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Bakelite

Material of a Thousand Uses

By Wm. R. Ellis

The author wishes to acknowledge his indebtedness to the Bakelite Corporation for the material for the following article and for the accompanying illustrations.

APPROXIMATELY one hundred years ago Friedrich Wohler, of Germany, and Marcellin Berthelot, of France, performed the first organic syntheses. It was from their work that chemists have been able to duplicate natural materials, and going beyond this, have succeeded in bringing forth new, hitherto unknown materials. Many new products have resulted from the organic chemist's research. These new products are often more durable and useful to industry than natural materials. One of the largest and most interesting fields of chemistry is the phenol resinoid industry, in which the foremost product is the material known as Bakelite, announced for the first time in 1909 by its discoverer, Dr. L. H. Baekeland. Prior to this announcement several attempts had been made by noted chemists in Europe to obtain synthetic resinous products by the condensation and interaction of phenolic bodies with aldehydes. The results obtained were discouraging and the products seemed unfit for industrial application because of the lack of uniformity in properties and characteristics.

In the United States, though, Dr. Baekeland, after several years' research, decided that the goal was not to find a substitute for the natural resins, but rather to employ these interesting reactions to yield a material that was entirely new. He has lived to see the commercial utilization of his own invention and today is active head of the Corporation which has made the name "Bakelite" a household term.

Phenol Resin

Perhaps the most interesting and important group of synthetic compounds are the phenol resinoids. In brief, they are the result of the interaction of

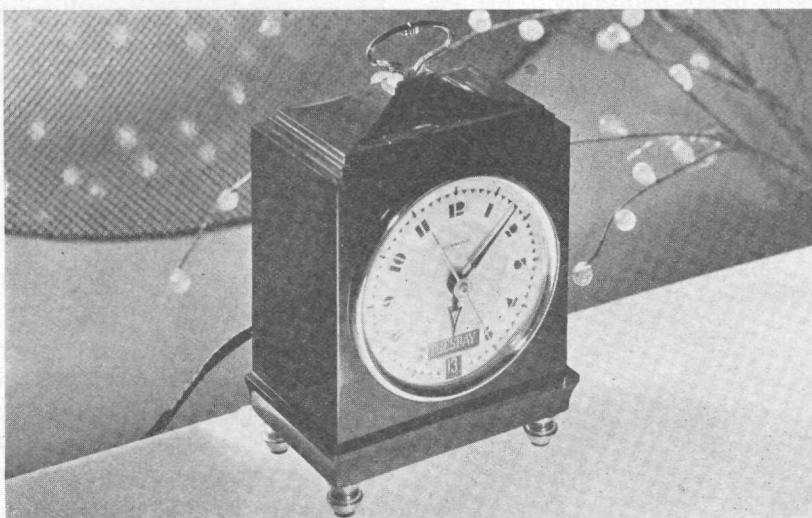
formaldehyde and phenol (carbolic acid). Through variations in manufacturing technic, many types of phenolic products are obtained. In every case the resultant product is a hard, strong, inert substance, with neither taste nor odor. In no way does the phenol resinoid resemble its two malodorous parents. Further, it possesses properties differing widely from these two well-known chemicals.

The Initial Material

Carbolic acid, known as phenol, is a by-product of the cokeoven. It is also prepared synthetically by indirect oxidation of benzol. Formaldehyde is commonly obtained by partial oxidation of methyl alcohol. In the manufacture of Bakelite resinoid, weighed quantities of phenol and formaldehyde solutions are placed in a jacketed kettle and steam is turned into the jacket until the reaction proceeds actively. In a few hours, when this reaction has been completed, it is found that the contents of the kettle have separated into two layers, water above, and a layer of molten resinoid below.

Freed from water, we have the clear, amber-hued material which is the basis of the various forms of phenol resinoid products. Though in appearance these products are similar to nature's resins, they differ so greatly in their properties that the term "Resinoid" has been coined to fit them. This term more properly emphasizes the fact that this material is man made. At this stage the resinoid,

like natural resins, may be readily melted and dissolved. After further processing with heat, however, the material takes permanent form, after which it can never again be melted or placed in solution. The chemist calls this change of properties, "polymerization," or freezing by heat.



