The Properties and Application Progress of Sorona Fiber

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Abstract - Sorona fiber was produced from renewable resources with excellent performance of ordinary synthetic. In this paper, throughout the production process and internal molecular structure of Sorona fiber, the author introduced its environmental protection, tensile elasticity, easy dyeing and other properties and the current application.

1. Introduction
With the continuous improvement of people's living standards and the change of concepts, the requirements for clothing are not limited to wearing and aesthetics. On the contrary, higher requirements are put forward for functionality and comfort. Environmental and ecological textiles have attracted more and more attention, which has promoted the emergence of various new fibers.

PTT (polytrimethylene-terephthalate) fiber is the abbreviation of polytrimethylene terephthalate fiber. It was first produced by Shell Chemical Company and DuPont from the petroleum process route and the biosynthetic process route through PTA (terephthalic acid) and PDO (1, 3-propylene glycol) which is formed by esterification and polycondensation [1]. Due to the high manufacturing cost of PDO and its strong dependence on petrochemical resources, the application of DuPont Sorona fiber produced by biotechnology has become more and more widespread. This article discusses the characteristics and applications of Sorona fiber, and looks forward to the future development trend.

2. Introduction to Sorona fiber
Sorona fiber is a new type of polyester that is newly industrialized by DuPont and has achieved great success. It combines the softness of nylon, the bulkiness of acrylic, the stain resistance of polyester, and its inherent elastic function. With the combination of the excellent wearability advantages of various fibers, Sorona fiber has become a new broad category of fibers with a wide range of applications.

The main synthesis process (biochemical method) of Sorona fiber is as follows: Firstly, with the action of bacteria (after genetic modification), PDO is produced through fermentation from glucose which is obtained from corn. Secondly, PDO is distilled, purified and dehydrated to become a clear and slightly sticky liquid. Finally, after adding PTA, esterification, polycondensation and slicing, Sorona fiber can be prepared [2].

The surface morphology and structure of Sorona fiber is basically similar to PET. It is a smooth strip shape with strong fiber luster and voids on the surface. It can be made into a variety of special-shaped fibers of different shapes, such as triangles, trilobal shapes, etc. In terms of chemical structure, Sorona fiber is somewhat different from several synthetic fibers (Table 1). It has one more
methylene group (-CH2-) than PET. The molecular structure in the crystal is in a spiral zigzag and the macromolecules have "odd carbon Structure" [3] (Figure 1).

Table 1 Molecular structure comparison of Sorona fiber, PET, PBT and PA [4]

| Fiber type                        | Number of methylene groups | Features                                                                 |
|-----------------------------------|----------------------------|--------------------------------------------------------------------------|
| Sorona fiber (Polytrimethylene terephthalate) | 3                          | Helical molecular chain is helical which is easy to elongate; Odd carbon effect |
| PET (Polyethylene terephthalate)  | 2                          | Fully extended configuration of molecular chain                           |
| PBT (Polybutylene terephthalate)  | 4                          | High length of methly chain; Great flexibility                           |
| PA (Polyamide)                    | 6                          | Linear long-chain molecules and fully extended plane zigzag configuration |

3. Sorona fiber characteristics

3.1 Environmental friendliness
The Sorona fiber produced by the biochemical method has the following three-fold environmental protection value. 1) 37% of raw materials come from natural renewable resources instead of petrochemical raw materials, thereby reducing dependence on petroleum resources; 2) Sorona fiber with the same output consumes 30 less than nylon fiber based on petrochemical raw materials; 3) Sorona fiber with the same output emits 63% less carbon dioxide (ie greenhouse gas) than nylon fiber based on petrochemical raw materials.

3.2 Softness
Sorona fibers (filaments and textured yarns), compared with fabrics in the normal size range, have a higher level of flexibility. Because of the smaller external force required to be bent, Sorona fiber of the same size is more flexible than PET and nylon.
3.3 Stretching resilience
The molecular chain of Sorona fiber has a zigzag configuration along the fiber axis, which makes it easy to stretch and has good elasticity. Because the stretched fiber unit crystal length is the maximum stretched configuration of the repeating unit, it has good elasticity and stretch recovery. For example, Sorona fiber (full-drawn yarn) has an elastic recovery rate of 100% when it is stretched by about 120%, while Sorona fiber (textured yarn) has an elastic recovery rate of 100% when it is stretched by 145%. In addition, the zigzag structure of Sorona fiber makes it even better in resilience and shape retention than spandex. This zigzag structure is relatively close to nylon fiber, and has the characteristics of nylon fiber.

3.4 Low temperature susceptibility
Sorona fiber is a kind of fiber that is easy to dye at low temperature. Because of its low glass transition temperature, which is about 45°C~65°C [5], and the lattice accumulation of Sorona fiber is looser than that of PET fiber, it can be dyed at atmospheric pressure without a carrier. When dyeing with disperse dyes, the dye uptake rate can be very good under the temperature of 110°C~120°C. In addition to shortening the dyeing time and reducing the energy consumption in the entire dyeing and finishing process, the various color fastness indexes of the dyed Sorona fiber are good as well.

3.5 Thermal stability
The melting point of Sorona fiber ranges from 237°C to 248°C, while PET fiber is at 260°C. It has better heat setting properties and is easy to process [6]. Heat setting will not reduce the tensile resilience of Sorona fiber, but the setting temperature of more than 160°C will destroy its soft touch, so the setting temperature is generally 140°C~150°C.

