Environmental Friendly Development of Regenerated Cellulose Fiber Production
Mei-cui Yu and Jin-xie Wan

ABSTRACT

According to the development course of modern textile industry, synthetic fiber made of petroleum has occupied an important place in textile products for its low cost and varieties. However, due to petroleum shortage and people’s strengthened emphasis on ecological issues, regenerated cellulose fiber made of cellulose extracted from plants gradually goes on the market and become accepted by the public. This paper will, based on three development stages of regenerated cellulose fiber, introduce production characteristics at different stages and their influences over the environment, and summarize positive impact of regenerated cellulose fiber production on ecological environment at three development stages.

INTRODUCTION

The textile industry has been regarded as a traditional heavy pollution industry since ancient times. Its demand for petroleum and plenty of discharged waste water, waste residue and waste gas in the printing and dyeing process have affected balance and development of the ecological system. For instance, there will be plenty of waste water in such procedures as bleaching, washing and finishing before the printing & dyeing of textiles. Besides, the dyes and dyeing auxiliaries added in the production process often contain formaldehyde. In case that such untreated printing & dyeing wastewater is discharged into rivers, lakes or even the sea, it will surely destroy the water body, soil and ecosystem therein. In recent years, great importance attached to sustainable development and green ecology has prompted the traditional textile industry to conduct reform in multiple aspects, such as improving production technology, enhancing treatment of “three wastes”, and trying to reduce pollution in the last step of production discharge to the minimum. However, to advance the environmental protection cause, we should work from the source. The raw material of all traditional synthetic fiber such as dacron, spandex and acrylic fiber is petroleum. Today, as petroleum resources are getting exhausted day by day, choosing green renewable environmental friendly raw materials is an important way out for sustainable development of traditional textile industry.
Regenerated cellulose fiber is regenerated fiber of cellulose II. The raw material is natural plant cellulose. Compared with synthetic fiber, it is environmentally friendly and recurrent, and it doesn’t contain harmful substances. Besides, it’s more low-carbon and safer than synthetic fiber. Earlier at the beginning of the 20th century, people worked out viscose with gossypin. It’s the earliest regenerated cellulose fiber. However, as industrialization was carried out, less costly raw materials of synthetic fiber and progress of production technology, regenerated cellulose fiber was greatly impeded in industrialized large-scale production. In late 1990s, the contradiction between environment and industrialized production became more and more severe, which urged people to conduct new studies and improve sustainable fiber production. Regenerated cellulose fiber again attracted universal attention and gained rapid development.

The development of regenerated cellulose fiber can be divided into three stages each of which has representative products. Product performances and environmental friendly characteristics vary. Next typical products of three stages will be analyzed in detail to explore the development of regenerated cellulose fiber in ecological aspect.

**VISCOSE**

At the beginning of the 20th century, the entire world faced cotton shortage. Viscose was a new type of regenerated cellulose fiber produced to replace cotton fiber. Viscose, with cotton cellulose as its raw material, was made into sodium sulfate cellulose solution after going through such procedures as alkalization, aging and sulfuration. Then it’s concluded with wet spinning. At that time, petroleum was no longer selected as the raw material; instead, new type of cotton fiber was used to produce viscose. Through special processing, cotton fiber was processed into new type of fiber which had similar tissue elements with cotton. Sustainable production and cheapness of the raw material became a key breakthrough in textile industry. Yet, due to its limitation in production technology, its manufacturing process still caused inevitable pollution. Generally it’s divided into two aspects:

**Pollution in the Process of Preparing Glue Fiber Solution.**

To prepare glue solution, pulp needs to be extracted from cellulose raw materials. After treatment of sodium hydroxide and carbon dioxide, it will go through such procedures as steeping, squeezing, smashing, aging, sulfonating, dissolving, filtering and defoaming. Alkaline solvent is required in processes such as steeping, aging and sulfuratng. In the end, redundant alkali liquor is removed via squeezing and filtering to eventually get needed glue solution. All these processes are strong chemical reactions which have greatly changed the physical property of raw materials and consume time and resources. From today’s natural ecology perspective, it’s no longer in line with green production. Moreover, because of limited production capacity, the waste glue solution in the workshop and unprocessed alkali liquor are discharged into the ecological system. Besides, it will consume excessive raw materials and cause water pollution and soil pollution.
Pollution in Viscose Post-treatment Process