ELECTRIC CALENDAR CLOCK WITH BAKELITE MOLDED CASE

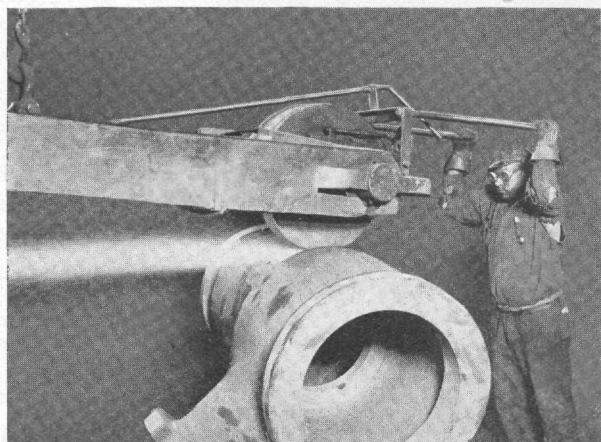
Phenol resinoid has served industry so well and has demonstrated such amazing versatility, due to its unusual variety of desirable properties that it may be well to discuss here the six general types of materials produced from the initial resinoid, and include in a later article a reference to some of the many thousands of finished products we encounter almost daily. The six general classes are: (1) Transparent Materials. (2) Molding Materials. (3) Laminated Sheets, Tubes, and Rods. (4) Liquid Products—Varnish, Lacquer, Enamel, Cement—Baking type. (5) Synthetic Resins for air-drying paints and varnishes. (6) Special Resinoids.

Transparent Materials

The unpolymerized resin already referred to is placed in an autoclave and then heat and pressure are applied for a few hours. Generally the temperature employed is about 300° F., while the pressure ranges from 50 to 100 pounds per square inch. The heat causes the transformation to a hard, strong, insoluble, infusible state, while the pressure prevents cracking, which would otherwise result from the rapid condensation. The resulting product is a dense, strong, solid, light in weight, having a tensile strength of about 7,000 pounds per square inch cross section, and a specific gravity of 1.27. It will not melt or burn, is resistant to dilute and mineral acids, and most other reagents.

Molding Material

The molding material is generally prepared by the impregnation of a dilulose substance with the initial resinoid. In the production of suitable molding material fibrous substances, such as woodflour, are thoroughly incorporated with the resinoid. It is important to turn out a product which will have adequate flow in the mold when heat and pressure are applied. The filler gives greater toughness and less shrinkage than would be the case if the resinoid were employed alone. The woodflour, color pigment, and unpolymerized resinoid are ground and thoroughly mixed. The powder thus formed is run through hot rollers which reduces the resinoid to a molten state. The material emerges from the rolls in sheet form whence it is cooled and ground very finely to insure uniformity. The material, in powder form, is now ready for market. The



High Speed Grinding Wheel

molds are made of hardened steel and mounted in hydraulic presses. The molding material is accurately measured out and placed in the mold. A pressure of about a ton to a square inch, and a temperature of about 350° F. transforms the molding material to a permanent, strong, infusible and insoluble state. The molded object is removed from the mold and the process repeated.

Laminated Products

The unpolymerized resinoid is dissolved in alcohol or other suitable solvents, at which stage it has the appearance and consistency of a varnish.

Sheets of paper or cloth are dipped into it and piled one upon the other to the desired height. The stacked sheets are then placed between the heated platens of a hydraulic press which, employing roughly the same heat and pressure as described under Molding Material, fuses the sheets together and sets them into a compact and uniform plate. These plates in no way resemble the layers of paper or cloth from which they are built. They are dense, tough, high in mechanical and dielectric strength, and cannot be resoftened by heat. Tubes and rods of this material are manufactured by variations in technic, employing steel mandrels and molds.

Liquid Products

In manufacturing the numerous liquid products of the baking type, such as varnishes, lacquers, enamels, cements, the initial resinoid is first placed in solution. To obtain best results baking at temperatures ranging from 170° F. to 300° F., is necessary. The period of baking, ranging from one-half to several hours, will vary, depending on the type of material used and the nature of the work. These products are very important industrially, possessing, in common, the advantages of dielectric strength, hardness, and resistance to corrosion.

Synthetic Resins

Supplementary to the baking finishes, described in the preceding paragraphs, is the new line of synthetic resins employed in the manufacture of paints and varnishes of the air-drying type. These quick-drying finishes are made by the leading varnish manufacturers in the United States, who procure the resins from Bakelite Corporation. Though introduced but a few years ago, these resins have given industry a new conception of paint and varnish durability.

Special Resinoids

Numerous special resinoids have been developed with widely varying characteristics. Very important is the resinoid employed as a bond for grinding wheels and other abrasive products.

After many years of patient research a new resinoid suitable for denture purposes has been developed. The finished dentures resemble very closely the natural color of skin tissue. They retain their color, life and strength over a long period of time, do not stain, and are sanitary.

A new flexible resinoid has been employed with great success in the manufacture of waterproof fabrics.

EDITOR'S NOTE: Another article by Mr. Ellis, dealing with the subject of the "Uses of Bakelite Materials," is to follow in the next issue of the OHIO STATE ENGINEER.