A Revolution in Textiles

When it first entered the public consciousness in 1938, nylon claimed a novelty no other product could match. Its predecessors, rayon and cellulose, had been touted as “artificial silk,” a phrase that implied both economy and imitation. But nylon was billed by its manufacturer, DuPont, as a thing unto itself. As the first commercially viable synthetic fiber, nylon ushered in a fashion revolution based on comfort, ease, and disposability. Its strength, elasticity, weight, and resistance to mildew helped the Allies win World War II. Behind the scenes the invention of nylon also transformed the chemical industry by proving that the composition of polymers could be predicted and engineered like many other chemical products. Today nylon—in toothbrushes, carpet, racket and guitar strings, surgical sutures, car parts, and, of course, hosiery—is all around us.
As hemlines continued to rise through- out the 1930s, silk and rayon stockings had be- come an increasingly necessary part of every woman’s wardrobe. American women bought an average of eight pairs of stockings per year, earning Japanese silk producers over $70 million annually. DuPont never intended to produce the stockings directly; rather, the company would provide nylon thread to mills that would knit and sell the hosiery. Before DuPont could take its new miracle fiber to the public, however, its leaders had to decide what to call it. In-house researchers had alternately been referring to what would later be nylon as Rayon 66, Fiber 66, or “Duparon,” a creative acronym for “DuPont pulls a rabbit out of [of] nitrogen/nature/nozzle/naphtha.” In 1938, through a decision-making process that remains somewhat obscure, the company settled on the word nylon. According to Ernest Gladding, manager of the Nylon Division in 1941, the name had originally been “Nuron,” which not only implied novelty but cleverly spelled “no run” backwards. Unfortunately, Nauro and other closely related words posed trademark conflicts, so the division proposed “Nilon.” Changing the name had originally been “Nuron,” which not only implied novelty but cleverly spelled “no run” backwards. Unfortunately, Nauro and other closely related words posed trademark conflicts, so the division proposed “Nilon.” Changing the name when he convinced Wallace H. Carothers, a young organic chemistry lecturer at Har- vard University, to join DuPont. Carothers proposed to center his research on polymer- ization, the process by which individual short molecules form long-chain macromolecules. Before Carothers’s groundbreaking work most chemists based their polymers on complicated “recipes” largely determined by chance. More- over, the nature of polymers was poorly under- stood, with some researchers convinced that the sticky resins represented complex colloidal sys- tems, while others advocated the long-chain mol- ecule theory originally advanced by Hermann Staudinger, a German chemist. Carothers hoped to offer definitive proof of Staudinger’s theory by con- structing polymers from small organic molecules with known reactivity at both ends. Carothers’s success was almost immediate. In April 1930 Julian W. Hill, a research associate in Carothers’s group, produced a long polymeric ester with known reactivity at both ends. This work was centered on “the object of estab- lishing or discovering new scientific facts” instead of research that “applied previously established scientific facts to practical prob- lems.” Stine’s proposal was new to industry—both General Electric and Bell Telephone operated industrial research laborato- ries—but his insistence that the research be “pure” or “fundamen- tal” was a fairly radical idea for a company focused on profits. Nevertheless, the executive committee approved a slightly modified version of Stine’s proposal in March 1927. Stine was granted $25,000 a month for research and was told to hire 25 of the best chemists he could find. The committee also approved funds to build a new laboratory, soon dubbed “Purity Hall” by DuPont chemists.

Stine encountered much more difficulty in attracting chemists to DuPont than he had anticipated, largely because aca- demic scientists doubted whether they would truly be allowed to do pure research in an industrial setting. A year later, however, he made a spectacular hire when he convinced Wallace H. Carothers, a young organic chemistry lecturer at Har- vard University, to join DuPont. Carothers proposed to center his research on polymer- ization, the process by which individual short molecules form long-chain macromolecules. Before Carothers’s groundbreaking work most chemists based their polymers on complicated “recipes” largely determined by chance. More- over, the nature of polymers was poorly under- stood, with some researchers convinced that the sticky resins represented complex colloidal sys- tems, while others advocated the long-chain mol- ecule theory originally advanced by Hermann Staudinger, a German chemist. Carothers hoped to offer definitive proof of Staudinger’s theory by con- structing polymers from small organic molecules with known reactivity at both ends. Carothers’s success was almost immediate. In April 1930 Julian W. Hill, a research associate in Carothers’s group, produced a long polymeric ester with a molecular weight of more than 12,000 by combining a dialcohol and a diacid—this was the first “polyester.” Hill’s poly- ester fibers had a remarkable property: when cooled, the thin, brittle filaments could be pulled into an elastic thread four times their original length. DuPont researchers soon realized, however, that this first polyester would never succeed as a commercial fiber be- cause its low melting point made laundering and ironing imprac- tical.

