge in air and increases the possibilities of fire hazards in the **spinning mill**.人造纤维 （MMF） 具有非常高的电阻，因此在纺纱机械的加工过程中，当它们相互摩擦时;纤维绒中会产生非常高的静电荷，导致空气中的静电荷泄漏，并增加纺纱厂发生火灾的可能性。

Also generation of static charge causes difficulty in material handling: the filaments in a charged warp will blow out away from one another; there will be “ballooning” of a bundle of slivers; cloth will not fold down neatly upon itself when it comes off a finishing machine and so on.此外，静电荷的产生也会导致材料处理困难：带电经纱中的细丝会彼此吹走;会有一捆条子的 “气球化”;当布料从整理机等处脱落时，它不会整齐地折叠起来。

Remedies: 补救 措施：

1. Use of electrostatic eliminators in the Textile Industries.静电消除器在纺织工业中的应用。
2. Use of proper Antistatic agents during spinning and finishing treatments of fabrics.在织物的纺纱和整理处理过程中使用适当的抗静电剂。

Low Pilling Resistance: 低抗起球性：MMFs are having high molecular weight and proneness to static generation due to which the bailing up of fiber ends on the surface of fabrics can be easily occurred. This gives unpleasant wearing comfort and also fabric lusture decreases.MMF 具有高分子量并且容易产生静电，因此很容易发生纤维末端在织物表面的凝固。这会带来令人不快的穿着舒适度，并且织物光泽度也会降低。

Remedies: 补救 措施：

1. Singeing of synthetic fabrics is done to reduce pilling. In this fabric is passed over a gas flame/ heated rollers to burn the protruding fibers.对合成织物进行烧毛以减少起球。在这种织物中，通过气体火焰/加热辊以燃烧突出的纤维。

Low Moisture Absorption: 低吸湿性：MMFs have very low moisture regain due to which sweat and moisture locks between the body and the fabric giving wearing discomfort.MMF 的水分回流率非常低，因此汗水和湿气会锁在身体和织物之间，给人带来穿着不适。

Remedies: 补救 措施：

1. Blending with natural fibers like **cotton**.与棉花等天然纤维混纺。
2. Making fibers of Trilobal cross-section.制作三叶横截面的纤维。

Low Air Permeability: 低透气性：Fabrics made up from MMFs are generally of high thread sets (no. of ends/ picks per inch) due to which air permeability and breathability of fabrics decreases which gives improper feel and heat retention during wearing.由 MMF 制成的织物通常具有高线组（每英寸的末端数/镐数），因此织物的透气性和透气性降低，从而在穿着过程中产生不合适的手感和保温性。

Remedies: 补救 措施：

1. Texturizing of yarns made from MMFs can increase the bulk of yarn increasing breathability of fabric.由 MMF 制成的纱线的变形可以增加纱线的体积，从而提高织物的透气性。

High Lusture: 高光泽度：Due to more regular and circular cross-section of MMFs, the fiber reflects more light than natural fibers resulting in very high lusture of the fabric which is very unpleasant to see by others.由于 MMF 的横截面更规则和圆形，纤维比天然纤维反射更多的光，导致织物的光泽非常高，这让其他人非常不舒服。

Remedies: 补救 措施：

1. Suitable Delustering agents like Titanium oxide (TiO2) are used during spinning of MMFs.在 MMF 的纺丝过程中使用合适的去污剂，如氧化钛 （TiO2）。

Rough or Harsh Feel: 粗糙或粗糙的感觉：**Synthetic fibers** may give rough/ harsh feel, causing itches (reddening of skin) and making it unsuitable for fabrics like pajamas, undergarments, etc.合成纤维可能会给人粗糙/粗糙的感觉，引起瘙痒（皮肤发红），使其不适合用于睡衣、内衣等面料。

Remedies: 补救 措施：

1. Use of proper Softening finishes on the fabric.在织物上使用适当的软化整理剂。

Low Resistance to Soiling:低抗污性：Fabrics made form MMFs can easily attract dirt and dust form environment due to static charge generation giving a fuzzy appearance to fabric.由 MMF 制成的织物很容易吸收环境中的污垢和灰尘，因为会产生静电，使织物看起来模糊不清。

Remedies: 补救 措施：

1. Use of proper soil resistant finishes on the fabric.在织物上使用适当的防污整理剂。

Low Heat Retention: 低保温性：Nylon is said to be cool in winter and warm in summer because fiber have low heat retention. The body heat cannot be stored between body and fabric due to absence of air pockets in the fabric.据说尼龙冬天凉爽，夏天温暖，因为纤维的保温性低。由于织物中没有气穴，体热无法储存在身体和织物之间。

Remedies: 补救 措施：

1. Fibers are made with hollow Cross-Section for better heat retention. 纤维采用空心横截面制成，具有更好的保温性。

8. 不同天然纤维的杂质百分比

Impurities of Different Natural Fibers with Percentage 不同天然纤维的杂质百分比

October 15, 2014 by Mazharul Islam Kiron 十月 15， 2014by Mazharul Islam Kiron

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Impurities of Different Natural Fibers with Percentage 不同天然纤维的杂质百分比

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Impurities in different natural fibers:不同天然纤维中的杂质：The term impurity is used to described material other than fiber which is found in raw or processed stock. Generally, impurities must be removed during the spinning process, so the type and amount of impurity is also of importance to the yarn manufacturer.术语杂质用于描述在原材料或加工原料中发现的纤维以外的材料。通常，在纺纱过程中必须去除杂质，因此杂质的类型和数量对纱线制造商也很重要。

Every **natural textile fiber** is made with a little bit of impurities which are totally unusable. Before use that fiber its need to remove those impurities from the fiber with keeps the useable part of that fiber. Various quantities of impurities and various types of impurities are included in textile natural fibers. Different types of natural fibers, impurities and quantities are given blew.每一种天然纺织纤维都是由一点点完全无法使用的杂质制成的。在使用该纤维之前，需要去除纤维中的这些杂质，以保持该纤维的可用部分。纺织天然纤维中包含各种数量的杂质和各种类型的杂质。给出了不同类型的天然纤维、杂质和数量。

Impurities of Cotton Fiber:棉纤维的杂质：Cotton is a uni-cellulose fiber. Cellulose is the use able and main part of the cotton fiber. 94% cellulose and 6% impurities are made a natural cotton fiber.棉花是一种单纤维素纤维。纤维素是棉纤维的可利用和主要部分。94% 的纤维素和 6% 的杂质制成天然棉纤维。

You may also like: Chemical Composition of Cotton Fiber 您可能还喜欢：棉纤维的化学成分

Fig: Cotton fiber 无花果：棉纤维

The name and the percentage of impurities are given below:杂质的名称和百分比如下：

- Protein ——————————1.3% 蛋白质 ——————————1.3%
- Pectin's ——————————1.2% 果胶——————————1.2%
- Oil, Fat, Wax ——————————0.6%油、脂肪、蜡 ——————————0.6%
- Mineral Matters ——————————— 1.3%矿产 ——————————1.3%
- Ash ——————————-0.5% 灰分 ——————————-0.5%
- Others ——————————1.1% 其他 ——————————1.1%

————————————————————————————

- Total Impurities ——————————6%总杂质 ——————————6%
- Cellulose ——————————- 94%纤维素——————————- 94%

————————————————————————————-……..Total: ——————————100%.....总计：——————————100%

NB: Cellulose is the main useable element in cotton fiber & the quantity of impurities and cellulose could be less or high.**铌：**纤维素是棉纤维中的主要可用元素，杂质和纤维素的数量可能会少或高。

Impurities of Jute Fiber:黄麻纤维的杂质：Jute fiber is a multi-cellulose fiber and the main useable element is cellulose in this fiber. Generally 65% Cellulose and 35% impurities are including in a jute fiber, It could be less or high.黄麻纤维是一种多纤维素纤维，这种纤维中的主要可用元素是纤维素。黄麻纤维中通常含

有 65% 的纤维素和 35% 的杂质，它可能更少或更高。

Fig: Jute fiber 图：黄麻纤维

Percentage and the name of impurities in jute are given below:黄麻中杂质的百分比和名称如下：

Hemicelluloses ——————————22.2%半纤维素 ——————————22.2%Lignin ——————————10.8%木质素 ——————————10.8%Color pigment, Regions and others ———2.0%彩色颜料、区域和其他 ———2.0%——————————Total Impurities ——————————35%总杂质 ——————————35%

Cellulose ——————————-65%纤维素 ——————————-65%——————————

Total: ——————————-100%总计：——————————-100%

NB: Cellulose is the main useable element in Jute fiber & the quantity of impurities and cellulose could be less or high.**铌：**纤维素是黄麻纤维中的主要可用元素，杂质和纤维素的数量可能会少或高。

Impurities of Wool Fiber:羊毛纤维的杂质：Wool is a natural animal fiber. The authentic element of wool is keratin. 61% keratin and 39% impurities are made-up the natural animal wool fiber. The impurities are Wool Wax or grease, Suint, dirt, burrs, minaret meters, water and others. Let's have a look of percentage. It's could be less of high.羊毛是一种天然的动物纤维。羊毛的正宗元素是角蛋白。61% 的角蛋白和 39% 的杂质由天然动物羊毛纤维组成。杂质是羊毛蜡或油脂、Suint、污垢、毛刺、尖塔仪表、水等。让我们看看百分比。它可以不那么高。

You may also like: Physical and Chemical Properties of Wool Fiber 您可能还喜欢：羊毛纤维的物理和化学性质

Fig: Wool fiber 图：羊毛纤维

Percentage and the name of impurities in wool are given below:羊毛中杂质的百分比和名称如下：

Wool Wax or grease ——————————11%羊毛蜡或油脂 ——————————11%Suint——————————8% 流 出 ——————————8%Dirt ——————————8% 污垢 ——————————8%Burrs minaret meters, Water and others ——12%毛刺尖塔仪、水和 其 他 ——12%——————————————————————————-Total Impurities ——————————39%总杂质 ——————————39%

Keratin ——————————61%角蛋白 ——————————61%——————————————————————————-Total: ——————————- 100%总计：——————————-100%

NB: Keratin is the main useable element in Wool fiber & the quantity of impurities and Keratin could be less or high.**铌：**角蛋白是羊毛纤维中主要可用的元素，杂质和角蛋白的数量可能会少或高。

Impurities of Silk Fiber:蚕丝纤维的杂质：Silk is a natural animal fiber which one is produce from silk worm. Sericin is the main impurities in the **silk fiber**. Fibroin is the main element is the main part of the silk its called pure silk.蚕丝是一种天然的动物纤维，由蚕制成。丝胶是丝纤维中的主要杂质。丝素蛋白是丝的主要元素，是真丝的主要部分，称为纯丝。

Fig: Silk fiber 图：蚕丝纤维

Percentage of impurities of silk fiber are given below:蚕丝纤维杂质的百分比如下：

Sericin ————————————————-22%丝胶 ————————————————-22%Wax ———————————————— 1.5% 蜡———————————————— 1.5%Mineral salt, color, Pigment and others ——0.5%矿物盐、色素、颜料和其他 ——0.5%————————————————————————————————————Total Impurities ————————————————-24%总杂质 ————————————————-24%

Fibroin ————————————————76%素蛋白 ————————————————76%————————————————————————————————-Total: ————————————————————————-100% 总 计 ： ————————————————————————-100%

NB: Fibroin is the main useable element in Silk fiber & the quantity of impurities and fibroin could be less or high.**铌：**丝素蛋白是丝纤维中的主要可用元素，杂质和丝素蛋白的数量可能会少或高。

9. 天然纤维和人造纤维的区别

Difference between Natural Fiber and Man Made Fiber 天然纤维和人造纤维的区别

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Difference between Natural Fiber and Man Made Fiber 天然纤维和人造纤维的区别

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Introduction: 介绍： Textile fiber is an individual, fine, hair-like substance, which forms the fundamental components of all textiles. There are mainly two types of fiber. One is natural fiber and another is synthetic or man made fiber. Natural fibers are extracted from plants and animals. Manmade fiber are polyester, rayon, viscose staple fiber. Its is a process of wood pulp chemically treated and processed to make a fiber equal to natural fiber with same qualities.纺织纤维是一种单独的、细小的、头发状的物质，它构成了所有纺织品的基本组成部分。纤维主要有两种类型。一种是天然纤维，另一种是合成纤维或人造纤维。天然纤维是从植物和动物中提取的。人造纤维是涤纶、人造丝、粘胶短纤维。它是木浆经过化学处理和加工的过程，以制造出与具有相同品质的天然纤维相等的纤维。

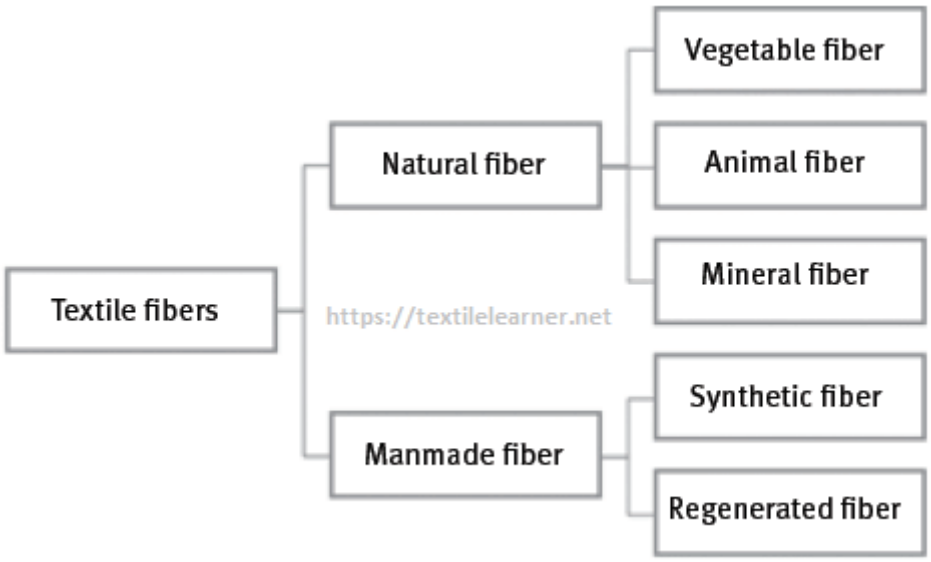

Fig-1: Classification chart of textile fibers 图 1：纺织纤维的分类图

Natural fibers: 天然纤维： Natural fibers are those provided by Nature in ready-made form and need only to be extracted. Natural fibers are divided into three main classes according to the nature of source (origin), i. e. vegetable fibers, animal fibers, and mineral fibers as shown in Fig-2. Natural fibers such as cotton fiber, jute

fiber, **wool fiber**, hemp, kenaf, jute, sisal fiber, banana, flax, oil palm, etc. have been in considerable demand in recent years due to their eco-friendly and renewable nature. In addition, the natural fibers have low density, better mechanical and thermal properties and are biodegradable.天然纤维是大自然以现成形式提供的纤维，只需要提取即可。天然纤维根据来源的性质（来源）分为三大类，即植物纤维、动物纤维和矿物纤维，如图 2 所示。棉纤维、黄麻纤维、羊毛纤维、麻、洋麻、黄麻、剑麻纤维、香蕉、亚麻、油棕等天然纤维由于其环保和可再生的特性，近年来需求量很大。此外，天然纤维密度低，机械和热性能更好，并且可生物降解。

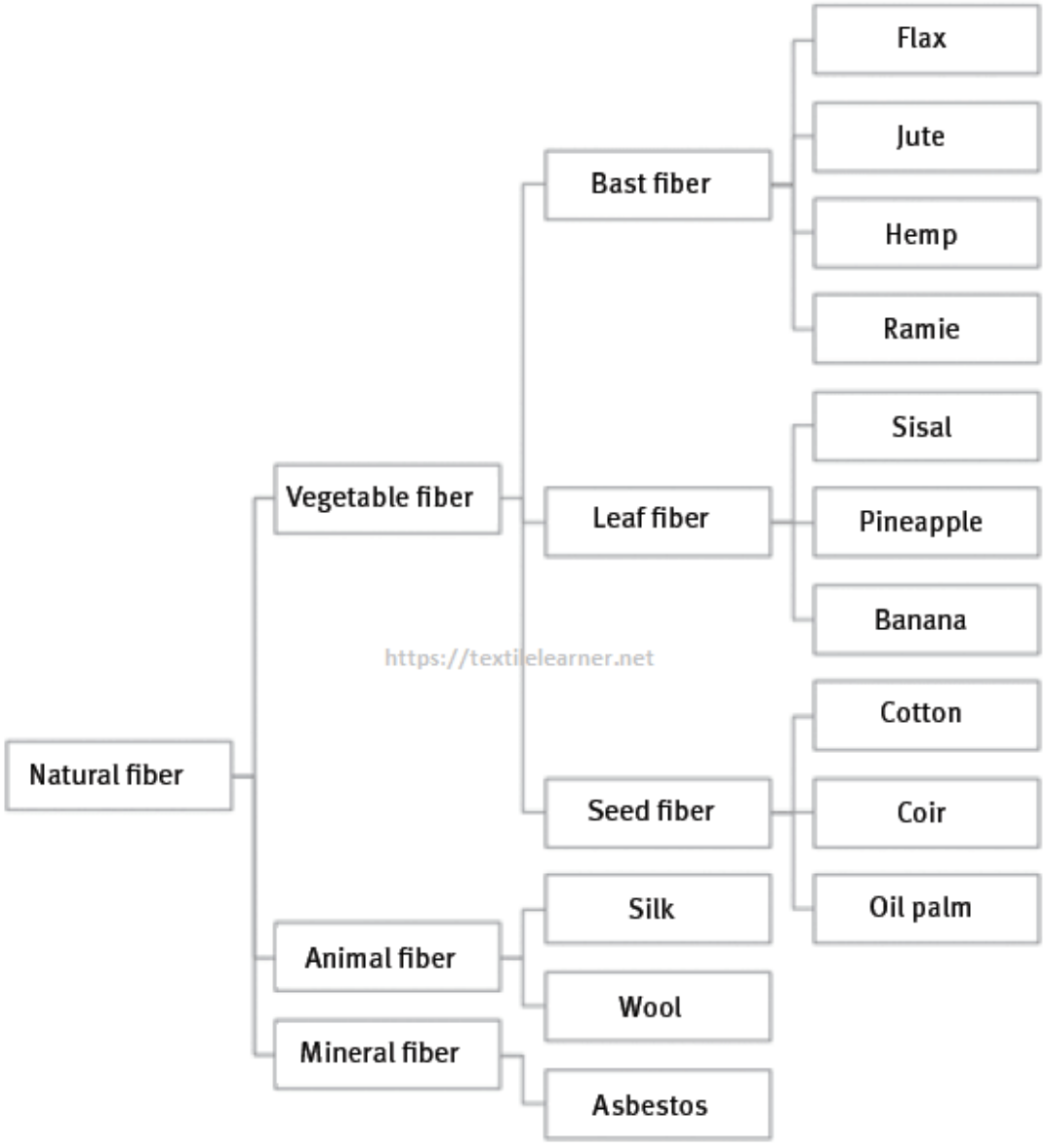

Fig-2: Natural fiber classification 图 2：天然纤维分类

Man Made fibers: 人造纤维：Man-made fibers are classified into synthetic and regenerated fibers as shown in Fig-3. The polymers used for the spinning of synthetic fibers are chemical based, while regenerated fibers are derived from a natural polymer, most commonly cellulose. Plyester, nylon, viscose, acetate, acrylic, carbon, aramid, **high performance fibers** etc manmade fiber.人造纤维分为合成纤

维和再生纤维，如图 3 所示。用于纺丝合成纤维的聚合物是化学基的，而再生纤维则来自天然聚合物，最常见的是纤维素。聚苯乙烯、尼龙、粘胶纤维、醋酸纤维、腈纶、碳纤维、芳纶、高性能纤维等人造纤维。

