100 years later, Bakelite shines By: **Bill Bregar**

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When Leo Hendrik Baekeland invented Bakelite in 1907, he changed the world — ushering in the Age of Plastics and transforming the way people lived.

The phenolic resin took off first as a superior, easily moldable insulator against heat and electrical current, then as a key material in Art Deco design.

Bakelite was the first truly synthetic plastic, “born of fire and mystery,” as *Time* magazine put it. This year marks the 100th anniversary of Bakelite. Baekeland filed his famous “heat and pressure” patent on July 13, 1907. The U.S. patent was granted on Dec. 7, 1909.

Bakelite became an almost instant hit. Baekeland's phenol formaldehyde came along just as America's electrical and automotive industries were beginning to take off. Manufacturers were starving for a better insulator that was easily moldable and inexpensive. Railways. Telephones. Iron ships. Aviation. Photography. All demanded a consistent, high-quality material that natural raw materials of the day could not provide. Boonton Rubber Co. of Boonton, N.J., made the first commercial compression molded Bakelite product: bobbin ends.

Impervious to temperature, acids and moisture, Bakelite was nearly indestructible. It went on to replace rubber, shellac and gutta-percha as an insulator. Applications quickly followed in toasters, coffee makers, hair dryers, electric irons, vacuum cleaners, lamp sockets, headphones and more. Major automotive uses included distributor caps, radiator caps, instrument panels, door handles and those classic heavy-duty steering wheels molded from black and brown Bakelite. Bakelite added a touch of style to radios and Parker pens — items that are valuable collectibles today.

Bakelite was not the first plastic. Depending on how liberally you define the word, animal bone could be a “plastic,” if softened and formed. Since the mid-1880s, some companies had used crude plunger-type presses to form shellac, as well as gutta-percha, into buttons, combs, jewelry and novelties.

And cellulose nitrate already was decades old by 1907. Englishman Alexander Parkes got the first patents on the material, which he called Parkesine, between 1855 and 1865, according to the book Plastics History — U.S.A. by J. Harry DuBois. In 1870, American inventor John Wesley Hyatt patented his material, Celluloid. Parkesine Co. quickly went out of business. Celluloid won out. But unlike Celluloid, Bakelite would not catch on fire or melt. And a safer version, cellulose acetate, was not on the market yet when Bakelite came out. Plus, Bakelite was a thermoset, a plastic that once formed, cannot be melted again. That made it a durable material well-suited for insulating. Bakelite magneto couplings and other parts made the modern Delco car ignition system possible, relegating the old hand-crank to the history books.

Both of the early thermoplastics, cellulose nitrate and cellulose acetate, are considered semisynthetic plastics, or the “natural plastics,” because they used a natural material — wood pulp or cotton, modified with acids. But Bakelite was 100 percent man-made. And the story of how a Belgium native came to invent it, in Yonkers, N.Y., combines elements of the U.S. story of immigration, dogged testing that finally leads to a breakthrough invention, and an entrepreneurial spirit. He always wanted to make something useful.

Coming to America

Leo Baekeland was born into humble beginnings on Nov. 14, 1863, in Ghent, Belgium. His father, Karel, was a shoemaker. Young Leo was learning the cobbler trade, and his father opposed his wish for an education. But his mother, Rosalia, a domestic servant, had always considered him to be gifted, according to the book, *They Made America*, by Harold Evans. She got their son a scholarship to a government high school, where he excelled. A childhood interest in photography got him interested in chemistry.

He went on to graduate with honors from Ghent University, studying under Professor Theodore Swarts. He fell in love with his mentor's daughter, Celine Swarts. After a short stint as a professor at another school, he returned to Ghent University to become a professor, do research, and be near Celine again. Professor Swarts did not approve of their relationship. But Baekeland married Celine Swarts on Aug. 8, 1889. Two days later they set sail for New York on a combined honeymoon and study trip, financed

though an academic fellowship. He was a rising star of chemistry in Belgium, but Baekeland never looked back to his native land. Instead, he made his famous breakthroughs in the United States.

At Ghent, Baekeland would have had a secure career and support for his chemistry experiments. But America was the land where applied science and raw commerce could bring good ideas to the marketplace. And New York was its epicenter. “He felt that the atmosphere over here was more conducive to his way of thinking and his innovative dreams of helping create something exciting in the world,” said Hugh Karraker, Leo Baekeland's great-grandson. Karraker, of Redding, Conn., has dedicated himself to publicizing Baekeland's accomplishments in this 100th anniversary year.