For the next four years attempts to create commercially viable synthetic fibers were stymied by the twin problems of low melting points and high solubility in water. In 1934 Elmer Bolton, the new chemical director at DuPont, urged Carothers to return to the problem. Carothers agreed, but this time he would focus on polyamides rather than polyesters. On 24 May 1934 a member of his research team, Donald D. Coffman, successfully pulled a fiber of a polymer based on an amonnoester. His fiber—ultimately the first nylon—retained the remarkable elastic properties of the polyesters but lacked their drawbacks. However, since the interme- diate used to form the polymer, an amonnomonic ester, was tremendously difficult to produce, Carothers and his associates kept looking. Within a year Carothers’s six researchers had narrowed the field to two possibilities: polyamide 5,10, made from pentameth- ylene diamine and sebacic acid; and polyamide 6,6, made from hexamethylenediamine and adipic acid. (The molecules are named for the number of carbons in the starting materials.) Carothers preferred 5,10, but Bolton pushed for 6,6 because the intermediates could be more easily prepared from benzene, a read- ily available starting material derived from coal tar. As Carothers’s declining mental health kept him increasingly absent from the laboratory, Bolton’s choice prevailed, and all hands turned to im- proving fiber 6,6.

Joseph Lavery, a chemical engineer working as a technician in the lab, later recalled that the lab workers were scaling up fiber 6,6 “from 1 ounce to 1 pound, 2 pounds, 50 pounds, 250 pounds, and eventually to 2,000 pounds.” Paul Flory, a young physical chemist who would later win the Nobel Prize in Chemistry for his work on polymers, helped the researchers stabilize the reaction by de- veloping a mathematical model for the kinetics of the polymer- ization reaction. In 1938 DuPont started construction on a nylon production facility in Seaford, Delaware, that could produce up to 12 million pounds of the synthetic fiber a year. It was time to in- troduce nylon to the American public.

ON THE MARKET

Nylon’s characteristics made for an ideal material to suit any num- ber of uses, but DuPont decided early on that it would focus on a single market: ladies’ full-fashioned hosiery. As hemlines contin- ued to rise throughout the 1930s, silk and rayon stockings had be- come an increasingly necessary part of every woman’s wardrobe. American women bought an average of eight pairs of stockings per year, earning Japanese silk producers over $70 million annually. DuPont never intended to produce the stockings directly; rather, the company would provide nylon thread to mills that would knit and sell the hosiery.

Before DuPont could take its new miracle fiber to the public, however, its leaders had to decide what to call it. In-house re- searchers had alternately been referring to what would become nylon as Rayon 66, Fiber 66, or “Duparon,” a creative acronym for “DuPont pulls a rabbit out of [of] nitrogen/nature/nozzle/naphtha.” In 1938, through a decision-making process that remains something of a mystery, the company settled on the word nylon. According to Ernest Gladding, manager of the Nylon Division in 1941, the name had originally been “Nauro,” which not only implied novelty but cleverly spelled “no run” backwards. Unfortunately, Nauro and other closely related words posed trademark conflicts, so the company dropped Nauro and other closely related words posed trademark conflicts, so the company dropped “Nilon.” Changing the name when he convinced Wallace H. Carothers, a young organic chemistry lecturer at Harvard University, to join DuPont. Carothers had hoped to offer definitive proof of Staudinger’s theory by constructing polymers from small organic molecules with known reactivity at both ends.

Carothers proposed to center his research on polymerization, the process by which individual short molecules form long-chain macromolecules. Before Carothers’s groundbreaking work most chemists based their polymers on complicated “recipes” largely determined by chance. Moreover, the nature of polymers was poorly understood, with some researchers convinced that the sticky resins represented complex colloidal systems, while others advocated the long-chain molecule theory originally advanced by Hermann Staudinger, a German chemist. Carothers hoped to offer definitive proof of Staudinger’s theory by constructing polymers from small organic molecules with known reactivity at both ends.