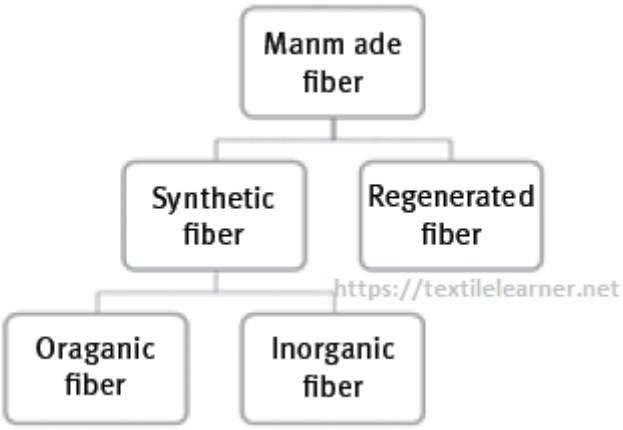

Fig: Classification of man made fiber 图：人造纤维的分类

Difference between Natural Fiber and Manmade Fiber:天然纤维和人造纤维的区别：

Fig-4: Natural fiber vs man made fiber 图 4：天然纤维与人造纤维

SL/No SL/无	Natural Fiber 天然纤维	Man Made Fiber 人造纤维
1	The fibers which we get from nature re called natural fiber.我们从大自然中获得的纤维称为天然纤维。	The fibers which are developed by man re called man-made fiber.人类开发的纤维称为人造纤维。
2	Generally fibers are hydrophilic.通常纤维是亲水性的。	Generally fibers are hydrophobic 通常纤维是疏水性的

3	No. of molecule controlled by nature.不。由自然控制的分子。	No. of molecule controlled by man.不。由人类控制的分子。
4	Length of the fiber is nature given.纤维的长度是自然给定的。	Length of the fiber is controlled by man.纤维的长度由人控制。
5	We get fibres as staple or filament.我们得到纤维作为短纤维或细丝。	No question about short or long staple fiber. It depends on man will.毫无疑问，短纤维或长纤维。这取决于人的意愿。
6	Less strength and durability.强度和耐用性较差。	More strength and durability.更坚固、更耐用。
7	No need to spinneret for spinning process.纺丝过程无需喷丝头。	Spinneret is essential for filament production.喷丝板对于长丝生产至关重要。
8	The fabric made from natural fiber is comfortable and good for health.由天然纤维制成的面料舒适且有益健康。	Man made fiber is not comfortable and not good for health.人造纤维不舒适，对健康不利。
9	Natural fiber is not favorable for finishing.天然纤维不利于整理。	Manmade fibers are favorable for finishing.人造纤维有利于整理。
10	Comparatively less durable than synthetic fiber.比合成纤维更不耐用。	Manmade fibers are more durable than natural fiber.人造纤维比天然纤维更耐用。
11	Fineness varies from one fiber to another fiber.细度因纤维而异。	Fineness depends on the manufacturers 纯度取决于制造商
12	Natural fiber has a great demand as humans wear.天然纤维在人类穿着时有很大的需求。	Synthetic fiber is widely used in every day life except humans wear.合成纤维广泛用于日常生活中，除了人类穿着。
13	Natural fiber is called environment friendly.天然纤维被称为环保型。	Manmade fibers are not environment friendly. Some fibers are harmful for the environment like: Polypropylene.人造纤维不环

		保。一些纤维对环境有害，例如：聚丙烯。
14	Natural fibers needs to scouring and bleaching process before wet processing.天然纤维在湿法加工之前需要经过煮练和漂白过程。	Scouring and bleaching is done in very few cases 在极少数情况下进行洗净和漂白
15	It is not possible to change in fiber structure.纤维结构不可能改变。	It is easy to change in fiber structure.纤维结构很容易改变。
16	It is expensive. 它很昂贵。	It is cheaper. 它更便宜。
17	Bears crimp naturally. 熊会自然弯曲。	We have to give crimp manually.我们必须手动进行压接。
18	It grows with its natural color. 它以其自然的颜色生长。	Colors are added in the solution bath as required.根据需要在溶液槽中添加颜色。
19	It is easy to dye the fiber.纤维很容易染色。	Coloration is not so easy as natural fiber.着色不像天然纤维那么容易。
20	Dust and impurities could be in natural fiber.天然纤维中可能含有灰尘和杂质。	No dust or impurities contain in synthetic fiber.合成纤维中不含灰尘或杂质。
21	The use of natural fibers are limited than manmade fiber.天然纤维的使用比人造纤维有限。	Manmade fibers are used in multi task than natural fiber.人造纤维比天然纤维用于多任务。

10. 尼龙：第一种合成纤维

Nylon: The First Synthetic Fiber 尼龙：第一种合成纤维

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Nylon: The First Synthetic Fiber 尼龙：第一种合成纤维

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Introduction: 介绍：Polyamides are polymers that contain an amide group (-CONH-) in it's backbone as a recurring part of the chain. They are frequently referred to as Nylon which has thermoplastic silky properties.聚酰胺是一种聚合物，其主链中含有酰胺基团 （-CONH-），是链中反复出现的部分。它们通常被称为尼龙，具有热塑性丝滑特性。

Nylon: 尼龙：Nylon was the first synthetic fiber produced in 1935 in USA. When less than 85% of amide linkage are attached directly to two aliphatic groups the polyamides are known as Nylon. Nylon fibers are made up of linear macromolecules whose structural units are linked by the amide (–NH–CO–) group. Therefore, these fibers are termed as the polyamides. The most common way for the production of nylon polymers is by the condensation of diamines with diacids.尼龙是 1935 年在美国生产的第一种合成纤维。当少于 85% 的酰胺键直接连接到两个脂肪族基团时，聚酰胺称为尼龙。尼龙纤维由线性大分子组成，其结构单元由酰胺 （–NH–CO–）基团连接。因此，这些纤维被称为聚酰胺。生产尼龙聚合物的最常见方法是二胺与二酸缩合。

Fig: Nylon fiber 图：尼龙纤维

Invention: 发明： Nylon was the first commercially successful synthetic polymer. Wallace Carothers is credited with the invention of synthetic rubber and nylon around 1933 at DuPont. It was first produced on February 28, 1935 at the DuPont Experimental Station. Fiber went commercial around 1938 and is still used extensively today. DuPont recouped all investment in Nylon 6,6 within 30 days of plant startup as there had been nothing like it before !!!尼龙是第一种在商业上取得成功的合成聚合物。Wallace Carothers 因 1933 年左右在杜邦发明合成橡胶和尼龙而受到赞誉。它于 1935 年 2 月 28 日在杜邦实验站首次生产。光纤在 1938 年左右开始商业化，至今仍被广泛使用。杜邦在工厂启动后的 30 天内收回了对尼龙 6,6 的所有投资，因为在此之前从未有过这样的投资!!

Nomenclature: 命 名 法： Nylons are formed mainly by condensation polymerization though they can also be formed by addition polymerization .尼龙主要通过缩合聚合形成，尽管它们也可以通过加成聚合形成。

It can be formed by 3 approaches –它可以由 3 种方法形成——

(1)From Aliphatic diamines & Aliphatic diacids –

$$nH_2N(CH_2)_xNH_2 + nHOOC(CH_2)_{y-2}COOH \rightarrow H-\left[NH(CH_2)_xNHCO(CH_2)_{y-2}CO\right]_n-OH+(2n-1)H_2O$$

(2)From Aliphatic Amino Acids –

$$nH_2N(CH_2)_{x-1}COOH \rightarrow H-[NH(CH_2)_{x-1}CO]_n-OH+(n-1)H_2O$$

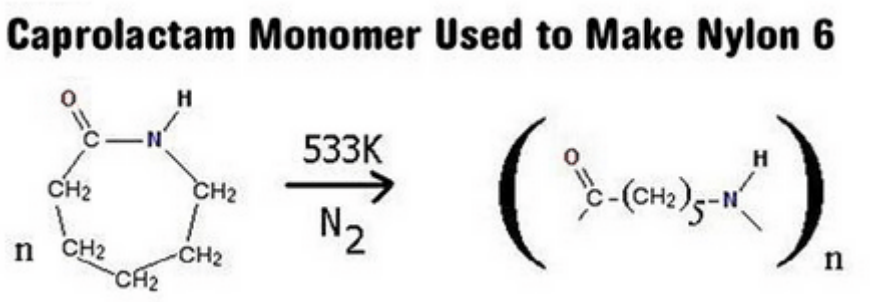
(3)From Lactams (Hydrolytic Polymerisation) –

$$nHN(CH_2)_{x-1}CO + H_2O \rightarrow H-[NH(CH_2)_{x-1}CO]_n-OH$$

Nylon 6,6: 尼龙 6,6： It's made from Adipic acid and Hexamethylene diamine. Both of these monomers contain 6 carbon atoms hence the name Nylon 6,6 . Before the name Nylon 6,6 was used, it was called by a codename "fiber 66".它由己二酸和己二胺制成。这两种单体都含有 6 个碳原子，因此得名尼龙 6,6 .在使用尼龙 6,6 这个名字之前，它的代号是"fiber 66"。

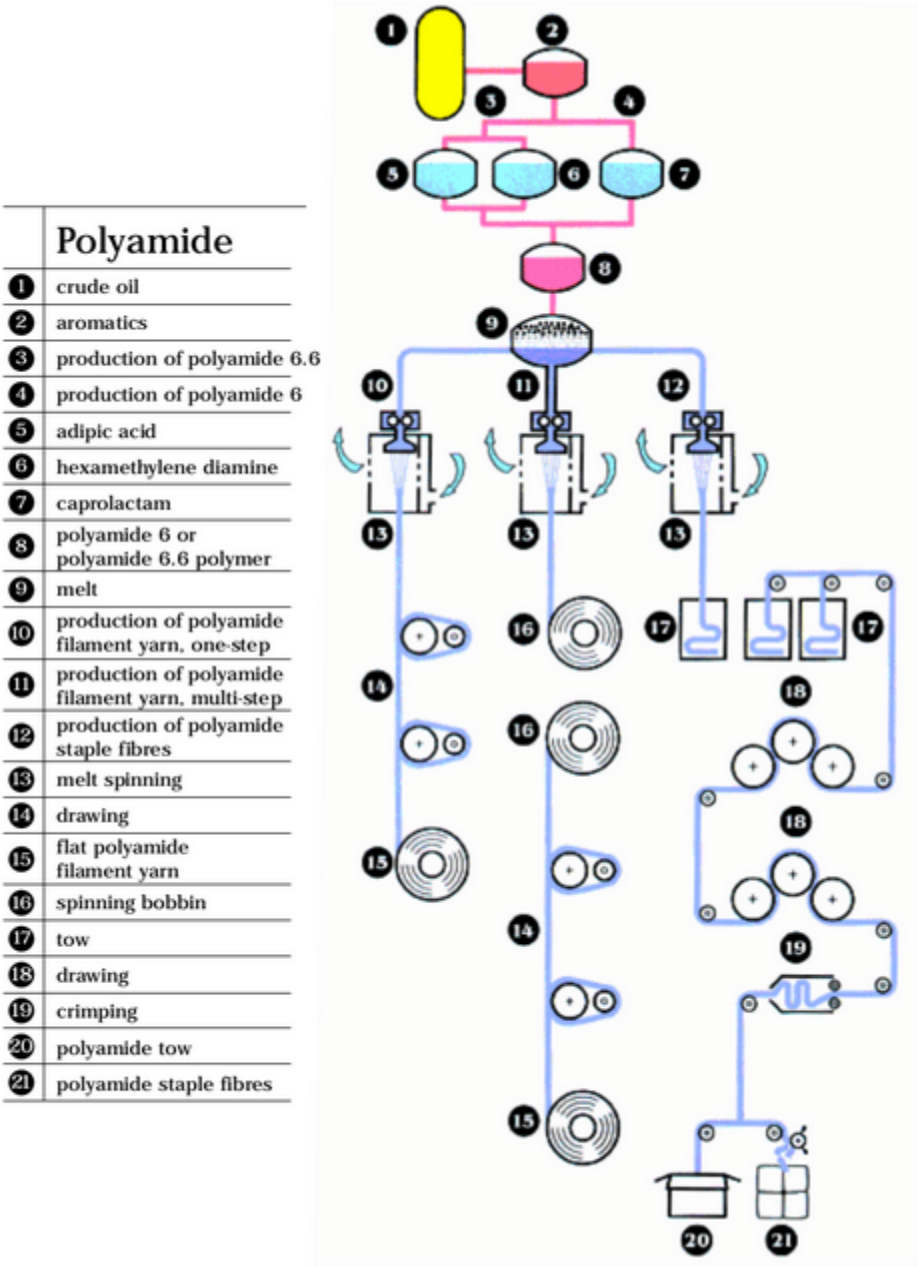
$$HOOC-(CH_2)_4-COOH(Adipic\ Acid)+H_2N-(CH_2)_6-NH_2(Hexamethylene\ Diamine) \rightarrow HO-[CO-(CH_2)_4-CONH-(CH_2)_6-NH-]_nH(Nylon\ 6,6)$$

Nylon 6: 尼龙 6： In 1938 Paul Schlack of the IG Farben Company in Germany polymerized Caprolactum & created a different form of the polymer identified as Nylon 6. It's a homopolymer which is formed by ring opening polymerisation.1938 年，德国 IG Farben 公司的 Paul Schlack 聚合了己内酰胺，并创造了一种不同形式的聚合物，被鉴定为尼龙 6。它是一种通过开环聚合形成的均聚物。



***The Degree of Polymerisaton for Nylon 6 & Nylon 6,6 ranges between 100 to 180 & their Average Molecular Weight ranges between 15,000 to 30,000 尼龙 6 和尼龙 6 的聚合物含量在 100 到 180 之间，它们的平均分子量在 15,000 到 30,000 之间。

Spinning Process Diagram:纺纱工艺图：

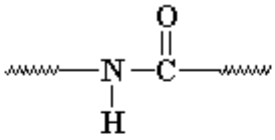


	Polyamide
1	crude oil
2	aromatics
3	production of polyamide 6.6
4	production of polyamide 6
5	adipic acid
6	hexamethylene diamine
7	caprolactam
8	polyamide 6 or polyamide 6.6 polymer
9	melt
10	production of polyamide filament yarn, one-step
11	production of polyamide filament yarn, multi-step
12	production of polyamide staple fibres
13	melt spinning
14	drawing
15	flat polyamide filament yarn
16	spinning bobbin
17	tow
18	drawing
19	crimping
20	polyamide tow
21	polyamide staple fibres

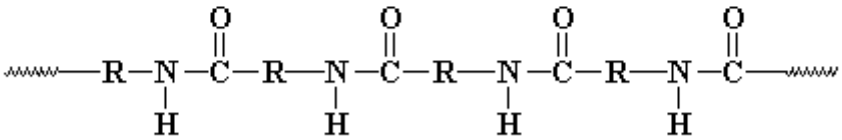
Fig: Spinning process of nylon 图：尼龙的纺纱工艺

Chemical Properties of Nylon:尼龙的化学性质：

(1) Swelling of Nylon:（1） 尼龙肿胀：The Oxygen of the Carbonyl group is slightly negative & the hydrogen (imino hydrogen) is slightly of positive charge. The polar group in Nylon and is responsible for swelling in water or in polar solvents or in dyeing with disperse & metallized dyes.羰基的氧稍微负，氢（亚氨基氢）稍微带正电荷。尼龙中的极性基团负责在水或极性溶剂中膨胀，或者在使用分散和金属化染料进行染色时膨胀。



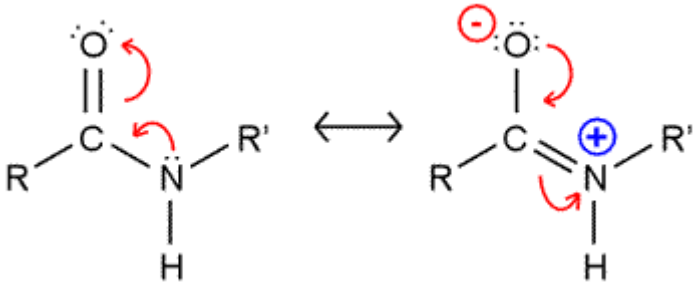
an amide group



a polyamide

(2) Melting of Nylon:（2） 尼龙的熔融：Melting point increases because of the following two reasons –熔点增加是由于以下两个原因 -

(a) The increase of CONH group to CH_2 groups:（a） CONH 组增加到 CH_2 组：The amide group is planar in nature because of the partial double bond character of C-N bond. It has been estimated that the barrier for rotation about this bond may be 63 Kj/mol (15 Kcal/mol) or higher. For this reason if the ratio of CONH group to CH_2 is high than melting temperature would be high also.酰胺基团本质上是平面的，因为 CN 键的部分双键特性。据估计，围绕该键的旋转障碍可能是 63 Kj/mol （15 Kcal/mol） 或更高。因此，如果 CONH 基团与 CH_2 的比率高，则熔融温度也会很高。



(b) Hydrogen Bond:（b） 氢键：The polar polyamide group is responsible for hydrogen bonding between polyamide chains. Whether the no. of CH_2 groups between CONH is odd or even is a very important factor.极性聚酰胺基团负责聚酰胺链之间的氢键。无论 no.的 CH_2 组在 CONH 之间是奇数或偶数是一个非常重要的因素。

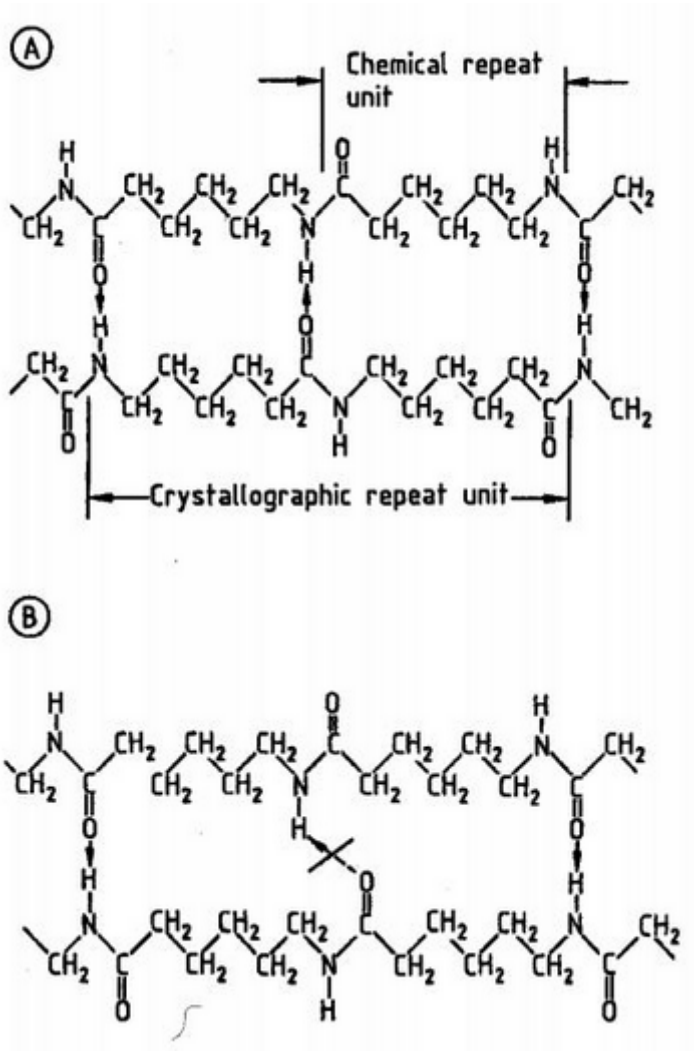


Figure: Schematic of a Hydrogen bonded sheet of PA 6 with antiparallel (A) & Parallel (B) orientation of amide group.图：具有酰胺基团反平行（A）和平行（B）方向的 PA 6 氢键片示意图。