Feeding off his love for photography, Baekeland first worked as a chemist in the photographic industry. A decade later, he was a partner in a company that invented Velox photo-printing paper. In 1899, George Eastman, whose Eastman Kodak Co. was bringing photography to the masses, bought Velox for $1 million.

Barely 36, Baekeland was a millionaire. He and his family moved to the Snug Rock estate overlooking the Hudson River in Yonkers. He never had to work again. Even so, an early retirement was the last thing on Baekeland's mind, according to his great-grandson. He used the money to finance independent research into one of his topics of study back in Ghent: the chemical reactions between phenols and formaldehydes. “He was not a man to sit still,” Karraker said. “He was an avid inquisitor. He questioned everything and wanted to follow up on this search for this substitute for shellac.” The master chemist also did not enjoy high-society life. “He shunned all the trappings of wealth,” Karraker said. “His thought was the rich were idle and he didn't want to be idle. He had a strong opinion about anybody talking a lot about their money.” Baekeland set up a small laboratory next to his home.

Better than a beetle

Baekeland was hardly alone in his quest for a better varnish. The shellac issue was one of the hot topics of chemical research at the turn of the century. The sole source of shellac was the excretions of the female Laccifer lacca beetle, found only in India and Southeast Asia. According to

They Made America, it took 15,000 female “lac” beetles six months to make enough resin for a pound of shellac. Other researchers also focused on mixing phenol and formaldehyde, which turned into a sticky mess of gunk. Baekeland's original goal was to come up with a shellac and varnish substitute that, after being applied to a piece of wood, would harden into an insoluble state by a chemical reaction.

Over several years, as the 20th century dawned, Baekeland methodically recorded experiments with endless combinations of conditions — adding different solvents, agents and fillers, and trying different degrees of heat and pressure. Again and again he failed. Eventually, he found that extreme heat greatly increased the chemical reaction, and pressure controlled the reaction. In a notebook, he wrote that the material he created was “insoluble in all solvents and does not soften.” He called the product by a name only a chemist could love: oxybenzylmethylenglycolanhydride. Thankfully, his notes also list the more user-friendly “Bakelite.” Soon, that brand would be known by millions around the world.

To cook the material, Baekeland developed an egg-shaped pressure vessel dubbed the Bakelizer, or, by its operators, Old Faithful. The Bakelizer now sits at the Smithsonian Institution's National Museum of American History in Washington. Old Faithful was set up in Baekeland's garage, adjacent to the lab. “After one serious laboratory fire, the doctor decided that he would rather lose the garage than the laboratory,” according to an account by one of his assistants, Lawrence Byck, quoted in *Plastics History — U.S.A.* Since electrical lines had not yet reached his neighborhood, Baekeland hooked up a steam engine from an old White steam automobile to run an agitator.

Byck described the hazards of a key part of the process.“In making the first varnishes, addition of the alcohol at the crucial moment had to be made much more quickly than was possible with the little hand pump. So the alcohol was dumped onto the hot resin through the open manhole by hand from buckets. This was always an interesting, if not to say an exhilarating moment. Lewis Taylor did this, invariably with the entire staff (and frequently the Baekeland family) as audience — at a safe distance. Alcohol vapor fires were commonplace; you smothered them out by the simple expedient of slamming shut the manhole door, cutting off the oxygen supply. The fires frequently flashed up the condenser and started small

fires in the second-story storage room of the garage.” That was how the first Bakelite was made for sale in 1909.

Baekeland's methodical, painstaking work to find the right combination won him the Perkin Medal, the highest honor for applied chemistry, in 1916, two years after Hyatt got the award. According to *Plastics History —U.S.A.*, C.F. Chandler made this comment in presenting the medal: “When phenol is let to react with formaldehyde under ordinary circumstances, almost anything can happen but the formation of Bakelite.”

New business model

Baekeland publicly announced Bakelite on Feb. 5, 1909, in a technical presentation before the American Chemical Society's New York Section. His original plan was to license other companies to manufacture Bakelite. He would act as a consultant. Unfortunately, the outside manufacturers made too many production errors. So, by 1910, he opened his own factory, General Bakelite Co. in Perth Amboy, N.J. Sales grew rapidly, from 700,000 pounds in 1913 to 8.8 million pounds in 1922, according to *They Made America*. He set up factories and licensees in Europe and Japan, spreading Bakelite around the world.