Carothers proposed to center his research on polymerization, the process by which individual short molecules form long-chain macromolecules. Before Carothers’s groundbreaking work most chemists based their polymers on complicated “recipes” largely determined by chance. Moreover, the nature of polymers was poorly understood, with some researchers convinced that the sticky resins represented complex colloidal systems, while others advocated the long-chain molecule theory originally advanced by Hermann Staudinger, a German chemist. Carothers hoped to offer definitive proof of Staudinger’s theory by constructing polymers from small organic molecules with known reactivity at both ends.

As hemlines continued to rise through- out the 1930s, silk and rayon stockings had become an increasingly necessary part of every woman’s wardrobe. As hemlines continued to rise through- out the 1930s, silk and rayon stockings had become an increasingly necessary part of every woman’s wardrobe. As hemlines continued to rise through- out the 1930s, silk and rayon stockings had become an increasingly necessary part of every woman’s wardrobe. As hemlines continued to rise through- out the 1930s, silk and rayon stockings had become an increasingly necessary part of every woman’s wardrobe. As hemlines continued to rise through- out the 1930s, silk and rayon stockings had become an increasingly necessary part of every woman’s wardrobe. As hemlines continued to rise through- out the 1930s, silk and rayon stockings had become an increasingly necessary part of every woman’s wardrobe. As hemlines continued to rise through- out the 1930s, silk and rayon stockings had become an increasingly necessary part of every woman’s wardrobe. As hemlines continued to rise through- out the 1930s, silk and rayon stockings had become an increasingly necessary part of every woman’s wardrobe. As hemlines continued to rise through- out the 1930s, silk and rayon stockings had become an increasingly necessary part of every woman’s wardrobe. As hemlines continued to rise through- out the 1930s, silk and rayon stockings had become an increasingly necessary part of every woman’s wardrobe. As hemlines continued to rise through- out the 1930s, silk and rayon stockings had become an increasingly necessary part of every woman’s wardrobe. As hemlines continued to rise through- out the 1930s, silk and rayon stockings had become an increasingly necessary part of every woman’s wardrobe. As hemlines continued to rise through- out the 1930s, silk and rayon stockings had become an increasingly necessary part of every woman’s wardrobe.
Everywhere the stockings appeared, newspapers reported on "nylon riots" in which hundreds, sometimes thousands, of women lined up to compete for a limited supply of hosiery. The shortage of stockings was a major problem for DuPont, which had captured an astonishing 30% of the full-fashioned hosiery market within two years of nylon's introduction. To regain control of nylon's publicity, DuPont ran a story based on the newly released patent (U.S. 2,130,948). The article claimed that nylon could be prepared from cadaverine, a substance formed during putrefaction in dead bodies. However, this story received little coverage, and for many years thereafter DuPont's publicity department stressed that nylon was derived solely from coal, air, and water.

Nylon stockings represented only the beginning of what would soon become a fashion revolution. Cheap and colorful, nylon stockings transformed the way women looked and dressed. By the late 1960s synthetics had moved firmly off the runways and into the mass markets—and therein lay their downfall. Victims of overexposure, nylon and polyester seemed suddenly out of date, and their shiny luster started to look tacky. In the wake of Rachel Carson’s Silent Spring (1962) and a growing environmental popularity in the 1990s as technical innovations improved their feel and performance, never again would synthetic fibers dominate the market as they did in the 1950s and 1960s.

Yet nylon is here to stay. We may not be wearing it as much, but in one form or another nylon surrounds us in our homes, offices, leisure activities, and transportation. The polymer revolution ushered in by nylon's discovery has left us with a world of plastics that would be unrecognizable to our grandparents' generation. Today manufacturers worldwide produce around 8 million pounds of nylon, accounting for about 12% of all synthetic fibers. Nylon may no longer be DuPont's most profitable product, but it remains one of its most important inventions.

Audra J. Wolfe is editor in chief of Chemical Heritage. This article has been excerpted from Molecules That Matter, a forthcoming compilation of essays to accompany the traveling exhibit by the same name, opening at CHF's Clifford C. Huch Gallery in August 2008.

FOR FURTHER READING


ALWAYS IN FASHION

Nylon stockings represented only the beginning of what would soon become a fashion revolution. Cheap and colorful, nylon stockings transformed the way women looked and dressed.