If the no. of CH_2 group between amide groups is odd & the orientation of the chain is anti-parallel/opposed (Fig. A) than it allows complete hydrogen bonding.But if the orientation of the chains are parallel/same the bonding is not complete.如果 no. 酰胺基团之间的 CH_2 组是奇数的，链的方向是反平行/对立的（图.A） 的 100 次 10 次 7 次 7 次 7 次 2 次 2 但是，如果链的方向平行/相同，则粘合不完整。

Now the changing from a parallel array to anti-parallel array requires the inverting of the whole chain in case of odd no. but only a segmental lateral movement is needed if the no. of CH_2 group is even (Ex. Nylon 6,6).现在从并行阵列更改为反并行阵列需要在奇数 no 的情况下反转整个链。但如果 NO.CH_2 组是偶数（例如尼龙 6,6）。

So the Nylon 6 polymer has lower melting point than Nylon 6,6 因此，尼龙 6 聚合物的熔点低于尼龙 6,6

***Based on this we can say that the polyamide having odd no. of CH_2 group will have lower melting temperature that the similar kind of polyamide having a even

no. of CH_2 group***基于此，我们可以说聚酰胺具有奇数 no。的 CH_2 组将具有比同类聚酰胺更低的熔融温度，偶数没有。CH_2 组***

(c) Introduction of Side Chains:（c） 侧链介绍：If side chains are introduced into the carbon skeleton then it interferes with the intermolecular forces between the amide groups. It results in reduction of melting point and increases solubility in organic solvents.如果将侧链引入碳骨架中，则会干扰酰胺基团之间的分子间作用力。它导致熔点降低并提高在有机溶剂中的溶解度。

(d) Introduction of Aromatic Ring:（d） 芳香环介绍：when the amide group is connected to aromatic rings it results in chain stiffening and higher melting temperature. This class of polyamides are called aramids which usually degrades without melting so it can't be melt spun.当酰胺基团连接到芳香环时，会导致链变硬和熔化温度升高。这类聚酰胺称为芳纶，通常在不熔化的情况下降解，因此不能熔融纺丝。

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11. 合成纤维和再生纤维的制造工艺

Manufacturing Process of Synthetic and Regenerated Fibers 合成纤维和再生纤维的制造工艺

November 13, 2021 by Mazharul Islam Kiron 十一月 13， 2021by Mazharul Islam Kiron

What is Synthetic and Regenerated Fibers?什么是合成纤维和再生纤维？
The term synthetic fiber relates to fibers formed from polymers constructed from chains grown via a controlled chemical process. The synthetic fibers are result of the extensive research to improve the properties of naturally occurring animal and **vegetable fibers**. These synthetic fibers are produced by the extrusion of a polymeric material having synthetic origin through spinneret into air or water. This fiber forming polymers are obtained generally from petro chemicals. Therefore, these fibers are called **synthetic fibers**. This category would include nylon, Kevlar, poly (ethylene terephthalate) (PET), and polyethylene, whereas fibers formed from so-called natural polymers are not considered to be true synthetic and are termed regenerated fibers. This latter category consists of **viscose rayon** and cellulose acetate along with some more recent developments such as chitosan, which is formed from the abundant chitin material found in sea crustaceans. Despite the now dominance of the true synthetics in the fiber market, it was the early development of regenerated cellulosics that would lay the ground work for many of the processes and techniques that are now used to make fibers from natural and synthetic feedstocks.合成纤维一词是指由聚合物构成的纤维，这些聚合物由通过受控化学过程生长的链构成。合成纤维是广泛研究的结果，旨在改善天然存在的动植物纤维的特性。这些合成纤维是通过喷丝头将具有合成来源的聚合物材料挤出到空气或水中而制成的。这种纤维形成聚合物通常从石油化学品中获得。因此，这些纤维被称为合成纤维。这一类别包括尼龙、凯夫拉尔、聚对苯二甲酸乙二醇酯 （PET） 和聚乙烯，而由所谓的天然聚合物形成的纤维不被认为是真正的合成纤维，被称为再生纤维。后一类包括粘胶人造丝和醋酸纤维素以及一些最近的发展，例如壳聚糖，它是由海甲壳类动物中发现的大量甲壳素物质形成的。尽管真正的合成纤维现在在纤维市场上占据主导地位，但再生纤维素的早期发展为现在用于从天然和合成原料制造纤维的许多工艺和技术奠定了基础。

One of the key innovations in fiber science is the regenerated fibers. Regenerated fibers are produced from natural source with human interference. Several regenerated cellulosic fibers were produced from wood pulp such as viscose, **lyocell**, rayon, and modal, which have been used as reinforcements in composite processing. In the current context, this avenue shows more promise in terms of ecological impact and sustainable practices such as recyclability and reusability.纤维科学的关键创新之一是再生纤维。再生纤维是在人为干扰下从天然来源生产的。几种再生纤维素纤维由粘胶纤维、莱赛尔纤维、人造丝和莫代尔等木浆制成，这些纤维已用作复合加工中的增强材料。在当前背景下，这条途径在生态影响和可持续实践（如

可回收性和可再利用性）方面显示出更大的前景。

The basic element of a cellulose macromolecule is glucose. The empirical formula of cellulose is $(C_6H_{10}O_5)n$, where n represents the number of glucose molecules constituting the cellulose macromolecule and is called the degree of polymerization (DP). The α-cellulose (insoluble in cold dilute NaOH) has a DP greater than 200, while β-cellulose (hemicelluloses soluble in cold dilute NaOH) has DP less than 200. Wood pulp is used as the raw material for cellulose, and is refined to increase the percentage of α-cellulose. The percentage of up to 99 % can be obtained depending on the cleaning method. The regenerated fibers are produced according to the viscose spinning method.纤维素大分子的基本元素是葡萄糖。纤维素的经验公式为 （$C_6H_{10}O_5$）n，其中 n 表示构成纤维素大分子的葡萄糖分子的数量，称为聚合度 （DP）。α-纤维素（不溶于冷稀释的 NaOH）的 DP 大于 200，而 β-纤维素（可溶于冷稀释的 NaOH 的半纤维素）的 DP 小于 200。木浆用作纤维素的原料，并经过精炼以增加 α 纤维素的百分比。根据清洁方法的不同，可以获得高达 99% 的百分比。再生纤维是根据粘胶纺纱法生产的。

Synthetic and Regenerated Fibers Manufacturing Process:合成纤维和再生纤维制造工艺：

Synthetic fiber is that which is made from different types of polymers. It is not cultivated as the natural fiber. Regenerated fiber is created by dissolving the cellulose area of plant fiber in chemicals and making it into fiber again. Synthetic fibers for textiles are all produced using the same fundamental processing techniques. In this article I will discuss synthetic and regenerated fibers manufacturing process with diagram.合成纤维是由不同类型的聚合物制成的纤维。它不是作为天然纤维培养的。再生纤维是通过将植物纤维的纤维素区域溶解在化学品中并再次制成纤维而制成的。用于纺织品的合成纤维都是使用相同的基本加工技术生产的。在本文中，我将用图表讨论合成纤维和再生纤维的制造过程。

In principle, a polymer fluid is forced through a series of fine holes that create the basic shape. The fluid is then encouraged to harden through cooling, chemical, or thermodynamic processes, which lead to a solid filament. There are four methods of spinning filaments of manufactured fibers: wet, dry, melt, and gel spinning.原则上，聚合物流体被迫通过一系列细孔，从而形成基本形状。然后，通过冷却、化学或热力学过程鼓励流体硬化，从而形成固体细丝。纺制人造纤维长丝的方法有四种：湿法、干法、熔融纺丝和凝胶纺丝。

Melt spinning: 熔融纺丝：In **melt spinning**, The polymer chips are melted in a large hopper and passed through a metered pump before reaching the spinneret. The filaments then pass through cold air, which solidifies the filament before it is drawn and wound onto bobbins. Thermoplastic fibers are mainly produced with melt spinning. Nylon, polyester, and liquid crystalline aromatic polyester are all manufactured with melt spinning. They are first heated above their melting temperatures, then extruded through spinneret to form continuous fiber, followed by drawing, cooling, and winding. This process 在**熔融纺丝**中，聚合物片在一个大料斗中熔化，并在到达喷丝头之前通过计量泵。然后，细丝通过冷空气，使细丝凝固，然后被拉制并缠绕到线轴上。热塑性纤维主要通过熔融纺丝生产。尼龙、聚酯和液晶芳香族聚酯都是通过熔融纺丝制造的。它们首先被加热到熔化温度

以上，然后通过喷丝头挤出形成连续纤维，然后进行拉丝、冷却和缠绕。此过程 is schematically illustrated in Figure 1.如图 1 所示。

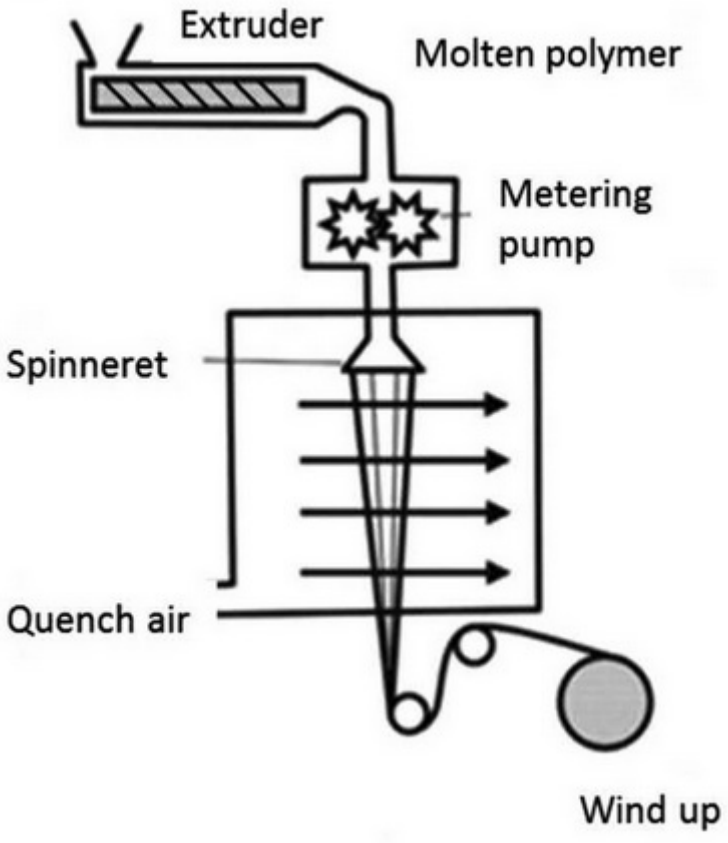

Figure 1: Schematic illustration of melt spinning process 图 1：熔融纺丝工艺示意图

Melt spinning has the advantage of requiring no solvents and uses the polymer as is. Polymer melts are typically highly viscous and generate a phenomenon known as exudate swell on leaving the spinneret. Exudate swell is caused by an essentially elastic material recovering from a temporary compression as it exits the orifice. The practical implications of exudate swell are that the filaments will always deviate from the cross-sectional shape 熔融纺丝的优点是不需要溶剂，并且按原样使用聚合物。聚合物熔体通常具有高粘度，并在离开喷丝头时产生一种称为渗出物膨胀的现象。渗出液膨胀是由基本弹性材料在离开孔口时从临时压缩中恢复引起的。渗出物膨胀的实际意义是细丝总是偏离横截面形状 of a complex orifice, meaning that overly complex fiber geometries may not be possible with melt spinning.的复杂孔口，这意味着过于复杂的纤维几何形状可能无法通过熔融纺丝实现。

Wet spinning: 湿纺：Solution spinning is typically used when melt spinning is not possible for non-thermoplastic and temperature-sensitive polymers. In this processing arrangement, the polymeric chains are dissolved in an appropriate solvent to form a viscous fluid. Typical solution concentrations can vary from 1%–25% depending on the polymer chain length, solvent system, and spin pack design. Once dissolved in solution, the chains are typically free to entangle and disentangle and move relative to each other. There are typically three variants of **wet spinning**, with the basic outline for each given in Figure. In all variants, a polymeric solution is pumped through a spinneret and filaments form through either evaporation or

precipitation. In dry–wet spinning, the solvent is volatile enough to evaporate rapidly, leaving behind a gradually solidifying filament with only a small amount of residual solvent. In air-gap and coagulation spinning, the spinneret is submerged or suspended just above a spinning bath and the solvent is precipitated out of the filament using a coagulant or nonsolvent system. The filaments then harden and undergo several washing and drying steps before final winding. As the rate of diffusion of coagulant and solvent is critical, this variant of wet spinning is typically significantly slower than melt spinning.当无法对非热塑性和温度敏感聚合物进行熔融纺丝时，通常使用固溶纺丝。在这种加工安排中，聚合物链溶解在适当的溶剂中以形成粘性流体。典型的溶液浓度可能在 1%–25% 之间变化，具体取决于聚合物链长度、溶剂系统和离心组设计。一旦溶解在溶液中，链通常可以自由缠结和解开，并相互相对移动。湿纺通常有三种变体，每种变体的基本轮廓见图。在所有变体中，聚合物溶液通过喷丝头泵送，并通过蒸发或沉淀形成细丝。在干湿纺丝中，溶剂的挥发性足以迅速蒸发，留下逐渐凝固的细丝，只有少量残留溶剂。在气隙和凝结纺丝中，喷丝头被淹没或悬浮在纺丝浴的正上方，并使用混凝剂或非溶剂系统将溶剂从细丝中沉淀出来。然后，细丝会变硬，并在最终卷绕之前经过几个洗涤和干燥步骤。由于混凝剂和溶剂的扩散速率至关重要，因此这种湿法纺丝的变体通常比熔融纺丝慢得多。

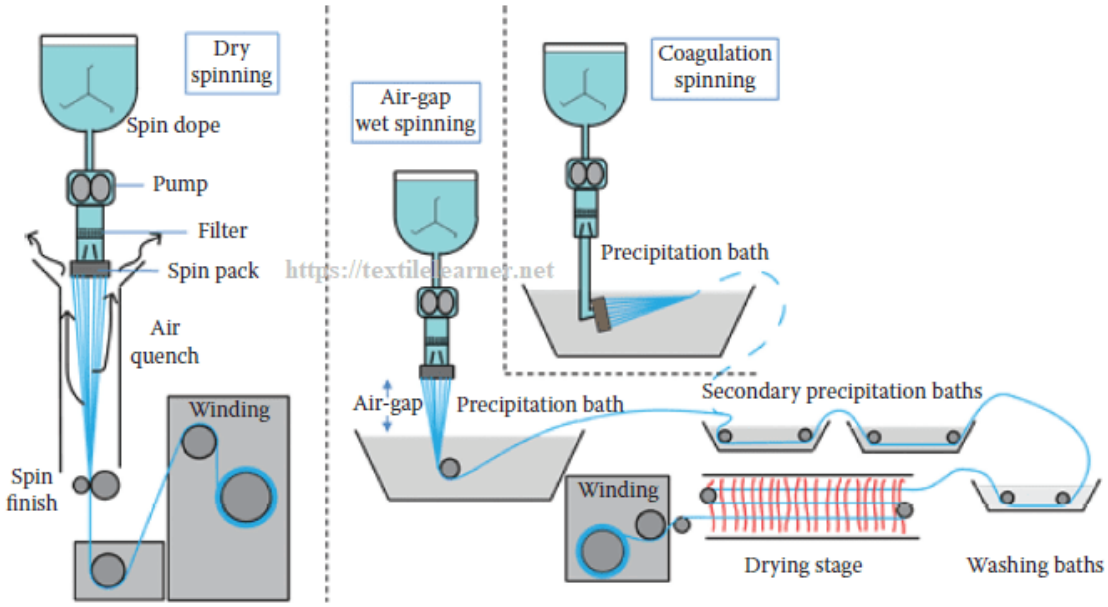

Figure 2: Schematic diagram of wet spinning 图 2：湿法纺丝示意图

The spinning of continuous filaments also allows for additives to be incorporated into the fibers at the time of formation. For example, spun-dyed fibers are created via the batchwise addition of colorants. This saves on any requirement to dye the fibers and is necessary for difficult to dye fibers such as polypropylene. However, the range of colors and minimum run quantity is often more limited.连续长丝的纺丝还允许在形成纤维时将添加剂掺入纤维中。例如，纺染纤维是通过分批添加着色剂制成的。这节省了对纤维进行染色的任何要求，并且对于难以染色的纤维（如聚丙烯）是必需的。但是，颜色范围和最小运行数量通常受到更多限制。

An additional point on synthetic fibers is that the manufacturing process often locks in tension and strains within the fibers on a molecular level. When these fibers

are subsequently heated for dyeing, bonding, or finishing, the fibers can contract as the strain is relaxed, which causes the yarn to shrink and the fabric to shrink in one if not two directions. This residual shrinkage is often removed through a finishing process known as **heat setting**. Here, fabrics are washed and allowed to shrink in a controlled manner through high-temperature ovens to remove as much as 20% shrinkage. This is a costly process, but the resulting fabric should be thermally stable in subsequent steps.关于合成纤维的另一点是，制造过程通常在分子水平上锁定纤维内部的张力和应变。当这些纤维随后被加热以进行染色、粘合或整理时，纤维会随着应变的松弛而收缩，这会导致纱线收缩，而织物在一个（如果不是两个）方向上收缩。这种残留的收缩通常通过称为**热定型**的精加工过程去除。在这里，织物被清洗，并通过高温烘箱以受控方式收缩，以去除多达 20% 的收缩。这是一个昂贵的过程，但所得织物在后续步骤中应具有热稳定性。

Dry spinning: 干纺：The polymer solution passes through a metered pump. Once through the spinneret, the filaments pass through warm air, which evaporates the solvent and dries the filament. The filament is then drawn and wound onto bobbins. Dry spinning is used to form polymeric fibers from solution. It is a direct process. Here a solvent and a solvent recovery plant are required. Washing is not done in this process. This process may be used for the production of Acetate, Tri-acetate, Acrylic, Modacrylic, PBI, Spandax and Vinyan.聚合物溶液通过计量泵。通过喷丝头后，细丝通过暖空气，热空气蒸发溶剂并干燥细丝。然后将细丝拉制并缠绕到线轴上。干纺用于从溶液中形成聚合物纤维。这是一个直接的过程。这里需要一个溶剂和一个溶剂回收设备。在此过程中不进行洗涤。该工艺可用于生产醋酸纤维、三醋酸纤维、丙烯酸、改性丙烯酸、PBI、Spandax 和 Vinyan。

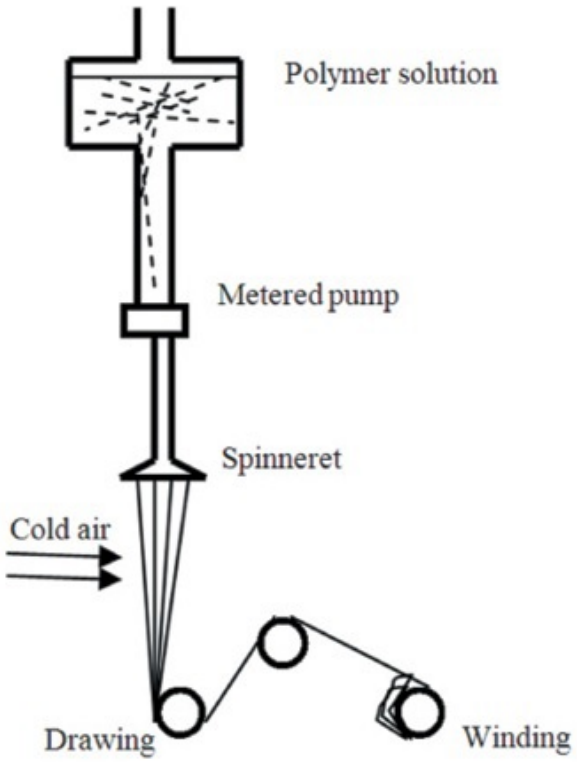

Figure 3: Schematic diagram of dry spinning process 图 3：干纺工艺示意图

Gel spinning: 凝胶纺丝： Gel spinning is also known as dry-wet spinning because the filaments are cooled by passing through cold air first and then into a cooling liquid bath. This is a special process used to achieve high strength or special fiber properties. The polymer starts in a partially liquid or gel state, unlike the other three processes which causes the polymer chains to be bound together at intervals in liquid crystal form, which results in very strong, inter-chain forces. The polymer chains in the fibers have a high degree of orientation, which vastly increases their tensile strength. This process is used on **aramid fiber** and polyethylene.凝胶纺丝也称为干湿纺丝，因为长丝首先通过冷空气冷却，然后进入冷却液浴。这是用于实现高强度或特殊纤维特性的特殊工艺。聚合物以部分液态或凝胶态开始，这与其他三个过程不同，其他三个过程导致聚合物链以液晶形式间隔结合在一起，从而产生非常强的链间力。纤维中的聚合物链具有高度的取向，这大大提高了它们的拉伸强度。该工艺用于芳纶纤维和聚乙烯。

