Bakelite: 80 Years Since the First Synthetic Resin

Synthetic plastics in all their varied forms and types have become an important part of everyday life—from industry, to architecture and home building, to medicine, science, and art. It seems difficult to imagine that less than a century ago only a few difficult-to-obtain natural substances were known for all the same applications.

In 1909, Leo H. Baekeland introduced the world to "bakelite," the first completely synthetic resin, which could be molded and used in hundreds of different ways. This year marks the 80th anniversary of Baekeland's material. Bakelite demonstrated the enormous potential of synthetic resins and opened the door for the booming plastics industry in the 20th century.

Commercial molding of natural "plastic" substances began in 1845 in the United States. These natural substances were the forerunners for artificial plastics—guttapercha (a milky juice from the Malaysian Palaquium gutta trees), lac (a sticky material given off by scale insects in India and Burma, it is the basis for shellac), and cemented asbestos (asbestos fibers mixed with an adhesive). From 1845 to the early 1900s, industry used these natural "plastics" to mold brush handles, phonograph records, electrical insulation, and knobs. However, the natural materials were lacking—some were difficult to mold, others broke easily, and the raw materials were difficult to obtain in the first place.

In 1869, John W. Hyatt invented celluloid, the first major commercial plastic material. Hyatt, a printer in Albany, New York, was seeking a substitute for ivory to be used in making billiard balls. He combined camphor with cellulose nitrate (obtained by dissolving cotton fibers in a solution of alcohol) to create celluloid. Cellulose nitrate, also called pyroxylin at the time, had been used seven years before by English chemist Alexander Parkes to create a plastic material, Parkesine. Parkes's associate, Daniel Spill, invented a similar material, Xylonite, in 1867. Both of these materials, though, were inferior to Hyatt's celluloid.

Celluloid was flexible and durable—it could be sawed and carved or made into sheets, which led to the creation of many commercial products such as combs, dentures, clock cases, and photographic film. But celluloid was very flammable and difficult to mold. Chemists and inventors continued to search for superior materials. In 1884 the French chemist Hilaire Chardonnet created viscose rayon, the first synthetic fiber. In 1901 A. Smith created the first alkyd (glycerophthalic) resin, finally in 1913 as Glyptal. In 1908 Jacques E. Brandenberger, a Swiss chemist, invented cellophane.

During the same period, British and American chemists experimented with combining phenol (carbolic acid) with formaldehyde, which produced a resinous byproduct. But the two chemicals reacted violently, and would-be inventors could not control the reaction. In 1909, though, Leo H. Baekeland, a Belgian-born chemist living in New York City, succeeded in controlling the reaction and produced the first completely synthetic resin, which he marketed under the trade name of Bakelite.

Baekeland had already made his fortune by introducing Velox paper, which was widely used in photography. He was born in Ghent, Belgium in 1863, and after receiving his doctorate in natural sciences in 1884, he remained as a professor of chemistry and physics. Impatient with the academic life, he visited New York in 1889 while on his honeymoon and decided to stay, first working for a photographic company and then as the head of his own company, the Nepera Chemical Company, making his Velox photographic paper. In 1899 Baekeland sold the Velox process to Eastman-Kodak for one million dollars.

Rather than relaxing as a millionaire for the rest of his life, Baekeland continued his chemical researches. In the next few years he obtained patents for processes to dissolve salt in spent electrolytes and to make more durable diaphragms by treating asbestos cloth with gummy iron hydroxides.

In 1905 he turned his attention to the manufacture of condensation products from phenol and formaldehyde—as described in 1872 by Adolf von Baeyer—intending to make a better varnish than natural shellac. On February 8, 1909, Baekeland gave a lecture before the American Chemical Society, surveying previous attempts at putting the phenol-formaldehyde reaction to industrial use, which had only resulted in slow processes and brittle products.

"By the use of small amounts of bases," Baekeland said in his lecture, "I have succeeded in preparing a solid initial condensation product, the properties of which simplify enormously all molding operations." He continued to describe three stages of the reaction of phenol or its derivatives with formaldehyde or other aldehydes, producing a water-soluble intermediate product. The intermediate product could be used to impregnate wood, paper, cardboard, or fabrics. The final stage of the reaction resulted in a resinous mass that could be converted to a fine, dry powder and then set into its final shape by compression molding under heat and pressure.

Baekeland had begun making his phenolic resin two years before, but was unable to produce anything remotely like shellac. By working under certain reaction conditions, he could make an amberlike resin, but didn't immediately recognize its value as a plastics material. Then a rubber manufacturer in Boonton, New Jersey, Richard W. Seabury, showed that Bakelite could be molded. As an experiment, Seabury mixed the Bakelite resin with asbestos fibers and molded a part for an electrical instrument.

Bakelite was clear or light golden colored, much like Celluloid, but it was much harder. Bakelite could be molded and machined, and had excellent electrical properties as well. The material was hard and tough, could resist high temperatures, and had good dimensional stability. Bakelite also resisted swelling and dissolution in water and all organic solvents. Adolf Luft and L. Blumer (in 1902) and H. Story (in 1905) had taken out patents for products similar to Bakelite, but their materials were far inferior. Baekeland himself invented several other special phenolic compounds for molding, casting, and laminating products. The first thermosetting polymer, Bakelite became popular for use in making telephones, handles for pots and irons, pipe stems, radio cabinets, as well as many products in the electrical and automotive industry. By 1930, the Bakelite Corporation operated a 128-acre plant at Bound Brook, New Jersey.

Bakelite's wide industrial applications where natural resins, rubber, or celluloid were not suitable, stimulated research to find other synthetic plastics. Today, phenolic plastics are still used widely, and their production technology has changed little from Baekeland's techniques.

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