Another innovation came when Bakelite was patented as a replacement for shellac in grinding wheels. That development helped the auto industry move into mass production.

Since Bakelite was so radically new, General Bakelite issued a series of “information bulletins” to explain the phenolic to consumers. “It is not merely a mixture or a so-called 'compound' like so many rubber-, shellac- or other resinous-composites, but a well-defined chemical substance of specific properties; it thus adds an important member to the industry of plastics.”

The Bakelite resin could be compression molded from a loose powder or compressed into a preform, then molded. The company also supplied liquid resins. Boonton Rubber was the first Bakelite molder. Other early users were General Electric Co., Westinghouse Electric Co., American Insulator Corp., Remy Electric Co. and Kellogg Switchboard Co. General Electric licensed Bakelite as an insulator in 1909, then began to develop its own resins. Scores of local molders sprang up. Some became quite large, such as Chicago Molded Products Co. and General Industries Co. of Elyria,

Ohio, which began compression molding Bakelite car-horn buttons in 1915. Kurz-Kasch Inc. founded in Dayton, Ohio, in 1916, continues to be a major thermoset molder today. Mack Molding Co. is another company today with roots in Bakelite. Before Donald S. Kendall, a chemist, co-founded Mack in 1920, he had experimented with Bakelite and urea at Thomas Edison Cos., trying to find a good replacement for wax used in phonographic records. Mack's first product was thermoset bottle caps. Charles Burroughs Co. provided many of the compression molding presses.

Competitors to Bakelite sprang up, like Condensite Co. and Redmanol Chemical Products Co. (maker of “Redmanol, The Perfect Molding Compound”). Baekeland vigorously defended his patents. Following a series of patent battles, He issued licenses to both companies. In 1922, he negotiated a merger between General Bakelite, Remanol and Condensite to form Bakelite Corp.

In the 1920s and 1930s, radio was becoming a national obsession. Millions of radios brought Bakelite into the American home, helping it become a symbol of modern life.

Bakelite Corp. worked closely with designers to promote the plastic. The designers also benefited as the company ran a series of advertisements about how Bakelite, and modern design, could help move the country forward in the Great Depression.

Baekeland sold the company to Union Carbide Corp. in 1939. He retired to Florida, sailing his yacht, gardening and writing. He died in 1944, at the age of 80. He made the cover of *Time* magazine in 1924. The story noted: “Those familiar with its possibilities claim that in a few years it will be embodied in every mechanical facility of modern civilization.” That did not happen for the thermoset phenolic. But the *Time* writer could not have foreseen the coming thermoplastics movement, which became a tidal wave after William H. Willert invented the reciprocating- screw injection molding machine in 1952, to replace the old plunger machines.

Today, thermoplastics dominate the industry. Thermosets are just a tiny slice. But Bakelite is still being made, for wide-ranging applications. “Almost all brakes on cars, mass-transit trucks, even aircraft are made from phenolic resin,” said Julia Harp, vice president of Hexion Specialty Chemicals Inc. Hexion was formed in 2005 from a merger of Borden

Chemical Inc., Bakelite AG and two other companies. Bakelite AG, of Iserlohn, Germany, dates to 1910 when Baekeland founded the company with Rutgers AG. Bakelite still has some of its classic applications in automotive and electrical products. But the material also is used in space shuttles, Harp said.

Sumitomo Bakelite Co. Ltd., a phenolics maker in Japan that dates to an early license, no longer uses the formal Bakelite trade name on its materials, a spokesman said. But Sumitomo Bakelite does use some names that are well-known in history, including Durez, Vyncolit and Rogers.

Thermosets may be in the minority today. But in this 100th-year anniversary, the industry is looking back to the days when thermosets ruled.

“He actually founded the synthetic plastics industry, and 100 years later, we're still innovating based on his legacy,” said Kurt Swogger, vice president of business development at Dow Chemical Co. Dow bought Union Carbide in 1999. Swogger, who earlier was Dow's vice president of performance plastics and chemicals, thinks modern America needs a dose of the hard work and determination of the man from Belgium. “If we had more people with a hunger in them like Dr. Baekeland, our society would be a lot better off,” he said.

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