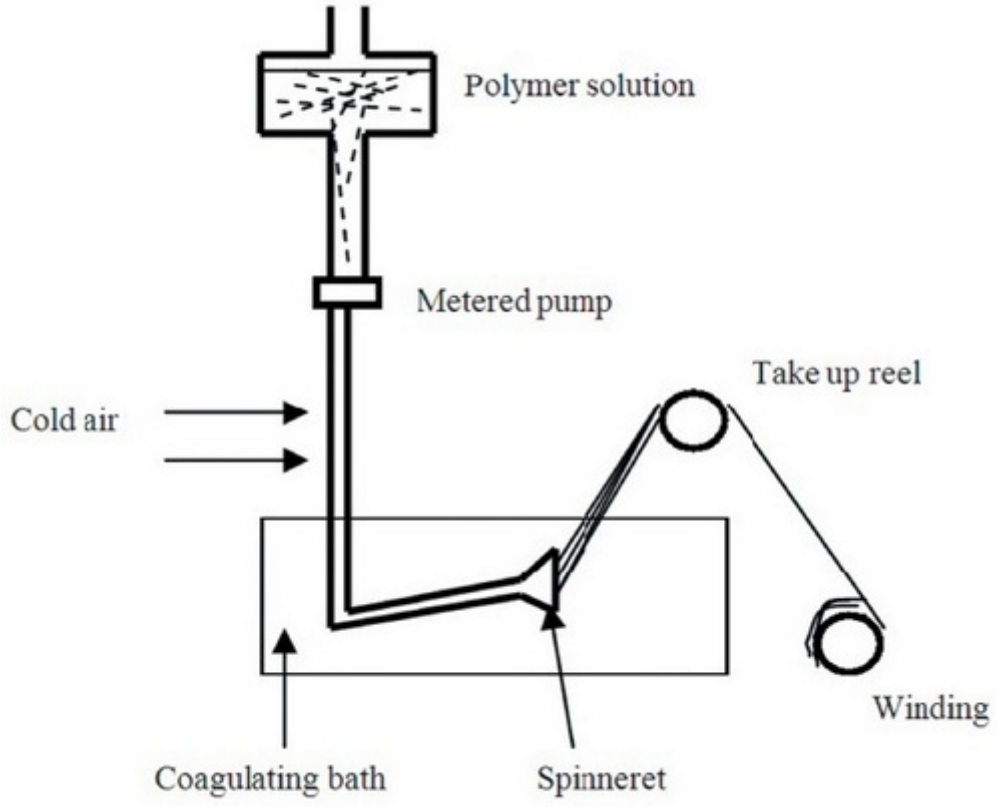

Figure 4: Schematic diagram of gel spinning 图 4：凝胶纺丝示意图

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6. Cut Protective Textiles By Daniel (Xuedong) LiCut Protective Textiles 作者：Daniel（Xuedong） Li

12. 不同类型的人造纤维及其应用

Different Types of Man Made Fibers with Their Application 不同类型的人造纤维及其应用

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Different Types of Man Made Fibers with Their Application 不同类型的人造纤维及其应用

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Fig: Different Types of Man Made Fibers 图：不同类型的人造纤维

Textile fibers are either found in nature or made by man. **Natural fibers** are obtained from plants, animals and minerals, while man made fibers are produced either purely chemically (Synthetic fibers) or by modifying natural fibers by chemical means (Regenerated fibres). The polymers used for the spinning of synthetic fibers are chemical based, while regenerated fibers are derived from a natural polymer, most commonly cellulose. In this article I will discuss about introduction, applications, advantages and disadvantages of different man made fibers.纺织纤维要么存在于自然界中，要么由人类制造。天然纤维是从植物、动物和矿物中获得的，而人造纤维则是纯化学（合成纤维）或通过化学手段改性天然纤维（再生纤维）生产的。用于纺丝合成纤维的聚合物是化学基的，而再生纤维则来自天然聚合物，最常见的是纤维素。在本文中，我将讨论不同人造纤维的介绍、应用、优缺点。

Fibers 纤维	Description 描述	Applications 应用	Advantages 优势	Disadvantages 弊

Acetate and triacetate fibers 醋酸纤维和三醋酸纤维	This type of fiber is known as a regenerated man made material. Acetate is derived from cellulose by reacting purified cellulose from wood pulp with acetic acid and acetic anhydride in the presence of sulfuric acid. Both materials are heat resistant below their melting point.这种类型的纤维被称为再生人造材料。乙酸盐是通过在硫酸存在下将木浆中的纯化纤维素与乙酸和乙酸酐反应而得的纤维素。这两种材料的耐热性低于其熔点。	The largest volume application for acetate fiber is cigarette filters, but it is also widely used in women's wear. The luxurious fibers are available in a wide range of colors and lusters.醋酸纤维的最大体积应用是香烟过滤嘴，但它也广泛用于女装。奢华的纤维有多种颜色和光泽可供选择。	They are fast drying are resistant to moths and mildew. Triacetate has excellent sunlight resistance but acetate does not. They are shrink-resistant and wrinkle-resistant.它们快干，耐飞蛾和霉菌。三醋酸酯具有优异的耐日光性，但醋酸盐则不然。它们具有抗缩和抗皱性。	Disadvantages include poor abrasion resistance, susceptible to attack by household chemicals.缺点包括耐磨性差，易受家用化学品的侵蚀。

Fibres 纤维	**Discription 描述**	**Applications 应用**	**Advantages 优势**	**Disadvantages 弊**
Acrylic and modacrylic fibers 腈纶和改性腈纶纤维	These fibers are unique among synthetic fibers because they have an uneven surface. The fibers are formed by additional polymerization of at least 85% by weight of acrylonitrile or vinyl chanide.这些纤维在合成纤维中是独一无二的，因为它们的表面不平整。纤维是通过至少85%（按重量计）的丙烯腈或乙烯基 chanide 的额外聚合形成	Acrylic fibers can be artificial wool because it has the warmth and softness of wool but does not absorb water. It is often used as cold weather fiber for blankets and sweaters.腈纶纤维可以是人造羊毛，因为它具有羊毛的保暖柔软性，但不吸水。它通常用作毯子和毛衣的寒冷天气纤维。	They have a high resistance to chemical and biological degradation as well as degradation from sunlight. Acrylic is lightweight and strong.它们对化学和生物降解以及阳光降解具有很强的抵抗力。亚克力重量轻且坚固。	High heat can melt the fabric.高温会使织物熔化。

	的。			

Fibres 纤维	Description 描述	Applications 应用	Advantages 优势	Disadvantages 弊
Aramid and polyimide fibers 芳纶和聚酰亚胺纤维	Polyimide fiber is spun from the polymer by wet or dry processing techniques. This is done using a polar organic solvent.聚酰亚胺纤维是通过湿法或干法加工技术从聚合物中纺出的。这是使用极性有机溶剂完成的。	Polyimide fabric is flame retardant and can be used in high- temp applications.聚酰亚胺织物具有阻燃性，可用于高温应用。	These fibers are lighter and tougher than steel.这些纤维比钢更轻、更坚韧。	

Fibres 纤维	Description 描述	Applications 应用	Advantages 优势
Carbon and graphite 碳和石墨	These fibers are strong, light, and can be mixed with other materials. Carbon fiber technology converts carbon to graphite to form tightly packed fibers.这些纤维坚固、轻便，可以与其他材料混合。碳纤维技术将碳转化为石墨，形成紧密堆积的纤维。	The material is used to produce high-quality devices such as golf-clubs and fishing rods and can be used for composites for air crafts and autos.该材料用于生产高尔夫球杆和钓鱼竿等高质量设备，并可用于飞机和汽车的复合材料。	

Fibres 纤维	Description 描述	Applications 应用	Advantages 优势	Disadvantages 弊
Nylon 尼龙	It is an artificial fiber made of polyamide which contains carbon, oxygen, nitrogen, and hydrogen. The material is also resistant to wrinkling, does not absorb water, and it dries quickly, Exceptionally strong,	Nylon can be used in carpet. High-filament nylon yarns are often blended with spandex and used in athletic apparel, swimwear, and hosiery. nylon products include luggage,	The fiber is durable, strong, resists stains, hides soil, resists mildew and bacteria, prevents static, and is resistant to abrasion.纤维耐用、坚固、耐	Disadvantages include: the fabric melts when exposed to high heat, can be uncomfortable to wear next to skin, and absorbs oil and grease.缺点包括：织物在高温下会融化，贴身

	Elastic, Lustrous, Easy to wash, Resistant to damage from oil and many chemicals,Can be precolored or dyed in wide range of colors, Resilient, Filament yarns provide smooth, soft, long-lasting fabrics.它是一种由聚酰胺制成的人造纤维，含有碳、氧、氮和氢。该材料还具有抗皱性，不吸水，干燥快，异常坚固、有弹性、有光泽、易于清洗、耐油和许多化学品的损坏，可以预着色或染色成多种颜色，有弹性的长丝纱线提供光滑、柔软、持久的织物。	carpeting materials and hosiery because of its elastic recovery ability. 尼龙可用于地毯。高丝尼龙纱线通常与氨纶混纺，用于运动服装、泳装和袜子。尼龙产品包括箱包、地毯材料和袜子，因为它具有弹性恢复能力。	污渍、隐藏污垢、抗霉菌和细菌、防止静电、耐磨。Easy to dye, 易染色，Resistant to damage from oil and many chemicals,耐油和许多化学品的损坏，	穿着会不舒服，并吸收油脂。Can cause skin deases 可引起皮肤萎缩

Fibres 纤维	Description 描述	Applications 应用
Elastomeric fibers 弹性纤维	They are cross linked natural and synthetic rubbers, spandex fibers (segmented polyurethanes), anidex fibers (cross linked polyacrylates) and the side-by-side biconstituent fiber of nylon and spandex. The fibers can have elongations (400-800%) at break and recover fully and rapidly.它们是交联天然橡胶和合成橡胶、氨纶纤维（分段聚氨酯）、anidex 纤维（交联聚丙烯酸酯）以及尼龙和氨纶的并排双组分纤维。纤维在断裂时可以伸长 （400-800%），并完全迅速地恢复。	The term elastomer is derived from elastic polymer, which is also known as rubber.弹性体一词源自弹性聚合物，也称为橡胶。

Fibres 纤维	Description 描述	Applications 应用
Fluropolymer Fluropolymer 聚氯乙烯	It is a high-performance material that has high strength and	They are used in nonstick cook and bake ware..他们

	durability. Fluoropolymers are resistant to many chemicals and high heat.它是一种高性能材料，具有高强度和耐用性。含氟聚合物耐许多化学品和高热。	用于不粘烹饪和烘焙器具..

Fibres 纤维	Description 描述	Applications 应用	Advantages 优势	Disadvantages 弊
Spandex or elastoester 氨纶或弹性酯	Spandex is a lightweight manufactured material that can be stretched over 500% without breaking. Elastoester is a substitute for spandex. Stronger, more durable and higher retractive force than rubber,Lightweight, soft, smooth, supple,氨纶是一种轻质制造材料，可以拉伸超过 500% 而不会断裂。弹性酯是氨纶的替代品。比橡胶更坚固、更耐用、回缩力更高，重量轻、柔软、光滑、柔软、	It is used when a stretch fiber is needed. Garments where comfort and fit are desired: hosiery, swimsuits, aerobic/exercise wear, ski pants, golf jackets, disposable diaper, waist bands, bra straps and bra side panels,当需要弹力纤维时使用它。需要舒适合身的服装：袜子、泳衣、有氧/运动服、滑雪裤、高尔夫球夹克、一次性尿布、腰带、文胸带和文胸侧板，	It is a soft fabric that is resistant to abrasion and can resist body oils, perspiration and detergents. It does not have static or pilling problems.它是一种柔软的面料，耐磨损，可以抵抗身体油脂、汗水和清洁剂。它没有静电或起球问题。	Ironing, if required, should be done rapidly. Do not leave the iron too long in one position. Use low temperatures setting.如果需要，应迅速熨烫。不要将熨斗放在一个位置太久。使用低温设置。

Fibres 纤维	Description 描述	Applications 应用	Advantages 优势	Disadvantages 弊
Polyolefin fibers 聚烯烃纤维	They are produced by chain growth polymerization of olefins (alkenes) and contain greater than 85% polymerized ethylene,	Polyolefin fibers are resistant to stains, sunlight, odor and chemicals, mildew, rot, and weather. They are fast drying and have a high	The advantages of this material include its strength, ability to float, lightness, and resistance to abrasion.这种	Disadvantages include problems with static and pilling as well as a low tolerance for high temperature which tends to cause swelling in the presence aromatic

	propylene, or other olefin units. 它们由烯烃（烯烃）的链生长聚合制成，含有超过 85% 的聚合乙烯、丙烯或其他烯烃单元。	wick-ability making them useful for spill cleanup.聚烯烃纤维耐污渍、阳光、气味和化学品、霉菌、腐烂和天气。它们干燥快，吸芯能力强，可用于清理溢出物。	材料的优点包括其强度、漂浮能力、轻便性和耐磨性。	and chlorinated hydrocarbons.缺点包括静电和起球问题，以及对高温的耐受性低，这往往会导致在芳烃和氯化烃存在的情况下膨胀。

Fibres 纤维	Description 描述	Applications 应用	Advantages 优势	Disadvantages 弊
Polyester 聚酯	The most important synthetic fiber. They contain at least 85% of polymericester of a substituted aromatic carboxylic acid including, but not restricted to, terephthalic acid and f-hydroxybenzoic acid. The manufacturing process uses melt-spinning so the size and shape can be adjusted for specific applications.最重要的合成纤维。它们含有至少 85% 的取代芳香羧酸的聚合物，包括但不限于对苯二甲酸和 f-羟基苯甲酸。制造过程使用熔融纺丝，因此可以根据特定应用调整尺寸和形状。	It is utilized in all types of clothing, home furnishings, and as a reinforcing fiber in tires, belts, and hoses. New insulating polyester fiberfill are used in high-performance outdoor wear.它用于所有类型的服装、家居用品，并用作轮胎、皮带和软管的增强纤维。新型保暖聚酯纤维填充物用于高性能户外服装。	It’s versatile and has low raw material and production costs. Polyester is resistant to abrasion, has the ability to spring back into shape, does not absorb water, and dries quickly. 它用途广泛，原材料和生产成本低。涤纶耐磨，具有回弹成型的能力，不吸水，干燥快。	Disadvantages include, melting when exposed to high heat and it absorbs oils and grease making it difficult to clean. It does attract static electricity, 缺点是暴露在高温下会熔化，并且会吸收油脂，因此难以清洁。它确实会吸引静电，

Fibres 纤维	Description 描	Applications 应	Advantages 优	Disadvantages 弊

	述	用	势	
Polyethylene 聚乙烯	It is produced by the formation of an ester bond between terephthalic acid and ethylene glycol. The material floats, resists chemicals and water, and exhibits superior fiber-to-fiber abrasion. Polyethylene fibre has a round cross section and has a smooth surface. Fibres made from low molecular weight polyethylene have a grease like handle.它是通过在对苯二甲酸和乙二醇之间形成酯键而产生的。该材料可漂浮、耐化学品和水，并表现出卓越的纤维间耐磨性。聚乙烯纤维具有圆形横截面和光滑的表面。由低分子量聚乙烯制成的纤维具有类似油脂的手柄。	Polyethylene fibers are used in police and military ballistic vests, helmets and armored vehicles, sailcloth, fishing lines and lifting slings, cut-resistant gloves, and a wide range of safety apparel. Medical implants, cable & marine ropes, sail cloth, fish net, useful in geotextile application.聚乙烯纤维用于警察和军用防弹背心、头盔和装甲车、帆布、钓鱼线和起重吊索、防割手套以及各种安全服装。医疗植入物，电缆和海洋绳索，帆布，鱼网，在地理纺织应用中非常有用。	High Molecular Weight Polyethylene (HMWP) is one of the world's strongest and lightest fibers. Polyethylene fiber is pound-for-pound 10 times stronger than steel. Polyethylene is insoluble in most of the common organic solvents at room temperature.高分子量聚乙烯（HMWP）是世界上最坚固、最轻的纤维之一。聚乙烯纤维的强度是钢的 10 倍。聚乙烯在室温下不溶于大多数常见的有机溶剂。	Bad affect on environment.对环境有不良影响。

Fibres 纤维	Description 描述	Applications 应用	Advantages 优势
Polypro-pylene 聚丙烯	It is a vinyl polymer, similar to polyethylene. The structure has a methyl group attached to every other carbon in the backbone chain.它是一种乙烯基聚合物，类似于聚乙烯。	Polypropylene is used for indoor-outdoor carpeting because it doesn't absorb water.聚丙烯用于室内外地毯，因为它不吸水。	Improve toughness, Provide excellent impact resistance, Reduce haze, Provide excellent organoleptics 提高韧性， 提供出色的抗冲击性， 减少雾度， 提供出色的感官

	该结构具有一个甲基，连接到主链中的每个其他碳。		体验

Fibres 纤维	Description 描述	Applications 应用	Advantages 优势
Polyphenylene sulfide (PPS) 聚苯硫醚（PPS）	It is a specialty fiber characterized with high resistance to thermal and chemical attack as well as resistance to heat, solvents, acids and alkalis, mildew, UV light, and abrasion. .它是一种特种纤维，具有很高的耐热性和耐化学腐蚀性，以及耐热、耐溶剂、耐酸碱、防霉、耐紫外线和耐磨损的特点。.	PPS can be used for home interior, automobile, filter bag cloth for a coal-fired boiler, electrical insulation, and as filter material for liquid and gas.PPS 可用于家居内饰、汽车、燃煤锅炉的滤袋布、电气绝缘，以及用作液体和气体的过滤材料。	Reduce haze, Provide excellent organoleptics 减少浑浊，提供出色的感官效果

Fibres 纤维	Description 描述	Applications 应用	Advantages 优势
Polyvinyl chloride (PVC)/ Vinyl 聚氯乙烯（PVC）/ 乙烯基	These fibers have a polyethylene hydrocarbon backbone with a substituted functional group to determine the physical and chemical properties of the fiber.这些纤维具有聚乙烯烃主链和取代官能团，以确定纤维的物理和化学性质。	In everyday life, they are all around us, from construction profiles to medical devices, from roofing membranes to credit cards, from children's toys to pipes for water 在日常生活中，它们无处不在，从建筑型材到医疗设备，从屋顶膜到信用卡，从儿童玩具到水管	They do not burn, and they resist many chemicals.它们不会燃烧，并且对许多化学物质有抵抗力。

Fibres 纤维	Description 描述	Applications 应用	Advantages 优势
Latex 乳胶	Latex fabric derives from the latex fibre which comes from the milky or colourless sap of certain plants. It can be mixed with other fibres to make materials such as spandex.乳胶织物来源于乳胶纤维，乳胶纤维来自某些植物的乳白色或无色汁液。它可以与	Examples of latex products include gloves, soles and mattress pads.乳胶商品的示例包括手套、鞋底和床垫。	It is resistant to light and heat and is waterproof.它耐光、耐热且防水。