Viscose, after wet spinning and cooling, still needs treatment of washing, desulfurating, oil applying and drying. All these processes require use of chemical raw materials, which is bound to produce strong acid and strong alkali waste water. These substances with strong solubility will bring about immense damages to ecological environment. In addition, according to existing survey studies, the production of viscose filament yarn will cause greater pollution: under certain conditions and for production of the same quantity of filament and short thread, the waste water rising from filament production is one times greater than that discharged in producing short thread. In the last step of discharge, the treatment of black liquor in cotton pulp remains a difficulty. Ordinary equipment can hardly meet with discharge standards and it costs more to operate new technologies which are difficult to promote at present.

It can be seen from the analysis above that viscose, as the representative of the first generation of regenerated cellulose fiber, demonstrates green ecology and sustainable development in terms of raw materials but plenty of pollutions are still generated in the production and post-treatment process. It’s not only related with the then production technology level but also closely related with people’s concept.

MODAL FIBER

Modal fiber is the representative of the second generation of regenerated cellulose fiber. It’s a new type of cellulose fiber developed and produced in 1980s by Lenzing Company of Austrian. Such fiber derives from the *zelkova schneideriana* in European shrubs. Cellulose pulp is made out of wood pulp. Spinning and cooling are conducted after multiple procedures, and eventually green cellulose fiber with high-tech content is solidified. Modal fiber not only inherits the environmental friendly advantage of viscose to choose *zelkova schneideriana* to produce pulp solution, but also pays greater attention to ecological balance in production process compared with the first generation of viscose. It’s demonstrated in its production step and post-treatment step in detail.

Attention to Energy Saving and Environmental Protection in the Production Step.

The production technology and process of modal fiber are basically the same with viscose. It also needs to use alkali liquor to prepare cellulose solution and mold fiber through cooling. However, certain progress has been made in technologies of modal fiber which make modal fiber more in line with green and environmental friendly requirements for fiber. In terms of steeping, one-time steeping is adopted. Sulfite is used as the dissolving pulp and is a kind of non-toxic and recyclable organic solvent which can well control alkalization reaction in the dissolving and squeezing process. The filtering effect is favorable and product quality is high. All raw materials can be efficiently used without any waste. In the process of preparing viscose pulp, secondary steeping is more popular. In theory, new secondary steeping technology can enhance use efficiency of raw materials and save materials but such technology reduces cellulose content in pulp and further leads to defects in spinning.
Low-quality defects are waste of raw materials, and time-consuming and effort-consuming inefficient production is a waste of limited production resources as well. Nowadays, modal fibers on the market are basically blended textiles with modal and cotton. This kind of fiber has the modal characteristics of the soft and smooth, and at the same time have the cotton characteristics of moisture absorption and stability. Their part of materials are come from zelkova which are though special processing, and other part of materials are come from the natural cotton. This blended fiber not only green and environmental protection, but also greatly reduces the production cost of enterprises, achieved the results that produce the highest efficiency of the product at the lowest consumption.

Attention to Its Relation with Ecological Environment in the Post-treatment Step.

Owing to progress in technologies and concepts, modal fiber production has started paying attention to waste water and solution produced in the post-treatment step. Chemical solvent is still used in the production process of modal fiber so certain harmful substance will be definitely left in its waste solution. However, by comparison, the harmfulness of chemical solution applied in modal fiber production process is greatly weaker than that of viscose, and part of it can be recycled, thus causing less pollution to the environment. Energy saving and recycling are emphasized in modal fiber production process. Reduction of harmful substances saves enterprises a lot of pollution control costs, goes beyond limitation in development and conforms to the country’s sustainable development strategy.

