

Fibers Make a Better Life

Naturally occurring fibers, such as cotton, flax, silk, and wool have been utilized by mankind for millennia. The silk gauze gown of Han-dynasty found in 1972 by archaeological discovery in Mawangdui Han Tomb weighs only 49 grams. It demonstrates the advanced silkworm cultivation, harvesting and weaving techniques in the early Han Dynasty in China. Even today, we are not able to replicate this silk gown with such light weight. For a long time, silk product from China means “fabulous”, “gorgeous”, “dreamlike clothes” to the western people.

The Renaissance made great contributions to the rise of modern science and technology in Europe. Robert Hooke (1635–1703), a genius scientist in England, proposed an idea of manufacturing artificial fibers which were comparable to silk using a process similar to the spinning of the silkworm and prophesied that those who could imitate “little silkworm” would be richly rewarded. But man knew of no way to make continuous long fibers like silk thread until the discovery of nitrocellulose. Count de Chardonnet, a French chemist, made the very first lustrous “artificial silk” by extruding a solution of nitrocellulose through tiny glass capillaries in 1889. However, this artificial silk was extremely inflammable that a spark would burn it almost instantly leaving no ash. Due to the complicated feeling to this artificial silk, it was popularly dubbed “mother-in-law silk”. The nitrocellulose fiber was later replaced by the two relatively unflammable fibers, cuprammonium rayon and viscose rayon. Rayon was recognized as the first man-made fiber.

DuPont paid considerable attention to rayon development in Europe, and realized that the man-made fiber industry was probably the most profitable industry in the United States, showing “great future possibilities”. Since the early 1920s, DuPont has continuously invested over \$100 million in rayon production for two decades. Rayon was developed to be a large and lucrative business, which further established DuPont’s leading position in the synthetic fiber revolution of polyamide, polyacrylic, and polyester. Nylon 6,6, discovered by Wallace Carothers was the first synthetic fiber in the 1930s. The great innovation of nylon fiber even dimmed the significant technique improvements of rayon. Followed by Nylon fibers, Orlon acrylic, Dacron polyester, Spandex polyurethane, Teflon fluorocarbon, and Nomex aramid were commercialized in 1950s. Owing to the large-scale production of raw materials from petrochemical industries, the advanced techniques of high-speed spinning and synthesis-melt-direct-spinning, as well as the excellent comprehensive performance, the annual production of polyester (mainly polyethylene terephthalate, PET) exceeded that of nylon in 1972. The dominant role of polyester in fiber demand has

continued in the last forty years. In 2020, China produced 49.22 million tons of polyester fibers, which occupied more than 70% of the total world production.

Due to the flexibility and diversified processability of fiber materials, their applications have evolved beyond ordinary fabrics and textiles. The increasing demand from high-tech field, especially from aeronautics and astronautics, spurred the development of high-performance fibers with high strength, stiffness, heat resistance, or chemical resistance. The three major high-performance fibers in the market are carbon fiber (black), aramid 1,4 (yellow), and ultra-high molecular weight polyethylene (white), which are widely used in reinforced composite materials and structure engineering. Other high-performance fibers include polybenzoxazole (PBO) fibers, aromatic polyimide (PI) fibers and different inorganic fibers. Besides, synthetic fibers with designated functions also show vast potentials in many fields, including energy, information, aerospace, construction, environment, and biomedicine.

The development of polymer fibers strongly depends on the close cooperation between academia and industry. Well trained young people with a solid background in organic chemistry and physical chemistry have established and developed the research and manufacturing of polymer materials and synthetic fibers in industry, which has in turn promoted the gradual formation of polymer and fiber programs in universities. Classic textbooks, such as *Principles of Polymer Chemistry* by Paul Flory and *Fundamentals of Fiber Formation* by Andrzej Ziabicki, have educated generations of students, providing strong support to the development of polymer and fiber industry. In China, to meet the urgent needs of talents in the chemical fiber industry, the first Synthetic Fiber Program was established at East China Institute of Textile Science and Technology (now Donghua University) in 1954 by Prof. Baojun Qian and Prof. Borong Fang. This program not only cultivated thousands of qualified graduates who made significant contributions to solving the clothing problems in China, but also initiated the studies on high-performance fibers in China. In 1950s, the first synthetic fiber, Nylon 6 fiber, was produced by Prof. Mingfang Yu and his team in China with fully domestically designed production line. In 1992, State Key Laboratory for Modification of Fibers and Polymer Materials was founded in Donghua University, committed to the development of advanced fiber materials to serve the national strategic needs in China. Great contributions have been made to both the fiber academia and industry since its establishment, including but not limited to the new technologies developed for the spinning of polyimide fibers, the successful preparation of high-performance PAN-based carbon

fibers, the technical support for the industrialization of meta-aramid fibers, melt-direct-spinning of polyester, organic-inorganic hybrid fibers, biomedical fibers and so on.

With the development of fundamental research and progress in manufacturing techniques, the synthetic fibers industry is witnessing a steady growth and now approximately 70% of the world's synthetic fibers are produced in China. However, the related theory and industrial development of high-performance fibers and their composite materials in China still lag behind those in the developed countries. Some key scientific and technological issues in the industrialization remain unsolved, thus parts of high-performance fiber and composite materials still rely on imports. In the 14th Five-year Plan, fiber materials, especially high-performance fiber materials, bio-based and sustainable fiber materials, were listed as the key materials that need to be improved or developed. In the meantime, the artificial intelligence is impacting every human being and the future of the world. As such, smart fibers with interactive functions are considered as the next-generation fibers. Fiber-based portable electronics and energy devices can be woven into wearable textiles, which can play key roles in smart healthcare, smart transportation, and smart life. Overall, the challenge in fiber preparation is how to make fibers with finer diameter, better chain orientation, fewer structure defects, and more functions with minimal energy consumption. Traditionally, the fiber industry involves spinning, twisting into yarns, weaving or knitting of yarn into fabrics, dyeing and finishing, etc. Nowadays, with soaring of high technology, the important topics of fibers may include, how to combine high-performance fibers with resin for light-weight composite materials, how to integrate functional fibers to intelligent materials, and how to assemble green fibers for health materials.

As a leading journal in the field of polymer science of China, *Chinese Journal of Polymer Science* (CJPS) is celebrating its 40th anniversary. We gladly see that CJPS is publishing more and more studies related to fibers, with 23 fiber related studies in 166 published studies in 2020, giving 312 citations. Fiber, plastic and rubber are listed as the three most important products of polymer materials. The progress of polymer science is undoubtedly closely related to the development and progress of fiber materials. While polymer chemistry aims to develop new polymers to produce fibers, polymer physics develops new theoretical tools and characterization methods to study the dynamic process of fiber spinning and structure evolution during fiber formation. Here we sincerely invite more researchers and scholars working in the fiber field to publish your outstanding work with CJPS. We believe CJPS is a great platform to present the most recent science and technology advances in the fiber field. We sincerely hope

these papers will provide our readers with a better understanding of fiber materials, especially the state-of-the-art in this field, and further can encourage and inspire more researchers to join us to make a better world with fiber materials.



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The views expressed in this editorial are those of the author.