	其他纤维混合制成氨纶等材料。		

Fibres 纤维	Description 描述	Applications 应用	Advantages 优势	Disadvantages 弊
Vinyon fiber or Vinal Vinyon 纤维或 Vinal	Vinyon is composed of 85% vinyl chlorideVinyon 由 85% 的氯乙烯组成 polymerize monomer units. Vinal fibers are at least 50% vinyl alcohol units in which at least 85% of the units are combined vinyl alcohol and acetyl cross linked units.聚合单体单元。Vinal 纤维是至少 50% 的乙烯醇单元，其中至少 85% 的单元是乙烯醇和乙酰基交联单元的组合。	Application of vinyon is limited because it dissolves easily in organic solvents. Vinal resembles cotton and high strength and abrasion resistance making it useful in many applications. The fiber is of low strength but has properties that make it useful in apparel where heat is not a factor.vinyon 的应用受到限制，因为它很容易溶于有机溶剂。Vinal 类似于棉花，具有高强度和耐磨性，使其在许多应用中都很有用。这种纤维强度低，但其特性使其可用于不考虑热量的服装。	The fibers have a high chemical resistance. They are also resistant to water.纤维具有很高的耐化学性。它们还具有防水性。	Vinyon does not burn; the fabric will melt at relatively low temperatures. and dissolve readily in many organic solvents, thereby limiting their application.Vinyon 不燃烧;织物会在相对较低的温度下熔化。并且易溶于许多有机溶剂，从而限制了其应用。

Fibres 纤维	Description 描述	Applications 应用	Advantages 优势	Disadvantages 弊
Rayon 人造丝	Rayon is a semi-synthetic or artificial fiber. Rayon is recognized by the name viscose rayon and art silk in the textile industry.This includes textile	Rayon is used in fashion, furnishings, sanitary products, diapers, and medical supplies.人造丝用于时装、家具、卫生用品、尿布和医疗用品。	Rayon typically has an elevated luster quality giving it a brilliant gloss Rayon is very soft, cool comfortable and very good absorbent	A disadvantage is that is loses 30-50% of its strength when wet, has poor resistance to abrasion, expensive, and stretches and shrinks more than

	fibers and filaments composed of regenerated cellulose, excluding acetate. It is produced from naturally occurring polymers. The fiber is sold as artificial silk and it has a serrated round shape with a smooth surface. 人造丝是一种半合成或人造纤维。人造丝在纺织工业中以粘胶人造丝和艺术丝绸的名称而闻名。这包括纺织纤维和由再生纤维素组成的长丝，不包括醋酸盐。它由天然存在的聚合物制成。这种纤维以人造丝的形式出售，呈锯齿状圆形，表面光滑。	Mainly, Rayon fibres are used in apparel industry such as Aloha shirts, blouses, dresses, Jackets, Lingerie, scarves, suits, ties, hats and socks. Some rayon fibres are for filling in Zippo lighters, furnishings including bedspreads, bedsheets, blankets, window covers, upholstery and slipcovers.人造丝纤维主要用于服装行业，如 Aloha 衬衫、衬衫、连衣裙、夹克、内衣、围巾、西装、领带、帽子和袜子。一些人造丝纤维用于填充 Zippo 打火机、家具，包括床罩、床单、毯子、窗帘、室内装潢和滑套。	property but could not be able to protect body heat and used in humid steamy climatic conditions.人造丝通常具有较高的光泽质量，使其具有明亮的光泽 人造丝非常柔软、凉爽、舒适且具有非常好的吸收性能，但无法保护体热，可在潮湿、潮湿的气候条件下使用。	cotton. Usual rayon fibres recommended care for dry cleaning purpose only.缺点是潮湿时会损失 30-50%的强度，耐磨性差，价格昂贵，并且比棉花更易拉伸和收缩。通常的人造丝纤维建议仅用于干洗目的。

13. 000 高性能纤维的最新发展 000

Recent Developments in High Performance Fibers 高性能纤维的最新发展

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Recent Developments in High Performance Fibers 高性能纤维的最新发展

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ABSTRACT 抽象 Over the last 5 years the global fiber market has moved further into a global commodity market. This change is redefining and accelerating global trade patterns at all levels of the high value chain. The development of special fibers is the consequence of merging fundamentals scientific and technical knowledge, as there is a quest for high performance fibers. Thus, constant and continued endeavors of fiber scientists jointly ventured with material technologies had made dreams into reality. These special fibers totally provide the potential for providing new technology. Over all world textiles, challenging a continued growth of hi-tech fibers in various fields. These fibers have high tenacity, high strength to weight ratio which are the prerequisites characteristics of **industrial textiles**.在过去的 5 年里，全球纤维市场进一步转变为全球商品市场。这一变化正在重新定义并加速高价值链各个层面的全球贸易模式。特种纤维的发展是基础科学和技术知识相结合的结果，因为人们追求高性能纤维。因此，纤维科学家与材料技术共同创业的持续努力使梦想成为现实。这些特殊纤维完全提供了提供新技术的潜力。纵观全球纺织品，挑战着高科技纤维在各个领域的持续增长。这些纤维具有高韧性、高强度重量比，这是工业纺织品的前提特性。

These find applications in every walk of life including Space, Ocean, composites, aircrafts, defense, automobile and many more. Our present paper deals with these special fibers and explores the wealth of their properties and application.这些应用涉及各行各业，包括太空、海洋、复合材料、飞机、国防、汽车等等。我们在本文中讨论了这些特殊纤维，并探讨了它们的特性和应用的丰富性。

INTRODUCTION: 介绍： Up to this time, two types of fibers have been available to human society, **natural fibers** that have existed for 4000 years and synthetic fibers. Artificial silk invented was a human dream. Then nylon introduced was finer than spider's thread, stronger than steel and more elegant than silk.到目前为止，人类社会已经可以使用两种类型的纤维，一种是已经存在了 4000 年的天然纤维和合成纤维。发明人造丝是人类的梦想。然后引入的尼龙比蜘蛛线更细，比钢更坚固，比丝绸更优雅。

Today synthetic fibers are not a mere alternative to natural fibers but are new materials of high functionality and high performance, which play a key role in the field of high technology. These new materials can be designed and produced

according to nature of their utilization. Synthetic fibers are made to replace natural fibers and to some extent it is succeeded. High performance fibers are developed now a days fibers of high modulus and high strength can now be produced from synthetic polymers of light wt and are widely employed in space. Due to limitations of natural fibers, synthetic fibers are developed and now-a-days developments are done in the fibers to achieve desired properties.今天，合成纤维不仅仅是天然纤维的替代品，而是具有高功能性和高性能的新型材料，在高科技领域发挥着关键作用。这些新材料可以根据其使用性质进行设计和生产。合成纤维是为了取代天然纤维而制造的，并在一定程度上取得了成功。高性能纤维现已开发出来，现在可以用轻重量的合成聚合物生产高模量和高强度的纤维，并广泛用于太空。由于天然纤维的限制，合成纤维被开发出来，现在对纤维进行开发以实现所需的特性。

The need for ultra light fibers of high strength is increasing as high technology responds to changes in the social environment so, developments are going on in the synthetic fibers. In future decades, metals are expected to be replaced by newly developed synthetic fibers, which can be superior to metal with respect to their strength and modulus. In all the fields, there is wide application of fibers.随着高科技对社会环境变化的响应，对高强度超轻纤维的需求正在增加，因此合成纤维正在不断发展。在未来几十年内，金属有望被新开发的合成纤维所取代，这些纤维在强度和模量方面可能优于金属。在所有领域，纤维都有广泛的应用。

Kevlar 凯夫拉	Application cables, rope making, fiber reinforcement, Industrial paper, friction products, thermo chromic fiber changes color as per environmental conditions.应用电缆、制绳、纤维增强、工业造纸、摩擦产品、热变色纤维会根据环境条件改变颜色。
Solar – X 太阳能 – X	Stores solar energy 储存太阳能
BEMBERG Micro-porous membrane (BMM)宾霸微孔膜 （BMM）	Diagnosis and treatment of AIDS 艾滋病的诊断和治疗

HIGH PERFORMANCE FIBERS: 高性能纤维：High performance fibers refer to high strength, high modulus, and wear resistant deformation resistant and high temperature resistant fibers. The high performance fibers industry is targeting those areas which are the domain of glass, polyester and nylon fiber reinforcements. Major applications for the high performance fibers are transportation, aerospace, **protective clothing**, marine (ropes and sails), hostile thermal and chemical environments (replacement for asbestos) and leisure activities industries (golf clubs and tennis rackets). Some of the successful high performance fibers are mentioned below.高性能纤维是指高强度、高模量、耐磨、抗变形和耐高温的纤维。高性能纤维行业的目标是玻璃、聚酯和尼龙纤维增强领域的领域。高性能纤维的主要应用是运输、航空航天、防护服、海洋（绳索和帆）、恶劣的热和化学环境（替代石棉）和休闲活动行业（高尔夫球杆和网球拍）。下面提到了一些成功的高性能纤维。

ULTRA HIGH MOLECULAR WEIGHT POLYETHYLENE (UHMWPE): 超高分子量聚乙烯 （UHMWPE）：It is having high molecular weight (106), produced by Gel spinning technique. It is having Low (0.97) specific gravity, high

Chemical & abrasion resistances and high strength comparable to Kevlar. It is used in anti ballistic protection, floatable ropes, and nets.它具有高分子量 （106），通过凝胶纺丝技术生产。它具有低（0.97）比重，高化学和耐磨性以及与凯夫拉相当的高强度。它用于防弹道保护、可漂浮绳索和网。

ALUMINA SILICA: 二氧化铝：Ceramic fibers reported with a very high temperature resistance, used for furnace insulation and hot air filtration.据报道，陶瓷纤维具有非常高的耐高温性，用于炉膛保温和热空气过滤。

MELAMINE: 三聚氰胺：These fibers having 50% by weight of melamine cross-linked polymer (specific gravity about 1.44). It is having outstanding heat blocking properties with low thermal conductivity and good elongation at break (about 18%).这些纤维具有 50%（重量比）的三聚氰胺交联聚合物（比重约 1.44）。它具有出色的热阻断性能、低导热性和良好的断裂伸长率（约 18%）。

DOMESTIC FIBERS: 国产纤维：Cotton, silk polyester, polyamide are used in medical applications. PP and Polyester is used in geo textiles and dry/liquid filtration due to its compatibility. Jute and coir (Ligno-Cellulosic) used in biodegradable products and in packaging industry. Nylon is been used in the anti-ballistic, Cord, protection and filtration applications.棉、丝绸涤纶、聚酰胺用于医疗应用。PP 和聚酯由于其相容性而用于土工织物和干/液体过滤。黄麻和椰壳纤维（Ligno-Cellulosic）用于可生物降解产品和包装行业。尼龙用于防弹、绳索、保护和过滤应用。

ARAMID FIBERS (PPTA): 芳纶纤维 （PPTA）：Kevlar was the first Aramid fiber produced by Du. Pont. Poly (p-phenylene Terephthalamide) PPTA is the polymer from which Kevlar Aramid fibers are produced. The term Aramid was adoped to distinguish the group from the aliphatic polymide. Prior to 1985 Du Pont was the company producing commercial quantities of PPTA, HM – 50. PPTA is generally synthesized via an acid chloride condensation of terephthaloy1 chloride (TPC), with p- Phenylene diamine (PDA)Kevlar 是 Du. Pont 生产的第一种芳纶纤维。聚（对苯对苯二甲酰胺）PPTA 是生产芳纶芳纶纤维的聚合物。芳纶一词被用来区分该组与脂肪族聚酰亚胺。在 1985 年之前，杜邦公司是生产商业数量的 PPTA、HM – 50 的公司。PPTA 通常是通过对苯二酰亚胺 （TPC） 与对苯二胺 （PDA） 的酰氯缩合反应合成的

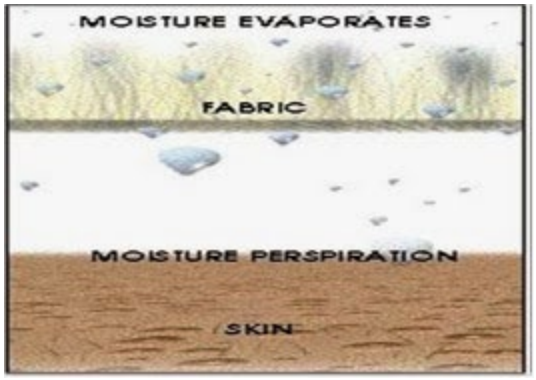
PPTA fibers have been designed for high strength applications. On an equal weight basis, these Aramid fibers are up to 10 times stronger than steel fibers of the same diameter. Along with exceptional strength, Aramids are also exceptionally stable in many corrosive environments.PPTA 纤维专为高强度应用而设计。在同等重量的基础上，这些芳纶纤维的强度是相同直径的钢纤维的 10 倍。除了卓越的强度外，芳纶在许多腐蚀性环境中也非常稳定。

Acrylic fibers: 腈纶纤维：Acrylic fiber's remarkable performance creates the year-around comfort consumers demand while producing a range of fabric advantages apparel manufacturers can utilize regardless of the season.腈纶纤维的卓越性能为消费者创造了全年所需的舒适感，同时为服装制造商提供了一系列不受季节限制都可以利用的面料优势。

Moisture Transport Is the Key to Comfort:湿气运输是舒适的关键：Acrylic fiber, with its inherent polarity (the ability to attract and convey moisture), is the

leading synthetic fiber for natural moisture transport (wicking), and is superior to fibers with topical finishes, which wash away. Acrylic fiber provides lifetime wicking capability to fabrics made from it. With acrylic garments in warm or cold climates, whether in active wear or spectator wear, you feel more comfortable because moisture management controls comfort.腈纶纤维具有固有的极性（吸引和输送水分的能力），是自然水分输送（芯吸）的领先合成纤维，优于具有局部整理剂的纤维，后者会被冲走。腈纶纤维为由它制成的织物提供终生芯吸的能力。在温暖或寒冷的气候下，无论是运动服还是观众服，您都会感觉更舒适，因为水分管理可以控制舒适度。

Increased Comfort in the "Dermisphere": 增加"Dermisphere"的舒适度： The dermisphere is the air space between your skin and your clothing (as shown in fig). The type of fibers and construction of the fabric directly affect the climate in your dermisphere, and determine how comfortable, or uncomfortable, you are regardless of the air temperature or activity in which you are engaged.真皮球是皮肤和衣服之间的空气空间（如图所示）。纤维的类型和织物的结构直接影响您真皮球的气候，并决定您的舒适度或不舒服程度，无论您从事的空气温度或活动如何。



A "dermisphere" covered by MICROSUPREME acrylic micro fiber. The skin is dry and comfortable because moisture is picked up by the fibers and transported to the garment' souter surface where it evaporates. The uncomfortable alternative is a damp (either hot or cold) dermisphere caused by fibers, which are not effective at insulating or transporting moisture 由 MICROSUPREME 丙烯酸超细纤维覆盖的"真皮球"。皮肤干燥舒适，因为水分被纤维吸收并输送到服装的外表面，在那里蒸发。不舒服的选择是由纤维引起的潮湿（热或冷）真皮球，它们不能有效地绝缘或运输水分

Moisture dissipation: 消湿： In the moisture dissipation test, fabrics are "spun dry" to evaluate drying time. All fabrics are started with their own percentage of moisture based on the fiber's moisture regain. Cotton, retaining the greatest amount of moisture and having the highest dry time, is used as a comparison. Data are expressed in percentages as compared to cotton, i.e. MICROSUPREME acrylic micro fiber dries 75% faster than cotton.在水分消散测试中，织物被"纺干"以评估干燥时间。所有织物都根据纤维的回潮率从自己的水分百分比开始。棉花保留最多的水分和最长的干燥时间，被用作比较。与棉花相比，数据以百分比表示，即 MICROSUPREME 腈纶超细纤维的干燥速度比棉花快 75%。

Fabric % 面料 %	Drying time faster than cotton 干燥时间比棉花快
MICROSUPREME MICROSUPREME 超强 Coolmax 酷麦克斯 Aquatec® Aquatec （阿夸特克酒店® Nylon 尼龙 Tactel® 塔克尔®	75% 70% 70% 60% 35%

MICROSUPREME: Acrylic Microfiber Takes Acrylic Into A New Dimension of Performance.**MICROSUPREME：** 丙烯酸微纤维将丙烯酸带入了性能的新维度。Garments made from fabrics of MICROSUPREME acrylic fiber take performance to a new dimension of creativity. Because of acrylic's ability to transport moisture and increase the "comfort-ability" of a garment, fabric designers can create constructions for all four seasons, enabling both the spectator and active participant to benefit. You not only get performance, but also luxurious touch and drape previously thought impossible. Due to its lower specific gravity, acrylic fiber also produces fabrics having more bulk without extra weight. Independent tests show that MICROSUPREME acrylic micro fiber is superior in comfort performance compared to other leading fibers.由 MICROSUPREME 腈纶面料制成的服装将性能提升到一个新的创意维度。由于腈纶能够输送水分并增加服装的"舒适度"，面料设计师可以为所有四个季节创造结构，使观众和积极参与者都能受益。您不仅可以获得性能，还可以获得奢华的触感和悬垂性，这在以前被认为是不可能的。由于其较低的比重，腈纶纤维还可以生产出体积更大的织物而不会增加重量。独立测试表明，与其他领先的纤维相比，MICROSUPREME 腈纶超细纤维在舒适性方面更胜一筹。

MICROSUPREME Acrylic Micro fiber – The Right Choice for All Reasons and Seasons.MICROSUPREME 腈纶超细纤维 – 适合所有原因和季节的正确选择。Acrylic, especially micro denier, not only creates greater comfort for the wearer, it also brings significant fabric advantages to all kinds of apparel.腈纶，尤其是微旦腈纶，不仅为穿着者带来更大的舒适度，还为各种服装带来显着的面料优势。

- Comfortable. 舒适。
- Soft, lasting hand 柔软、持久的手感
- Fabulous drapes. 华丽的窗帘。
- Easy washing, wrinkle resistance.易洗、抗皱。
- Beautiful, full-color dyeing.美丽的全彩染色。
- Brightly colorfast. 鲜艳的不褪色。
- Odor and mildew resistance.防臭和防霉。

For cold weather apparel acrylic provides outstanding insulation and warmth without extra weight.对于寒冷天气的服装，丙烯酸具有出色的绝缘性和保暖性，而不会增加重量。

Uses: 使用：

- Outerwear-Pile Fabrics 外套-绒毛面料

- Thermal Underwear 保暖内衣
- Socks/Tights 袜子/紧身裤
- Sweaters 毛衣
- Sleepwear 睡衣

Microfiber acrylic: 超细纤维腈纶：The new fiber is developing to be like cotton. There are `crevasses` in the fiber that diffuses light. This results in a more natural looking fiber, while regular acrylic is smooth and refracts light, giving the fiber an overall shine.这种新纤维正在发展成像棉花一样。光纤中有散射光的“裂缝”。这会产生看起来更自然的纤维，而普通丙烯酸是光滑的并折射光线，使纤维整体发光。

Low pill acrylic: 低丸亚克力：Now a day's low pill acrylic fiber also manufactured. That is especially good for school, career and military uniforms and a high performing fiber for socks. Along with all this `antimicrobial acrylic`, `acrylic blends`, and `acrylic-acetate blends also manufactured.现在一天的低丸腈纶也制造出来了。这特别适用于学校、职业和军装，也是袜子的高性能纤维。除了所有这些“抗菌丙烯酸”、“丙烯酸混合物”和“丙烯酸醋酸酯混合物”之外，还生产了这些混合物。