3.6 Dimensional stability
Sorona fiber has good dimensional stability. When the Sorona fiber content in the blended fabric reaches a certain proportion, the fabric can be machine-washed. After washing in the washing machine, it will not be felted. The surface will be smooth and wrinkle-free, the appearance of the garment will be maintained well, and it has excellent ease of care for both wearing and washing.

3.7 Other properties
Sorona fiber has the structural characteristics of benzene ring and methylene group, which makes it also have excellent properties such as wrinkle resistance, acid and alkali resistance, water resistance, light resistance, insect resistance, and stain resistance.

Sorona fiber not only has the excellent properties of a variety of synthetic fibers, but also makes up for their inherent shortcomings. The strength of Sorona fiber is lower than that of PET, but it maintains the advantages of bright color and non-fading of PET, and highlights the characteristics of soft touch; Sorona fiber has the same fluffy properties as acrylic fiber, but has better wear resistance and better wear resistance than acrylic fiber and less static electricity; Sorona fiber has the softness of nylon and strong stain resistance, and has good color fastness and drape; Sorona fiber has the same elasticity as spandex, and is easier to wash and dry while the price is much lower than spandex. Because it is compatible with the characteristics of a variety of synthetic fibers, this provides a broader space and imagination for its practical application.

4. Application
Through Sorona fiber, high-quality fiber products of various specifications can be produced, including short fiber, bi-component fiber, mono-component fiber, special-shaped cross-section fiber and moisture-wicking fiber. Through these fibers with different functions, different fabrics can be produced, from light lining cloth, UV-resistant swimwear and comfortable garments, to thick polarized fabrics and fashionable outerwear. The fiber made of Sorona can be blended or interwoven with any natural or synthetic fiber, even elastic fiber, so as to give the fabric a very soft hand feeling,
long-lasting shape retention, bright colors, excellent color fastness, good moisture absorption and perspiration performance, comfortable stretch recovery, stain resistance and wrinkle resistance, etc. At present, there are mainly the following types of products:

4.1 Carpet products
Carpet products made of Sorona fiber have durability, lodging resistance, excellent softness and stain resistance. It can withstand the highest level of walking flow test, and can provide incredible abrasion resistance and resilience; you can walk on the carpet without worrying about damage because Sorona fiber has a unique tooth saw-shaped crystal structure. Its super resilience makes the carpet have good lodging resistance. For the reason of that Sorona fiber has long-lasting natural stain resistance, oil stains, fruit stains, wine stains, etc. cannot leave any stains on carpets made of Sorona fiber in daily life.

4.2 Denim fabric
At present, the use of Sorona fiber to develop denim fabrics is one of the major trends. The denim fabrics produced by blending Sorona fiber and cotton fiber in a certain proportion have the following advantages: low shrinkage of the finished product, soft hand feeling, comfortable elasticity and excellent recovery performance, moisture absorption and ventilation, smooth fabric, good color fastness, etc.

Because Sorona fiber's unique molecular structure and physical form can ensure the fabric's lasting and stable elasticity, Sorona fiber denim fabric has enough elasticity to satisfy consumers' comfortable wearing experience, and can prevent the fabric from bulging and loosening. Whether it is stretching, sun exposure, or harsh washing and fabric post-processing, good results can be achieved.

4.3 Car supplies
Because the automobile products made of Sorona fiber have the advantages of not being easily deformed, low warpage and improving the appearance, Toyota applies it to the interior parts of automobiles for roof skins, sun visors, pillar decorations and car foot pads and also to the outlet of the dashboard air-conditioning system.

4.4 Other products
Sorona fiber is blended with Modal, Lyocell, cotton and other cellulose fibers to make knitted fabrics, which can improve the hand feel, dimensional stability, pilling and anti-ultraviolet radiation properties of the cellulose fiber fabric to varying degrees. The fabric's thermal insulation, air permeability and antistatic properties can also meet the requirements of wearing comfort. It is currently being widely used in knitted underwear fabrics and mid-to-high-end casual knitwear.

An environmentally friendly cool fabric developed based on Sorona fiber and Flycool cool yarn, which can combine the environmental protection of Sorona raw material and the cool feeling function of Flycool raw material. After the instant cooling sensation test, the characteristic value Q-max is 0.14, which can fully meet the cooling sensation requirement. After entering the market, the product has been widely recognized by users and has good economic benefits. At the same time, another type of FooxMet T-shirt based on Sorona fiber can clearly feel cool on the body surface contact surface when wearing it. Sorona fiber not only has strong water absorption and sweat absorption performance, but also has a diffusion and evaporation performance that is 6 times higher than that of ordinary cotton. You can experience a cool feeling from the rapid evaporation.

The swimsuit made of Sorona fiber not only has a unique soft feel, but also has excellent color fastness to chlorinated water and UV resistance, and it is not easy to fade after repeated use.

Sorona fiber, as a green and environmentally friendly high-performance polymer platform that has emerged in recent years, can bring textile fabrics a series of advantages such as reproducibility, functionality, comfort and processability. The products developed based on Sorona fiber are not
limited to this. The continuous strong interest and attention of industry insiders indicates that the innovation of the textile industry is about to come again under the promotion of Sorona fiber.

5. Conclusion
As a type of fiber produced from renewable resources, Sorona fiber, due to its environmental friendliness and the excellent performance of a variety of synthetic fibers, can further replace traditional chemical fibers as raw materials for many products in the future. With the deeper application, Sorona fiber will also have excellent application prospects in non-woven fabrics and decorative articles.

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