Modal fiber shows affinity to dyestuff for it’s easy to color and fix. Hence, it can save cost and reduce discharge of waste water in the printing and dyeing step which has such procedures as bleaching, washing and sorting. All these require varied dyestuff and dyeing auxiliaries. Industrial dyestuff, dyeing auxiliaries and dye-fixing agents applied in modern factories all contain methanal so the environmental problems rising from such waste water are obvious. Modal fiber, with its desirable dyeing performance, can reduce use of industrial dyestuff and dyeing auxiliaries in the printing and dyeing step, especially methanal which is used to fix color. In addition, modal fiber well solved the problem of last generation viscose fibre which are uneven dyeing and unstable dyeing, achieved the craft that spinning and weaving after dyeing, reduced water use and wastewater discharge greatly.

TENCEL FIBER

Since 1990s, with more and more severe ecological environment problems and procedural and industrialized production of regenerated cellulose fiber, R & D and application of regenerated cellulose fiber has entered a new development stage. The short fiber represented by Tencel fiber and long fiber represented by Newcell are typical products of the third generation of regenerated cellulose fiber.[1] For Tencel fiber, also known as “Lyocell”, needle-leave trees are deemed as the raw material to produce cellulose pulp and then it’s mixed with NMMO solution which will be heated to entire dissolution. Later, new type of regenerated cellulose fiber is formed after procedures such as cleaning.[8] Compared with the two former generations, Tencel fiber is not only greatly improved in fabric performance such as strength,
moisture absorption, stability, drapability and comfort but also comply with modern consumption demands with its green and environmental friendly nature. It’s lauded as “green fiber of the 21st century”[8]. Besides, by comparison, Tencel fiber’s progress in environmental protection is manifested in the following two aspects as well:

**Production Process is Improved and Simplified.**

In terms of preparing fiber solution pulp, Tencel fiber differs greatly from viscose and modal fiber. Pure physical methods are used to process cellulose raw materials in Tencel fiber. Produced pulp solution and eventually discharged waste solution are natural and can be degraded without producing other harmful chemical substances. It’s more stable and safer. After dissolving cellulose raw materials through high heat, it’s cleaned with special process. Further, spinning can be directly conducted. Its fiber structure is green and degradable organic compound, molecular organizational and structure are stable. It won’t generate any chemical change neither will it cause any harm to human body nor produce pollution in the environment. Compared with complicated chemical pulp making process, physical process used for Tencel production is not only environmental friendly but also saves cost, enhances efficiency and creates greater fortune and profit. The simplified and improved production process means that companies can reduce the cost of production, and then consumers have more purchases, and the market share of Tencel fiber can compete with chemical synthetic fiber, form the virtuous cycle of market, to guide the consumer consumption idea gradually.

**Chemical Solvent Used is Safe and Harmless, and Can Be Recycled**

Ammonium chloride needs to be applied in Tencel fiber production process. It’s a kind of colorless and transparent alkalescency liquid which is soluble in water, and characterized by mild nature and weak stimulation. Such solvent is natural and harmless to the environment and human body. Besides, it’s applied to the detergent used for tableware and washroom. The use of ammonium chloride won’t produce any by-product, waste and waste residue. It can be recycled and biodegraded with a recovery rate of over 99%. No pollution will be caused to the ecological system and environment.

According to the analysis of Tencel fibre production process above, Tencel fibre use physical methods instead of complicated chemical pulp making process production, it no longer lingers at governance and discharge reduction; rather, it puts an end to harmful substances and chemical solvents from the production source, thus saving cost and thoroughly addressing the pollution problem.

**SUMMARY**

It can be founded from the overview of three production stages of regenerated cellulose fiber and their representative products that with development of the era and progress made in production technologies, the production of regenerated cellulose fiber has been moving towards ecological environmental protection and sustainable development. The first generation of viscose takes the lead in using natural plant
fiber in terms of raw material but due to limitations in production technology and concepts, it still causes excessive energy consumption and pollution in the production process; the second generation represented by modal fiber solves the traditional problem of waste water and solution to some extent based on viscose production. Yet, its process and production technologies are basically the same and the source of pollution still remains; with emergence of the third generation led by Tencel fiber, key changes take place in the production process. Resources are greatly saved in both raw material processing and the production process, and zero pollution discharge is fundamentally realized. The development of regenerated cellulose fiber is a positive example on environmental protection development of textile industry, and also a progress of production and consumption value on modern society. Green and environmental protection fiber will become an irreversible trend in the development of the textile fiber.

REFERENCES