Magic fiber for AIDS diagnosis and treatment: 用于艾滋病诊断和治疗的魔术纤维：Ashai Chemical Industry Co. have developed a porous hollow fiber membrane BEMBERG MICROPOROUS MEMBRANE [BMM] to filter out and isolate AIDS virus [acquired immune deficiency syndrome virus] and hepatitis type B in blood. BMM is made from cellulose fiber [BEMBERG] regenerated from cuprammonium solutions of cotton linters.Ashai Chemical Industry Co. 开发了一种多孔中空纤维膜 BEMBERG 微孔膜 [BMM]，用于过滤和分离血液中的艾滋病病毒 [获得性免疫缺陷综合症病毒] 和乙型肝炎。BMM 由棉短绒的铜铵溶液再生的纤维素纤维 [BEMBERG] 制成。

Synthetic polymers are known to cause blood clotting as a result of protein adsorption. However, regenerated cellulose is free from this problem, and for this reason, is used for the artificial kidney in the form of hollow fiber. In order to allow proteins to permeate, but isolate viruses using the same membrane, it is necessary to have homogeneous pores in the membrane, which are larger than proteins but smaller than viruses. To produce such cellulose membranes having homogeneously distributed pores of predetermined diameter. Spherical B-type hepatitis virus and AIDS virus have a diameter of 42 nm and 90-100 nm. Respectively. Thus the membrane needs to have pores of 30-40 nm or 40-75 in diameter, respectively, to isolate these viruses. A single layer of membrane is not sufficient to isolate such viruses completely. Consequently BMM has a multi-layer structure of 100-150 layers. 已知合成聚合物会因蛋白质吸附而导致血液凝固。然而，再生纤维素没有这个问题，因此，以中空纤维的形式用于人工肾。为了让蛋白质渗透，但使用相同的膜分离病毒，必须在膜上具有均匀的孔，这些孔比蛋白质大，但比病毒小。生产具有预定直径均匀分布的孔的这种纤维素膜。球形 B 型肝炎病毒和艾滋病病毒的直径分别为 42 nm 和 90-100 nm。分别。因此，膜需要分别具有直径为 30-40 nm 或 40-75 nm 的孔，以分离这些病毒。单层膜不足以完全隔离此类病毒。因此，BMM 具有 100-150 层的多层结构。

This manufacturing multi layer hollow fiber membrane is produced by wet spinning from cuprammonium solution of cotton linter mixed with an organic solvent. The solution undergoes phase separation and is composed of two phases made up of concentrated and a dilute organic solvent. The concentrated phase forms a continuous organic solvent layer, and the dilute phase make up small organic solvent holes of a uniform size in the cotton linter solution. When spun, the resulting hollow fiber is made of 100-150 layers of cellulose membrane, with pores of a predetermined diameter [see Photo6.2] The pore size and the degree of crystallinity of BMM depends on many external factors such as temperature, solvent composition, component purity and time. Usually BMM is 300 to 400 um in outer diameter, 250 to 350 um in inner diameter, and is composed 40 um in thickness. The actual module is made of 300 BMM hollow fibers which together are 3 cm in diameter and 15 cm in length. Each layer of BMM has over a billion pores, which enables complete filtration and isolation of the viruses.这种制造的多层中空纤维膜是由棉短绒的铜铵溶液与有机溶剂混合通过湿法纺丝制成的。溶液经过相分离，由浓有机溶剂和稀有机溶剂组成的两相组成。浓相形成连续的有机溶剂层，稀相在棉短绒溶液中形成大小均匀的小有机溶剂孔。纺丝时，所得的中空纤维由 100-150 层纤维素膜制成，具有预定直径的孔 [见图 6.2]BMM 的孔径和结晶度取决于许多外部因素，例如温度、溶剂组成、成分纯度和时间。通常 BMM 的外径为 300 至 400 um，内径为 250 至 350 um，厚度为 40 um。实际模块由 300 根 BMM 中空纤维制成，这些纤维的直径为 3 厘米，长度为 15 厘米。BMM 的每一层都有超过 10 亿个孔，可以完全过滤和分离病毒。

Uses: 使用：It is capable of removing virus from plasma and so suppresses its multiplication. AIDS virus immersed into lymphocytes, grows there, and then overflows into plasma. If the isolation rate of virus from plasma is fast, the clinical progress of AIDS can be suppressed. This suppression of the AIDS virus can allow the reactivation of the metabolic functions of the human body, so that treatment efficiency will improve when combined with other medical treatments.它能够从血浆中去除病毒，从而抑制其增殖。艾滋病病毒浸入淋巴细胞中，在那里生长，然后溢出到血浆中。如果从血浆中分离出病毒的速度快，则可以抑制 AIDS 的临床进展。这种对艾滋病病毒的抑制可以使人体的新陈代谢功能重新激活，因此与其他药物治疗相结合时，治疗效率会提高。

Other applications of BMM are found, for example, in the complete isolation of virus during plasma medicines manufacture, the administration of fractionated plasma-producing medicines for hemophiliacs, and the prevention of virus infection during ordinal plasma transfusion.BMM 的其他应用包括血浆药物制造过程中的病毒完全分离、血友病患者分次血浆生成药物的给药以及在有序血浆输注期间预防病毒感染。

BMM is also useful for the isolation of hepatitis non-A non-B virus and in the study of unknown viruses or other physiologically active substancesBMM 还可用于分离非甲型肝炎非乙型病毒以及研究未知病毒或其他生理活性物质

Super absorbent fiber: 高吸水性纤维：In last few years, super absorbents in fiber from have become a commercial reality. The recent commercial availability of super absorbent fibers has spurred an enormous amount of development activity in

many market applications including telecommunications, packaging, horticulture, electronics and disposable hygiene products. Most recently the potential to benefit from their outstanding properties in a wide range of medical products have been recognized. The product is marketed as 'OASIS'. The product is based upon similar polymer chemistry to that for powders that is a cross-linked copolymer of acrylic acid. The advantages that fiber offers compared to fibers is due to their physical form, or dimensions, rather than their chemical nature. Whilst they do absorb fluids to a similar level as powders, they do, however, do it faster. This is due to the small diameter of the fibers, which is about 30 microns, which gives a very high surface area for contact with the liquid. Also the fiber surface is not smooth .It has a crenulated structure with longitudinal grooves. These are believed to be beneficial in transporting moisture along the surface. The lubricant has also been selected to enhance this wetting effect and results in a very high rate of moisture absorption. Typically the fiber will absorb 95% of its ultimate capacity in 15sec.在过去的几年里，纤维中的超级吸收剂已成为一种商业现实。最近高吸水性纤维的商业可用性刺激了许多市场应用的大量开发活动，包括电信、包装、园艺、电子产品和一次性卫生用品。最近，人们认识到了它们在各种医疗产品中的出色性能的潜力。该产品以"OASIS"的名义销售。该产品基于与粉末类似的聚合物化学性质，即丙烯酸的交联共聚物。与纤维相比，纤维提供的优势是由于它们的物理形式或尺寸，而不是它们的化学性质。虽然它们确实可以吸收液体到与粉末相似的水平，但它们确实吸收得更快。这是由于纤维的直径很小，约为 30 微米，这使得与液体接触的表面积非常高。此外，纤维表面不光滑。它具有带有纵向凹槽的锯齿状结构。这些被认为有利于沿表面输送水分。润滑剂也被选择以增强这种润湿效果，并导致非常高的水分吸收率。通常，光纤将在 15 秒内吸收其极限容量的 95%。

Properies 属性

Property 财产	Saline 盐水	Water 水
Free swell absorbency. 自由膨胀吸收性。 Retention (0.5psi) 保持力（0.5psi） Absorbency under load(0.25g/g) 负载吸收率 （0.25g/g）	40g/g 40 克/克 30 g/g 30 克/克 23 g/g 23 克/克	80 g/g 80 克/克 60 g/g 60 克/克 45 g/g 45 克/克

When the fibers absorb fluid it does not its fibrous structure. The resulting hydrogel is an entangled mass of swollen fibers. The gel has coherence and strength. A feature of the process is that the gel characteristics can be altered according to the end use requirements.当纤维吸收液体时，它不会吸收其纤维结构。所得水凝胶是一团缠结的肿胀纤维。凝胶具有连贯性和强度。该工艺的一个特点是可以根据最终用途要求改变凝胶特性。

When the fibers are allowed to dry out they return to their original form and are still absorbent. When the super absorbents absorb heterogeneous fluid such as blood, milk, or lattices the total absorbency is reduced due to deposition on the surface which

access of water. In the case of blood proteins are absorbed on the surface attached by the carboxylic acid groups in the polymer. With milk, the removal of the water causes the emulsion to break depositing faton the surface in addition to protein absorption. The magnitude of this effect is naturally affected by the surface to volume ratio of the super absorbent. The ratio about 8 times higher for oasis super absorbent fiber compared to typical super absorbent powder.当纤维变干时，它们会恢复到原来的形状并且仍然具有吸收性。当高吸收剂吸收异质流体（如血液、牛奶或晶格）时，由于水进入的表面沉积，总吸收率会降低。在血液的情况下，蛋白质在聚合物中羧酸基团附着的表面上被吸收。对于牛奶，水分的去除会导致乳液破裂，除了蛋白质吸收外，还会沉积在脂肪表面。这种效果的大小自然会受到高吸收剂的表面体积比的影响。与典型的高吸水粉末相比，oasis 高吸水纤维的比率高出约 8 倍。

The following features that may be required for use in medical product can be build up into nonwoven containing super absorbent fibers:用于医疗产品可能需要的以下特性可以构建到含有高吸水性纤维的无纺布中：

- High absorbency, even under pressure 即使在压力下也能保持高吸收性
- Softness and flexibility 柔软性和柔韧性
- Low migration of the super absorbent when dry and wet 高吸收剂在干湿时迁移率低
- High rate of liquid up-take.液体吸收率高。
- Fabric dispersion when wet 潮湿时织物的分散性

Super absorbent fabrics can contribute to the design of highly absorbent products because they can be incorporated at high levels in the non-woven fabrics. This leads to fabrics of low weight with high absorbency 高吸水性织物有助于设计高吸水性产品，因为它们可以高水平地掺入无纺布中。这导致织物重量轻，吸水性高

This feature of fibers not to migrate is a very important advantage. It allows the Super absorbent to be blended at high levels into an open structure without it falling out or its distribution in the fabric changing during storage, transport and use. This natural advantage gives more flexibility as to where the absorbent can be located.纤维不迁移的这一特点是一个非常重要的优点。它允许超级吸水剂以高水平混合成开放式结构，而不会在储存、运输和使用过程中脱落或在其织物中的分布发生变化。这种天然优势为吸收剂的放置位置提供了更大的灵活性。

The rate at which a non-woven fabric will absorb a liquid is a very important feature, which will particularly influence the likelihood of leakage in a hygiene product. It is a particular feature of super absorbent fibers that they absorb aqueous fluids very rapidly. Their free swell absorbency after only 15 seconds is equal to, or greater than, their retention capacity. This compares to less than half this absorbency for super absorbent powder containing fabrics. For all aqueous fluids a very rapid rate of absorption is always observed compared to powders.无纺布吸收液体的速度是一个非常重要的特征，它将特别影响卫生产品泄漏的可能性。高吸水性纤维的一个特殊特征是它们可以非常迅速地吸收水性液体。仅在 15 秒后，它们的自由膨胀吸收率等于或大于其截留能力。相比之下，含有高吸水性粉末的织物的吸水性不到一半。与粉末相比，对于所有水性流体，吸收速率始终非常快。

A unique advantage of a super absorbent in fiber form is that staple yarns can be spun in blends with other fibers. Yarns can be produced on warp woollen, DREF and semi worsted spinning systems but warp spinning is the preferred route as the lack of twist provides a yarn free to swell easily. It is possible to blend Oasis in these yarns with both natural and synthetics fibers.纤维形式的高吸收剂的一个独特优势是短纤纱可以与其他纤维混纺。纱线可以在经纱、DREF 和半精纺纺纱系统上生产，但经纱是首选路线，因为没有捻度使纱线容易膨胀。可以在这些纱线中将 Oasis 与天然和合成纤维混合。

Applications in medical products: 在医疗产品中的应用：Non-woven fabrics and yarns containing OASIS fiber super absorbent can be used for numerous applications where the properties of absorbency and/or swelling can be of use.含有 OASIS 纤维高吸水性的无纺布和纱线可用于许多具有吸水性和/或溶胀性的应用。

Disposable Incontinence Products:一次性失禁产品：High levels of super absorbent fiber can be incorporated into absorbent cores allowing the constructing of thin products with high absorbency.可以将高水平的高吸收纤维掺入吸收芯中，从而构建具有高吸收性的薄产品。

Wipes and absorbed pads: Addition of oasis to pads and wipes to improve their ability to rapidly immobilize large amounts of blood and other aqueous spillages in operating theatre, Analytical laboratory or general hospital use.湿巾和吸收垫：在垫和湿巾中添加绿洲，以提高它们在手术室、分析实验室或综合医院使用中快速固定大量血液和其他水溢出物的能力。

Disposal containers: 处置容器：Superabsorbent non-woven fabrics can be used as a lining for containers designed for the disposal of items contaminated with hazardous fluids to prevent leakage.高吸水性无纺布可用作容器的衬里，该容器设计用于处理被有害液体污染的物品，以防止泄漏。

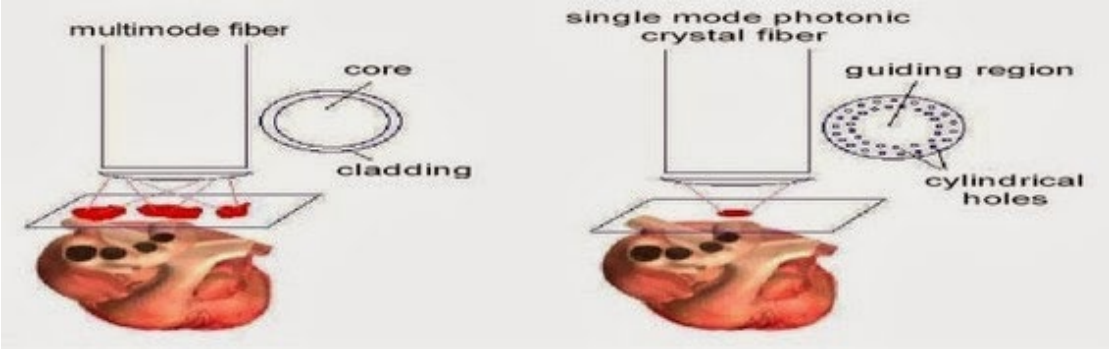
Drapes: 窗帘：In surgical gowns, oasis can be incorporated around the arm and neck cuffs to prevent blood ingress.在手术衣中，可以在手臂和颈部袖口周围加入 oasis 以防止血液进入。

Wound care: 伤口护理：Oasis can be included within secondary wound care products to provide additional capacity to absorbs wound exudates. This helps to decreases the frequency of dressing changes.Oasis 可以包含在二级伤口护理产品中，以提供额外的吸收伤口渗出物的能力。这有助于减少更换敷料的频率。

Ostomy bags: 造口袋：Oasis can be incorporated into ostomy and colostomy products and waste management devices to quickly solidify body fluids to improve ease of disposal.Oasis 可以整合到造口和结肠造口产品以及废物管理设备中，以快速凝固体液，从而提高处理的便利性。

Miscellaneous products: 其他产品：A number of other applications in the medical field are currently being evaluated including:目前正在评估医疗领域的许多其他应用，包括：

- Headbands for sweat control by surgeons,外科医生用于控制汗液的头带，
- Diagnostic testing, 诊断检测 /
- Hand sticks, 手杖，
- Dental pads. 牙垫。



The above figure shows use of multimode fibers in medical. So we can say that fiber plays an important role in our life.上图显示了多模光纤在医疗中的应用。所以我们可以说纤维在我们的生活中起着重要作用。

Bard backs smart fibers for surgery:Bard 支持用于手术的智能纤维： Shape-memory polymers have the potential to completely revolutionise medical surgery, as well as having a broad range of other applications, and the first product developed by mnemo Science was smart suture that ties itself into the perfect knot. This means that potentially, surgeons will be able to seal hard-to-reach wounds with the aid of a shape-shifiting thread that knows how to tie itself and never needs to be removed. The new 'smart' biodegradable plastic fiber can knot itself when heated to a few degrees above body temperature. Researchers belive the same material could be made to last much longer and one day be used for self repairing medical devices and also to shrink otherwise bulky implants such as screws that hold bones together.形状记忆聚合物有可能彻底改变医疗手术，并具有广泛的其他应用，mnemo Science 开发的第一款产品是智能缝合线，可将自身打成完美结。这意味着外科医生将能够借助知道如何自行打结且永远不需要移除的形状拟合线来密封难以触及的伤口。这种新的"智能"可生物降解塑料纤维在加热到比体温高几度时可以自行打结。研究人员相信，相同的材料可以制造得更耐用，有朝一日可以用于自我修复的医疗设备，还可以缩小原本笨重的植入物，例如将骨骼固定在一起的螺钉。

Spider silk: 蜘蛛丝： What is spider silk made of? It is a fibrous protein secreted as a fluid, which hardens as it oozes out of the spinnerets, which are mobile finger-like projections. As the fluid oozes out, the protein molecules are aligned in such a way that they form a solid; the process is not yet well understood. The spider hauls out the silk with its legs, stretching, fluffing it up or changing it in other ways to suit the purpose at hand.蜘蛛丝是由什么制成的？它是一种以液体形式分泌的纤维蛋白，当它从喷丝头渗出时会变硬，喷丝头是可移动的手指状突起。当液体渗出时，蛋白质分子以形成固体的方式排列在一起;这个过程还没有得到很好的理解。蜘蛛用腿拖出丝绸，伸展、蓬松或以其他方式改变它以适应手头的目的。

Fig: Spider silk 无花果：蜘蛛丝

Weight for weight, spider silk is up to 5 times stronger than steel of the same diameter. It is believed that the harder the spider pulls on the silk as it is produced, the stronger the silk gets. Spider silk is so elastic that it doesn't break even if stretched 2-4 times its length. Spider silk is also waterproof, and doesn't break at temperatures as low as -40 ^{0}C.与重量不同的是，蜘蛛丝的强度是相同直径钢的 5 倍。据信，蜘蛛在生产真丝时拉扯真丝越用力，真丝就越坚固。蜘蛛丝非常有弹性，即使拉伸 2-4 倍其长度也不会断裂。蜘蛛丝也是防水的，在低至 -40 ^{0}C 的温度下不会破裂。

There are 7 types of silk glands and "nozzles" but no spider has all 7 types 有 7 种类型的丝腺和"喷嘴"，但没有蜘蛛拥有所有 7 种类型

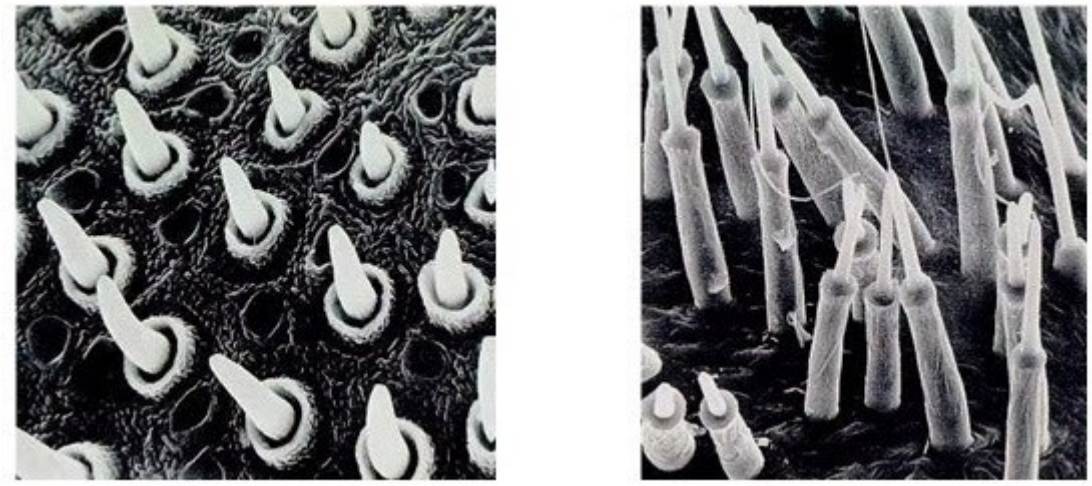


Fig. Two types of silk releasing tubes 无花果。两种类型的脱丝管

The material is elastic and only breaks at between 2 – 4 times its length. In the pictures a strand of a social spider, stegodyphus sarasinorum, is shown as normal size, stretched 5 times and 20 times its original length. Spider's silk is made up of chains of amino acids. In other words, it is simply a protein .The two primary amino acids are glycine and alanine. Spider silk is extremely strong — it is about five times stronger than steel and twice as strong as Kevlar of the same weight. Spider silk also has the ability to stretch about 30- percent longer than its original length without breaking, which makes it very resilient 该材料具有弹性，仅在其长度的 2 至 4 倍处断裂。

在图片中，一条群居蜘蛛 stegodyphus sarasinorum 的线被显示为正常大小，拉伸了 5 倍，是其原始长度的 20 倍。蜘蛛丝由氨基酸链组成。换句话说，它只是一个 蛋白质 .两种主要氨基酸是甘氨酸和丙氨酸。蜘蛛丝非常坚固——它的强度大约是钢的五倍，是同等重量的凯夫拉纤维的两倍。蜘蛛丝还具有比其原始长度长约 30% 而不断裂的能力，这使得它非常有弹性

Aramids: 芳纶：High tenacity aramid fiber: 高韧性芳纶纤维：Organic fibers. Closely related to the nylons, aramids are polyamides derived from aromatic acids and amines. Because of the stability of the aromatic rings and the added strength of the amide linkages, due to conjugation with the aromatic structures, aramids exhibit higher tensile strength and thermal resistance than the aliphatic polyamides (nylons). The para- aramids, based on terephthalic acid and p-phenylene diamine, or paminobenzoic acid, exhibit higher strength and thermal resistance than those with the linkages in meta positions on the benzene rings. The greater degree of conjugation and more linear geometry of the para linkages, combined with the greater chain orientation derived from this linearity, are primarily responsible for the increased strength. The high impact resistance of the para-aramids makes them popular for "bullet-proof" body armor. For many less demanding applications, aramids may be blended with other fibers.有机纤维。芳纶与尼龙密切相关，是从芳香酸和胺衍生的聚酰胺。由于芳香环的稳定性和酰胺键的强度增加，由于与芳香族结构的结合，芳纶表现出比脂肪族聚酰胺（尼龙）更高的拉伸强度和耐热性。基于对苯二酸和对苯二胺或氨基苯甲酸的对位芳纶比那些在苯环上间位键的对位芳纶表现出更高的强度和耐热性。对位键的更大程度的共轭和更线性的几何形状，以及从这种线性度得出的更大的链取向，是强度增加的主要原因。对位芳纶的高抗冲击性使它们成为"防弹"防弹衣的热门材料。对于许多要求较低的应用，芳纶可以与其他纤维混合。

High resistance aramid fibers: 高电阻芳纶纤维：Teiji conex is a meta linked aromatic polyamide fiber known for its heat resistance .it is a synthetic organic fiber comprised of polymetaphenylene iosthalic amide, which is formed by reaction from meta-phenylenediamine and isophthaloyl chloride. It decomposes at 4000C and having LOI 30. It is a white, highly functional fiber, which can be used for clothing to industrial material.Teiji conex 是一种元连接芳香族聚酰胺纤维，以其耐热性而闻名，它是一种由聚偏苯二胺和间苯酰氯反应形成的聚偏苯二胺组成的合成有机纤维。它在 4000C 和 LOI 30 时分解。它是一种白色、高功能性纤维，可用于服装到工业材料。

Continuous meta-type amide bonds to benzene rings render the following properties:与苯环相连的连续超位型酰胺键具有以下特性：

- High melting point and decomposition point.熔点和分解点高。
- High glass transition point.高玻璃化过渡点。
- Low oxidation decomposition rate.氧化分解速率低。

General properties: 一般特性：

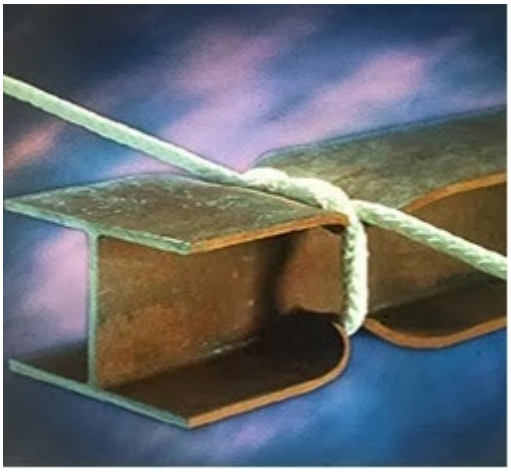
- High modulus. 高模量。
- High tenacity with low weight.高韧性，低重量。
- Low electrical conductivity.低导电性。
- High cut resistance. 高耐切割性。

- High chemical and temperature resistance.高耐化学性和耐温性。
- Low thermal shrinkage. 低热收缩率。
- Excellent dimensional stability.优异的尺寸稳定性。
- Do not corrode. 不要腐蚀。

Cut resistance aramid fiber:耐切割芳纶纤维：

Hoechst Research & Technology donated patent and other intellectual property rights, valued at $12 million, for its aramid cut-resistant fiber technology.

HDPE (high-density polyethylene): HDPE（高密度聚乙烯）： It can be extruded using special technology to produce very high molecular orientation. The resulting fiber combines high strength; chemical resistance and good wear properties with lightweight, making it highly desirable for applications ranging from cut-proof protective gear to marine ropes.它可以使用特殊技术挤出以产生非常高的分子取向。由此产生的纤维结合了高强度;耐化学性和良好的耐磨性，重量轻，使其非常适用于从防割防护装备到船用绳索的各种应用。



Since it is lighter than water, ropes made of HDPE float. Its primary drawback is its low softening and melting temperature.由于它比水轻，因此由 HDPE 制成的绳索可以漂浮。它的主要缺点是软化和熔化温度低。

Spectra fiber 1000: Spectra 光纤 1000： High-strength, lightweight polyethylene fiber:高强度、轻质聚乙烯纤维： Spectra® fiber 1000, the second in a series of Spectra® fibers, was developed to meet customers' needs for increased

performance. It is available in a multitude of deniers for use in a wide range of applications. This extended chain polyethylene fiber has one of the highest strength to weight ratios of any **manmade fiber**. Spectra® fiber 1000 has a tenacity 15 – 20 percent higher than that of Spectra® fiber 900. Spectra® fiber is, pound-for-pound, 10 times stronger than steel, more durable than polyester and has a specific strength that is 40 percent greater than aramid fiber. Specific performance is dependent upon denier and filament count.Spectra® fiber 1000 是 Spectra® 纤维系列中的第二款，旨在满足客户对提高性能的需求。它有多种旦数可供选择，可用于广泛的应用。这种长链聚乙烯纤维是所有人造纤维中强度重量比最高的纤维之一。Spectra® fiber 1000 的韧性比 Spectra® fiber 900 高 15 – 20%。Spectra® 纤维的强度是钢的 10 倍，比聚酯更耐用，比芳纶纤维高 40%。具体性能取决于旦尼尔和细丝数量。

Characteristics: 特性：

- Light enough to float (0.097 Specific Gravity)足够轻，可以漂浮（0.097 比重）
- High resistance to chemicals, water, and UV light 高耐化学性、耐水和耐紫外线性
- Excellent vibration damping 出色的减振性能
- Highly resistant to flex fatigue 高度抗弯曲疲劳
- Low coefficient of friction 低摩擦系数
- Good resistance to abrasion 良好的耐磨性
- Low dielectric constant makes it virtually transparent to radar 低介电常数使其对雷达几乎透明

Uses: 使用：

- Police and military ballistic vests and helmets 警察和军用防弹背心和头盔
- Composite armor for vehicles and aircraft 用于车辆和飞机的复合装甲
- Marine lines and commercial fishing nets 船用缆绳和商业渔网
- Industrial cordage and slings 工业缆绳和吊索

Melamine: 三聚氰胺：Definition for Melamine Fiber:三聚氰胺纤维的定义：A manufactured fiber in which the fiber-forming substance is a synthetic polymer composed of at least 50% by weight of a cross-linked melamine polymer.一种人造纤维，其中纤维形成物质是合成聚合物，由至少 50%（按重量计）的交联三聚氰胺聚合物组成。

Fiber is primarily known for its inherent thermal resistance and outstanding heat blocking capability in direct flame applications. This high stability is due to the cross linked nature of the polymer and the low thermal conductivity of melamine resin. In comparison to other melamine fiber offers an excellent value for products designed for direct flame contact and elevated temperature exposures.纤维主要以其固有的热阻和在直接火焰应用中出色的隔热能力而闻名。这种高稳定性是由于聚合物的交联性质和三聚氰胺树脂的低导热性。与其他三聚氰胺纤维相比，三聚氰胺纤维为直接接触火焰和高温暴露而设计的产品提供了极高的价值。

Moreover, the dielectric properties and cross section shape and distribution make it ideal for high temperature filtration applications. It is sometimes blended with

aramid or other performance fibers to increase final fabric strength.此外，介电特性、横截面形状和分布使其成为高温过滤应用的理想选择。它有时与芳纶或其他高性能纤维混纺，以提高最终织物强度。

Production: 生产：The production process is proprietary. It is based on a unique melamine chemistry that results in a cross-linked, non-thermoplastic polymer of melamine units joined by methylene and dimethylene ether linkages. In the polymerization reaction, methylol derivatives of melamine react with each other to form a three-dimensional structure. This structure is the basis for the fiber's heat stability, solvent resistance, and flame resistance.生产过程是专有的。它基于独特的三聚氰胺化学成分，可产生由亚甲基和二亚甲基醚键连接的三聚氰胺单元交联的非热塑性聚合物。在聚合反应中，三聚氰胺的羟甲基衍生物相互反应形成三维结构。这种结构是纤维热稳定性、耐溶剂性和阻燃性的基础。

Characteristics: 特性：

- White and Dyeable. 白色和可染色。
- Flame resistance and low thermal conductivity.阻燃性和低导热性。
- High heat dimensional stability.热尺寸稳定性高。
- Processable on standard textile equipment.可在标准纺织设备上加工。

Uses: 使用：

- Fire Blocking Fabrics: Aircraft seating, fire blockers for upholstered furniture in high-risk occupancies.防火织物：飞机座椅、高风险场所软垫家具的防火阻火器。
- Protective Clothing: Firefighters 'turnout gear, insulating thermal liners, knit hoods, molten metal splash apparel, heat resistant gloves.防护服：消防员的消防服、绝缘热衬垫、针织头罩、熔融金属防溅服、耐热手套。
- Filter Media: High capacity, high efficiency, high temperature bag house air filters.过滤介质：高容量、高效率、高温袋式除尘器空气过滤器。

Piezoelectric ceramic fiber: 压电陶瓷纤维：Lead Zirconate Titanate (PZT) active fibers, from 80 to 250 micrometers in diameter, are produced for the AFOSR / DARPA funded Active Fiber Composites 直径为 80 至 250 微米的锆钛酸铅 （PZT）活性纤维为 AFOSR/DARPA 资助的活性纤维复合材料生产

Consortium** (AFCC) Program and commercial customers. Cera Nova has developed a proprietary ceramics-based technology to produce PZT mono-filaments of the required purity, composition, straightness, and piezoelectric properties for use in active fiber composite structures. CeraNova's process begins with the extrusion of

continuous lengths of mono-filament precursor fiber from a plasticized mix of PZT-5A powder. The care that must be taken to avoid mix contamination is described using illustrations from problems experienced with extruder wear and metallic contamination.联盟** （AFCC） 计划和商业客户。Cera Nova 开发了一种基于陶瓷的专有技术，可生产具有所需纯度、成分、直线度和压电性能的 PZT 单丝，用于活性纤维复合结构。CeraNova 的工艺从从 PZT-5A 粉末的塑化混合物中挤出连续长度的单丝前驱体纤维开始。为避免混料污染而必须采取的措施，通过挤出机磨损和金属污染等问题进行说明。

Manufacturing: 制造业：CeraNova has developed a proprietary extrusion and firing method to ake round, straight and contamination free PZT fibers having composition and piezoelectric performance suitable for AFC use.CeraNova 开发了一种专有的挤出和烧制方法，可加工出圆形、直状和无污染的 PZT 纤维，其成分和压电性能适合 AFC 使用。

Raw materials and mixing:原料和混合：PZT-5A powder is mixed under high-shear conditions with a proprietary binder formulation until a homogeneous blend is achieved.PZT-5A 粉末在高剪切条件下与专有的粘合剂配方混合，直到获得均匀的混合。

The PZT particle size is submicron. Binders are added sequentially during the mixing process. As only 100 kilograms of mix are required to produce sufficient fiber for 20,000 AFC packs per year, mixing capacity will not constrain future AFCC production requirements.PZT 粒径为亚微米。在混合过程中依次添加粘合剂。由于每年只需 100 公斤混合物即可生产足够 20,000 个 AFC 包装的纤维，因此混合能力不会限制未来的 AFCC 生产要求。

Batch blending and remixing improves mix consistency and extrusion performance. Great care is taken to avoid contamination as this can result in extruder die blockage or unacceptable defects in fired fibers.批量混合和再混合可提高混合一致性和挤出性能。我们非常小心地避免污染，因为这可能导致挤出机模具堵塞或烧制纤维中出现不可接受的缺陷。

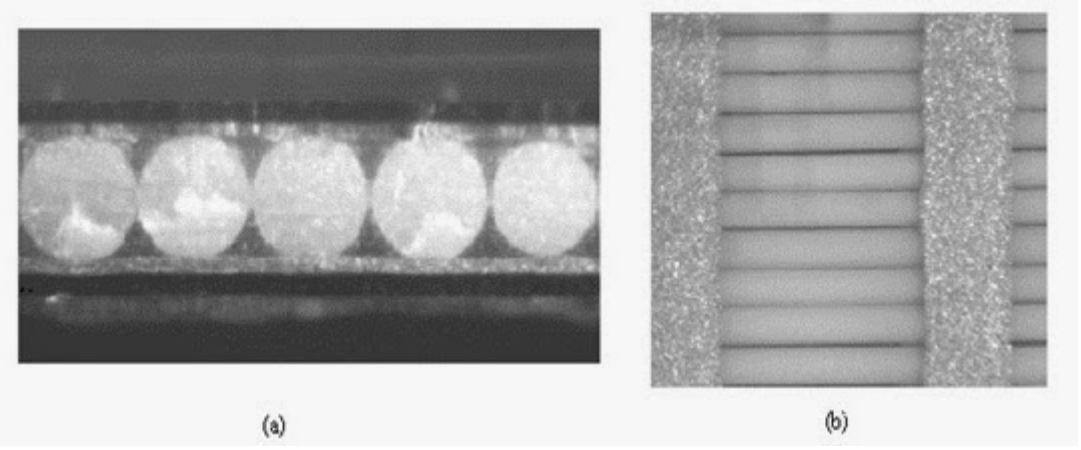


Fig: Cross section (a) and top view (b) of Continuum Control's Active Fiber Composite using an experimental electrode system. Note conformability of electrode around fiber. Fiber diameter is 130 micrometers; electrode spacing is 1 mm with a width of 0.5 mm.图：使用实验电极系统的 Continuum Control 活性纤维复合材料的横截面 （a） 和俯视图 （b）。注意纤维周围电极的

顺应性。纤维直径为 130 微米;电极间距为 1 mm，宽度为 0.5 mm。

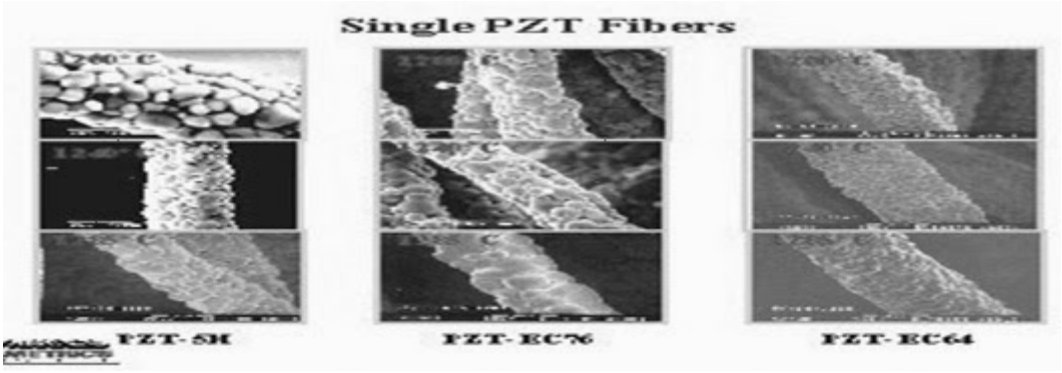


Fig: Shows the some of the single PZT fibers 图：显示了一些单 PZT 纤维

Properties: 性能：

- Diameters from 5 microns to 250 microns.直径从 5 微米到 250 微米。
- Flexible and lightweight.灵活轻便。
- Converts waste mechanical energy into electrical energy (vibration, motion)将废弃的机械能转化为电能（振动、运动）
- When the fibers are exposed to an electric field, they mechanically deform.当纤维暴露在电场中时，它们会发生机械变形。

Uses: 使用：

- Used in sonar, ultrasound, acoustic reproduction, energy harvesting, smart materials, smart sporting goods, and medical applications.用于声纳、超声波、声学再现、能量收集、智能材料、智能体育用品和医疗应用。
- Can be used to power independent Electronic Systems 可用于为独立的电子系统供电

Bicomponent fiber: 双组分纤维：Recently designed a bicomponent spin pack that resulted in spinning a very unusual fiber (see below). This fiber is a type of island-in-the-sea bicomponent where a dissolvable polymer (blue) is used to surround islands of a standard polymer such as polypropylene, nylon or polyester. In this case the fiber was spun with a 50/50 ratio of polyethylene and polypropylene. It is not know at this time if this same cross-section can be obtained with other polymer combinations.最近设计了一种双组分纺丝组，导致纺丝一种非常不寻常的纤维（见下文）。这种纤维是一种海中岛双组分，其中可溶解聚合物（蓝色）用于围绕标准聚合物（如聚丙烯、尼龙或聚酯）的岛屿。在这种情况下，纤维是用聚乙烯和聚丙烯的 50/50 比例纺制的。目前尚不清楚是否可以使用其他聚合物组合获得相同的截面。

After dissolving away the blue polymer, the resulting fiber consists of a single high denier snowflake center surrounded by multiple round and oval shaped microfilaments. The large core should provide good fiber and fabric strength and large surface area for absorption, and the microfilaments will provide softness as well as absorption. This type of fiber should be ideal for filtration applications both in woven and nonwoven construction. The dual shape microfilaments will enhance the loft of the fabric while the grooves in the core filaments may enhance particle trapping and absorption.溶解掉蓝色聚合物后，所得纤维由单个高旦雪花中心组成，周围环绕着多个圆形和椭圆形微丝。大芯应提供良好的纤维和织物强度和较大的吸收表面积，而微丝将提供柔软性和吸收性。这种类型的纤维应该是编织和非织造结构中过滤应用的理想选择。双形状的微丝将增强织物的蓬松度，而芯丝中的凹槽可能会增强颗粒的捕获和吸收。

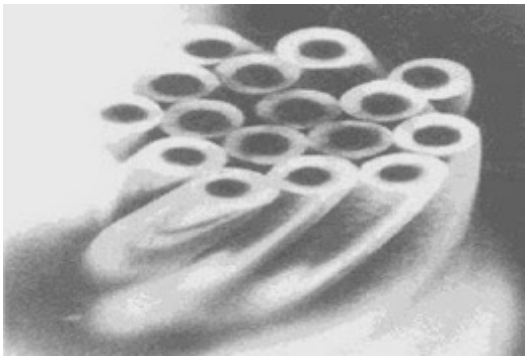
Power fibers that store solar energy: 储存太阳能的功率纤维： Heat regenerating fibers are produced from ceramic composites by applying heat insulation processing technology, which utilizes the far infrared radiation effect of ceramic. When heated ceramics radiate far infra –red radiation, which penetrates into the material and heats it homogeneously by activating molecular motion. Zirconium, magnesium oxide or iron oxide can be blended into synthetic fibers, because these materials radiate Ca.60 mW far infrared of wavelengths 8-14 um at a body temperature of 36 0C. These heat reradiating fibers are used for sportswear, bead-sheets, bed-cover materials, etc.热再生纤维是通过应用隔热加工技术以陶瓷复合材料制成的，该技术利用陶瓷的远红外辐射效应。当加热的陶瓷辐射远红外线时，红外线辐射会渗透到材料中并通过激活分子运动均匀地加热材料。锆、氧化镁或氧化铁可以混合成合成纤维，因为这些材料在 36 0C 的体温下会辐射波长为 8-14 um 的 Ca.60 mW 远红外线。这些热再辐射纤维用于运动服、珠片、床罩材料等。

A futuristic fiber material solar-α has been developed, which absorbs and preserves the optical energy of the sun. solar-α has been employed for a downhill skiing suit. In addition to its smooth surface and aerodynamic form, this downhill suit aimed to increase the insulating efficiency by solar-α in order to warm the muscle and bring out its best power.一种未来主义的纤维材料 solar-α 已经被开发出来，它可以吸收和保存太阳的光能。solar-α 已被用于高山滑雪服。除了光滑的表面和空

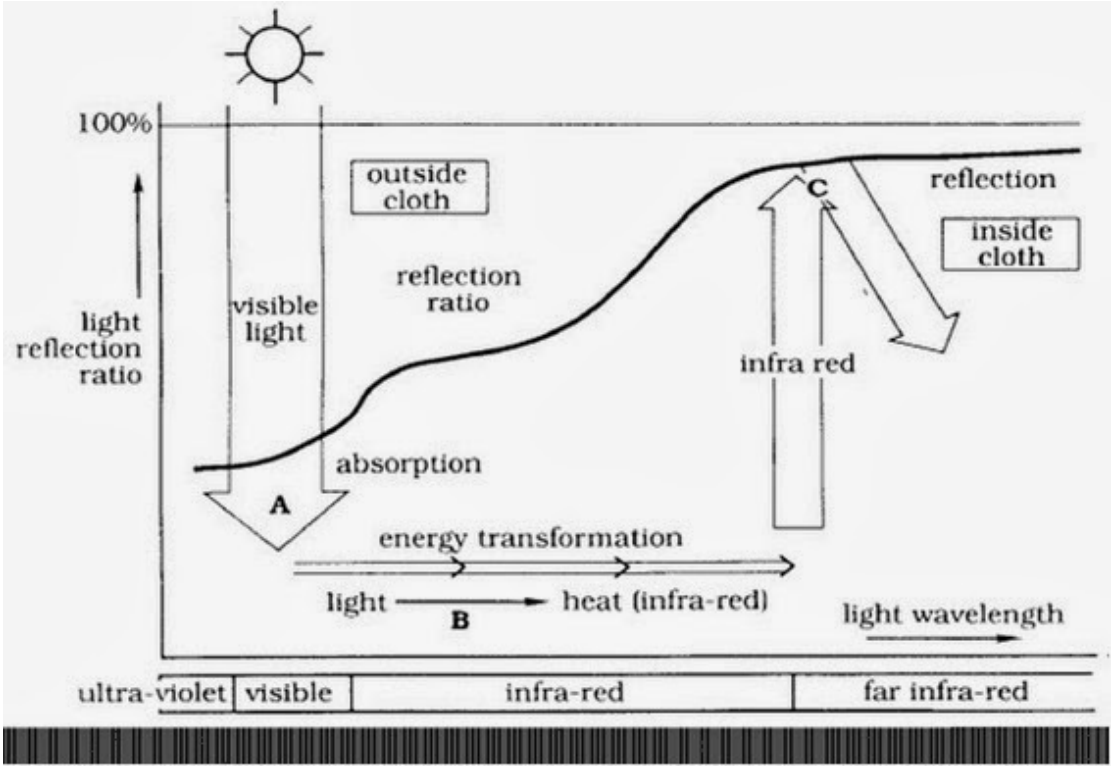
气动力学形式外，这款速降服还旨在通过太阳能 α 提高绝缘效率，以温暖肌肉并发挥其最佳力量。

Oxygen consumption must be reduced t o minimum to bring out power efficiently from muscle in severe climatic conditions. Zirconium carbide compounds are used is used for their excellent characteristics in absorbing and storing heat in a new type of solar system, including domestic water heaters and large-scale generators turbine. Zirconium carbide traps heat energy. It absorbs visible 在恶劣的气候条件下，必须至少减少耗氧量，才能有效地从肌肉中释放力量。碳化锆化合物因其在新型太阳能系统中吸收和储存热量的优异特性而被使用，包括家用热水器和大型发电机涡轮机。碳化锆捕获热能。它吸收可见的

rays and reflects the light of long wavelength, which makes up 95% of sunlight, and converts it into stored heat energy. Descente researchers applied these characteristics of Zirconium carbide on polyamide or polyester fibers. They developed the technology to enclose Zirconium carbide powder within the core of synthetic fibers (as shown in fig.)光线和反射占太阳光 95% 的长波长光，并将其转化为储存的热能。Descente 研究人员将碳化锆的这些特性应用于聚酰胺或聚酯纤维。他们开发了将碳化锆粉末封装在合成纤维芯内的技术（如图



The cloths made of these fibers solar-α absorbs solar visible radiation efficiently and converted it into heat in the form of infra-red radiation which released in the clothing.由这些纤维制成的布料具有太阳 α 能有效地吸收太阳可见辐射，并将其转化为红外线辐射形式的热量，从而在衣服中释放出来。



Body-responsive hollow fiber:人体响应式中空纤维：Hollow fiber has been scientifically proven to significantly increase oxygenated blood flow, which cans increase circulation and build strength. For diabetics, this improvement in skin oxygenation can accelerate wound healing and help eliminate pain due to decreased 90 blood flow. For people not affected by diabetes, this skin oxygenation helps speed recovery after exercise, boost energy levels and improve overall circulation.科学证明，中空纤维可以显着增加含氧血流量，从而可以增加血液循环和增强力量。对于糖尿病患者来说，皮肤氧合的这种改善可以加速伤口愈合，并有助于消除因 90 血流量减少而引起的疼痛。对于不受糖尿病影响的人来说，这种皮肤氧合作用有助于加速运动后的恢复，提高能量水平并改善整体血液循环。

Diabetics face two major issues neuropathy, or the loss of sensation, and atherosclerosis, or hardening of the arteries, which reduces the circulation of blood in the body. Atherosclerosis can lead to a number of conditions, including aching feet, leg pain and problems with wound healing. Symptoms include cold feet, pain in the legs when walking and pain in the feet when reclining. When worn on or near the skin, Hollow fiber responds to available light and the energy produced naturally by the body, converting light and they body's own energy in to the necessary wavelengths that make this usually unavailable energy accessible to the body-improving the body's circulation and oxygen levels.糖尿病患者面临两个主要问题：神经病变或感觉丧失，以及动脉粥样硬化或动脉硬化，这会减少体内血液循环。动脉粥样硬化会导致多种情况，包括脚痛、腿部疼痛和伤口愈合问题。症状包括脚冷、走路时腿部疼痛和斜倚时脚部疼痛。当佩戴在皮肤上或皮肤附近时，中空纤维会响应可用的光和身体自然产生的能量，将光和它们身体自身的能量转化为必要的波长，使身体能够获得这种通常无法获得的能量——改善身体的血液循环和氧气水平。

In addition to helping diabetics, this breakthrough textile has been shown to improve physical performance and recovery time among those without circulation problems. Holofiber is already being lauded by some of the world's top athletes, including top ranked female triathlete and Olympic silver medalists Michellie jones, who has been testing Holofiber for nearly two years. "As a professional athlete, you want everything you can possibly find to help get the best performance possible, "she said. "That's one of the things I like about Holofiber – the fact that it helps with recovery and circulation. What better way-there's no extra effort, and it really helps and benefits you." World's leading experts in diabetic foot complications, proved the effectiveness of Holofiber products in increasing oxygen levels in diabetic subject. There was a"… statistically significant change in transcutaneous oxygen – or the oxygen delivery to the skin – in hands and feet, on subjects wearing Holofiber gloves and socks compared to those wearing comparable non-Holofiber gloves and socks."除了帮助糖尿病患者外，这种突破性的纺织品还被证明可以改善没有血液循环问题的人的身体机能和恢复时间。Holofiber 已经受到一些世界顶级运动员的称赞，包括排名靠前的女子铁人三项运动员和奥运会银牌得主 Michellie Jones，她已经测试了近两年的 Holofiber。"作为一名职业运动员，你希望你能找到的一切来帮助获得最好的表现，"她说。这是我喜欢 Holofiber 的一点——它有助于恢复和循环。还有什么更好的方法 - 无需额外的努力，它真的对您有所帮助和好处。世界领先的糖尿病足并发症专家证明了 Holofiber 产品在增加糖尿病受试者氧气水平方面的有效性。有一个".....与佩戴同类非 Holofiber 手套和袜子的受试者相比，佩戴 Holofiber 手套和袜子的受试者手和脚经皮氧（或向皮肤输送的氧气）具有统计学意义的变化。

Among the manufacturers already offering Holofiber products or planning to introduce them are wickers in its t-shirts, shorts, sock and glove liners, Super feet in custom insoles, Achieve 02 in diabetic and medical socks and Callaway Golf in shoes. Holofiber is a proprietary product with a patent pending. It is a responsive material for textiles and other uses, and is not an additive or coating applied by spraying or dipping. Its properties do not wash or leach out of the fabric. All of the Holofiber material are incorporated into the fiber and are non-toxic and biologically benign 已经提供或计划推出 Holofiber 产品的制造商包括 T 恤、短裤、袜子和手套衬垫中的柳条、定制鞋垫中的 Super feet、糖尿病和医用袜中的 Achieve 02 以及鞋子中的 Callaway Golf。Holofiber 是一种专有产品，正在申请专利。它是一种用于纺织品和其他用途的响应材料，不是通过喷涂或浸渍涂抹的添加剂或涂层。它的特性不会从织物中洗涤或浸出。所有 Holofiber 材料都掺入纤维中，无毒且生物无害

POLYESTER: 聚酯：FORMALDEHYDE FUMES ABSORB POLYESTER: 甲醛烟雾吸收聚酯：A polyester fiber can be spun and woven into fabrics for upholstery, which will adsorb the fumes released by the formaldehyde adhesives used to make furniture. The fibers, and so the fabrics made from them, contain a nitrogen compound that is firmly bonded to the surface. It is this that absorbs the gas.聚酯纤维可以纺成和编织成室内装潢织物，这将吸附用于制造家具的甲醛粘合剂释放的烟雾。纤维以及由它们制成的织物含有一种牢固粘合到表面的氮化合物。正是这个吸收了气体。

The tests are conducted in environments in which the level formaldehyde was as high as 14 parts per million [ppm]. The fabrics reduced this level to just 0.06 ppm in 24 hours, the upper safety limit is considered to be 0.08 ppm. This fiber so much useful in the industry, for worker apparel and other purposes also.这些测试是在甲醛含量高达百万分之 14 [ppm] 的环境中进行的。织物在 24 小时内将这一水平降低到仅 0.06 ppm，安全上限被认为是 0.08 ppm。这种纤维在工业中非常有用，也可用于工人服装和其他用途。

Lightweight and air-insulating polyester fiber:轻质透气聚酯纤维：Sinkong Synthetic Fibers Corp. has adopted a new spinning technology to create Thermo Tech, a lightweight and air-insulating polyester fiber with a hollow cross-sectional area. The functional fiber is suitable for sportswear, thermal underwear, socks and bed sheets.Sinkong Synthetic Fibers Corp. 采用一种新的纺丝技术制造了 Thermo Tech，这是一种具有中空横截面积的轻质空气绝缘聚酯纤维。这种功能性纤维适用于运动服、保暖内衣、袜子和床单。

The hollowness of the fiber can be up to 30 percent, yielding a lower fiber density and enabling air to be trapped within the fiber to preserve body heat. The firm, resilient fiber lends a cotton like hand, rich feel, wrinkle-free and easy-to-clean properties to fabrics.纤维的空心度可高达 30%，从而产生较低的纤维密度，并使空气能够被困在纤维内以保持身体热量。坚硬、有弹性的纤维赋予织物如棉花般的手感、丰富的手感、无皱和易于清洁的特性。

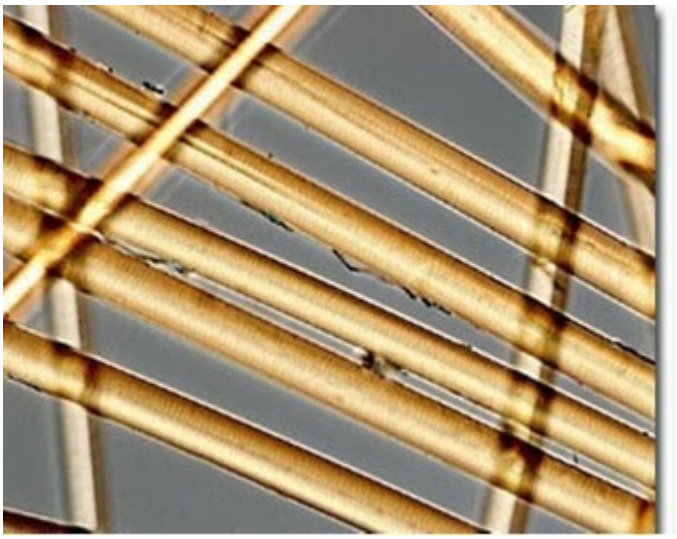
Thermo Tech is available in SDY and FOY versions in 60d/50f, 75d/50f, 75d/30f and 75d/36f specifications.Thermo Tech 提供 60d/50f、75d/50f、75d/30f 和 75d/36f 规格的 SDY 和 FOY 版本。

Cross sections of some of the new developed fibers:一些新开发的纤维的横截面：

Fig: New developed fibers 图：新开发的纤维

Kevlar: 凯夫拉尔：Five times stronger than steel, Kevlar is a synthetic fiber of the DuPont corporation that was first created in 1965 by scientists Stephanie Kwolek and Herbert Blades. Since that time, Kevlar has been utilized in a wide variety of applications and has helped save thousands of lives through its use in bulletproof vests. Sometimes referred to as a Space Age material, it is the chemical structure and processing of Kevlar that makes it so strong. More specifically, Kevlar contains both aromatic and amide molecular groups. When molten Kevlar is spun into fibers at the processing plant, the polymers produced exhibit a crystalline arrangement, with the polymer chains oriented parallel to the fiber's axis. The amide groups are able to form hydrogen bonds between the polymer chains, holding the separate chains together like glue. Also, the aromatic components of Kevlar have a radial orientation, which provides an even higher degree of symmetry and strength to the internal structure of the fibers.Kevlar 纤维的强度是钢的五倍，是杜邦公司的一种合成纤维，由科学

家 Stephanie Kwolek 和 Herbert Blades 于 1965 年首次发明。从那时起，Kevlar 已被用于各种应用，并通过将其用于防弹背心帮助挽救了数千人的生命。有时被称为太空时代材料，正是凯夫拉尔的化学结构和加工使其如此坚固。更具体地说，Kevlar 同时包含芳香族和酰胺分子基团。当熔融的凯夫拉纤维在加工厂纺成纤维时，生产的聚合物呈现结晶排列，聚合物链平行于纤维的轴线。酰胺基团能够在聚合物链之间形成氢键，像胶水一样将单独的链固定在一起。此外，Kevlar 的芳香族成分具有径向取向，这为纤维的内部结构提供了更高程度的对称性和强度。



Strength is not, however, the only advantageous feature of Kevlar fiber. Kevlar is also lightweight, flexible, and resistant to chemicals and flames. Together these characteristics make Kevlar extremely useful to humans. Some of the common items that contain Kevlar include sports equipment, such as skis and tennis rackets, highly protective gloves, parachutes, and tires. Kevlar is also frequently used to construct lightweight ropes, which have been used for such crucial applications as mooring the large vessels of the United States Navy and securing the airbags in the landing apparatus of the Mars Pathfinder 然而，强度并不是凯夫拉纤维的唯一优势特征。Kevlar 还重量轻、柔韧且耐化学腐蚀和阻燃。这些特性结合在一起，使 Kevlar 对人类非常有用。一些含有 Kevlar 的常见物品包括运动器材，例如滑雪板和网球拍、高度防护手套、降落伞和轮胎。凯夫拉尔还经常用于制造轻型绳索，这些绳索已用于诸如系泊美国海军的大型船只和将安全气囊固定在火星探路者号的着陆装置中

Fiber optics: 光纤：Optical fibers are thin strands of super-clean glass (fused silica), about the size of a human hair. Almost all fibers used today are single strands. Fiber bundles find use primarily in coherent and image transmitting optical systems. There are also plastic fibers for inexpensive, short distance transmission. The basic design of an optical fiber consists of two components – the core and the cladding. They build an optical waveguide, which conducts optical power (photons) in the form of light rays. Core and cladding differ primarily in the refractive index of the glass. The core's refractive index is slightly higher than the cladding's, thereby creating a boundary for a circular wave-guide. Fiber optic signaling in data transmission is increasingly being used in high-density applications. In the military, the Standard

Electronic Modules (SEM) of the Standard Hardware Acquisition and Reliability Program (SHARP) are widely used for high density electrical interconnects in card-edge-to-backplane interfacing.光纤是超洁净玻璃（熔融石英）的细股，大约有人类头发那么大。今天使用的几乎所有纤维都是单股纤维。光纤束主要用于相干和图像传输光学系统。还有用于廉价、短距离传输的塑料光纤。光纤的基本设计由两个部分组成——纤芯和包层。它们构建一个光波导，该光波导以光线的形式传导光功率（光子）。芯材和包层的主要区别在于玻璃的折射率。纤芯的折射率略高于包层的折射率，从而为圆形波导创建边界。数据传输中的光纤信号越来越多地用于高密度应用。在军事领域，标准硬件采集和可靠性计划（SHARP） 的标准电子模块 （SEM） 广泛用于卡边缘到背板接口中的高密度电气互连。

The advantages of fiber optics can be summarized as:光纤的优势可以概括为：

- Insensitive to EMI, RFI and EMP 对 EMI、RFI 和 EMP 不敏感
- Does not radiate energy 不辐射能量
- Low transmission losses 低传输损耗
- Wide transmission bandwidth 传输带宽宽
- Unaffected by Lightning 不受雷电影响
- Lightweight & non-corrosive.轻便且无腐蚀性。
- Absolutely safe in explosive environments 在爆炸性环境中绝对安全

CONCLUSION: 结论：Natural fibers have good properties but have some limitations; to overcome those synthetic fibers are produced. Still they have some drawbacks, to remove them developments are going on. Now days, almost in all the fields' fibers are used. Fibers can replace even metals, so enormous developments are done in fiber field. Now the aspect of eco-friendly, environment friendly (fiber) have came in future. Now in that respect development, research is going on.天然纤维具有良好的性能，但也有一些局限性;为了克服这些，产生了合成纤维。他们仍然有一些缺点，为了消除它们，开发正在进行中。如今，几乎所有的田地都使用了纤维。纤维甚至可以取代金属，因此纤维领域取得了巨大的发展。现在，环保、环保（纤维）的方面已经出现。现在在这方面，研究正在进行中。

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