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FOREST PRODUCTS LABORATORY
WOOD PLASTICS

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UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE
FOREST PRODUCTS LABORATORY
Madison, Wisconsin
In Cooperation with the University of Wisconsin

FOREST PRODUCTS LABORATORY WOOD PLASTICS[1]

Wood plastics which combine good strength, machining, and other physical properties with economical use of phenolic resin plasticizing agents have been developed at the Forest Products Laboratory. Some production of similar plastics on a commercial scale is under way at several Middle Western plants.

Basis of the Laboratory plastics is hydrolyzed wood, a substance from which part of the cellulose has been removed chemically, leaving the lignin and enough cellulose to serve as a filler which improves its strength properties. With plasticizers added, hydrolyzed wood can be molded under pressure into any desired shape. It is produced by either of two methods, acid-hydrolysis or aniline-hydrolysis. By varying time, temperature, and acid concentration in the acid-hydrolysis treatment, the lignin-to-cellulose ratio can be controlled. It has been found that this ratio very largely determines the properties of the finished material, other things being equal. A low ratio of lignin to hydrolyzed cellulose will have high strength values and low water resistance, whereas opposite effects will be obtained in a higher lignin-cellulose ratio.

Mill-run hardwood sawdust of maple, oak, hickory, gum, or aspen, and combinations of these species, has been used chiefly at the Laboratory. Hogged material from slabs, edgings, and woods waste can be successfully utilized so long as it is bark- and dirt-free. Such wastes need not be dried before processing. Coniferous woods usually produce materials with lower strengths than do hardwoods, but proper process modifications may make them equally suitable. Many plasticizing agents may be used after the wood has been hydrolyzed, depending upon the molding, finish, and other properties desired in the finished material.

Forest Products Laboratory Acid-Hydrolysis Method

In a typical hydrolysis pretreatment at the Laboratory, 100 parts of maple sawdust (dry weight) are mixed with 250 parts water and 3 parts sulfuric acid. The mixture is cooked in a rotating digester heated by direct steam for 30 minutes under 135 pounds pressure per square inch. The acid-sugar liquor is then drained off; the residue is washed with water until neutral to litmus, and dried. Yields are approximately 62 percent of the original wood waste -- somewhat higher if lower concentrations of acid are used.

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[1] This mimeograph is one of a series of reports issued by the Forest Products Laboratory to aid the Nation's defense effort.

Mimeo. No. 1382

This material, preferably after being ground to a particle size ranging from 40 to 100 mesh, is subject to hot pressing at 190° C. with the addition of water alone. Use of a plasticizer, such as a combination of aniline and furfural, reduces necessary pressing temperature to about 150° C. with marked modifications and improvements in the properties of the product.

The molding composition consists of 100 parts hydrolyzed sawdust (dry), 8 parts aniline, 8 parts furfural, 0.5 part zinc stearate, and 2 parts water. It is pressed for 3 minutes under pressure of 3,000 to 4,000 pounds per square inch. The resulting plastic product is black, opaque, lustrous in finish, and has a density of 1.4. Its machinability is good, it has a tensile strength of 3,500 pounds per square inch, a compressive strength of 21,000 pounds per square inch, flexural strength of 6,000 pounds per square inch, and water absorption (48 hour immersion) of 2.2 percent. Other physical properties established for it are:

Breakdown voltage (60 cycles) -- 484 volts per mil.
Impact (Izod) energy absorbed per inch of notch -- 0.33 ft.-lb.
Hardness (Rockwell 1/4-inch ball, 15 kg. load) -- 93-94.
Distortion under heat -- 251° F.

Forest Products Laboratory Aniline-Hydrolysis Method

Somewhat higher strength and water-resistance values are obtained in the plastic made with the aniline-hydrolysis method. It calls for mixture of 100 parts of sawdust (dry weight) with 100 parts of water and 21 parts of aniline, and cooking for 180 minutes under digester pressure of 160 pounds per square inch. The digested material is washed with water until neutral to litmus and dried and ground to a particle size of 40 to 80 mesh. The yield will approximate 95 percent by weight of the original wood waste.

A satisfactory molding composition may be prepared with 100 parts of the aniline-treated sawdust, 8 parts furfural, 2 parts water, and 0.5 part zinc stearate. This is pressed for 3 minutes at 155° C. under 3,500 to 4,000 pounds pressure per square inch. The plastic product formed is also opaque, black, and of lustrous finish, with a density of 1.4. Of good machinability, it has a tensile strength of 5,500 pounds per square inch, compressive strength of 21,000 pounds per square inch, and flexural strength of 7,000 to 8,000 pounds per square inch. Other values are:

Breakdown voltage (60 cycles) -- 420 volts per mil.
Water absorption (48 hours immersion) -- 1.07 percent.
Impact (Izod) energy absorbed per inch of notch -- 0.44 ft.-lb.
Hardness (Rockwell, 1/4 inch ball, 15 kg. load) -- 95-96.
Distortion under heat -- 275° F.

General

The products produced by both processes, except those with very high lignin content, have high shock resistance and do not fade on exposure to ultraviolet light; in fact, samples exposed to ultraviolet light for more than 144 hours were blacker and shinier than before exposure. Exposure on the Laboratory's paint-test fence for more than 2 years shows that they have a high degree of weather resistance, the surfaces being affected less than painted or varnished wood surfaces during similar exposure.

Applications of thin wood veneer, paper, and the like, to the surface during the molding cycle produced strong, shiny, attractive surfaces. Paints, lacquers, and enamels can be applied; there is no tendency to bleed or stain the painted surface. Painted and lacquered surfaces exposed on the paint-test fence for 2 years show that the plastic's paint holding powers are superior to those of either wood or metal.

These plastics can be readily molded about relatively heavy metal inserts as in a molded steering wheel; in addition to being cheaper than the commonly used moldings, they have superior aging characteristics. They should be suitable for gear shift knobs, and other uses where their black color is not objectionable.

Both of the foregoing molding compounds can be molded in relatively thick sections (experimental moldings up to 2 inches have been made) with very little difficulty in obtaining a uniform cure throughout the molded piece.

These materials are not completely thermosetting in nature, and must be cooled approximately 20° C. before removal from the mold. They also have a somewhat lower mold flow than commonly used materials. Both the thermosetting qualities and the mold flow, however, can be improved by the addition of 15 percent of a thermosetting phenolic resin to the aniline-furfural molding powders, making them very satisfactory.

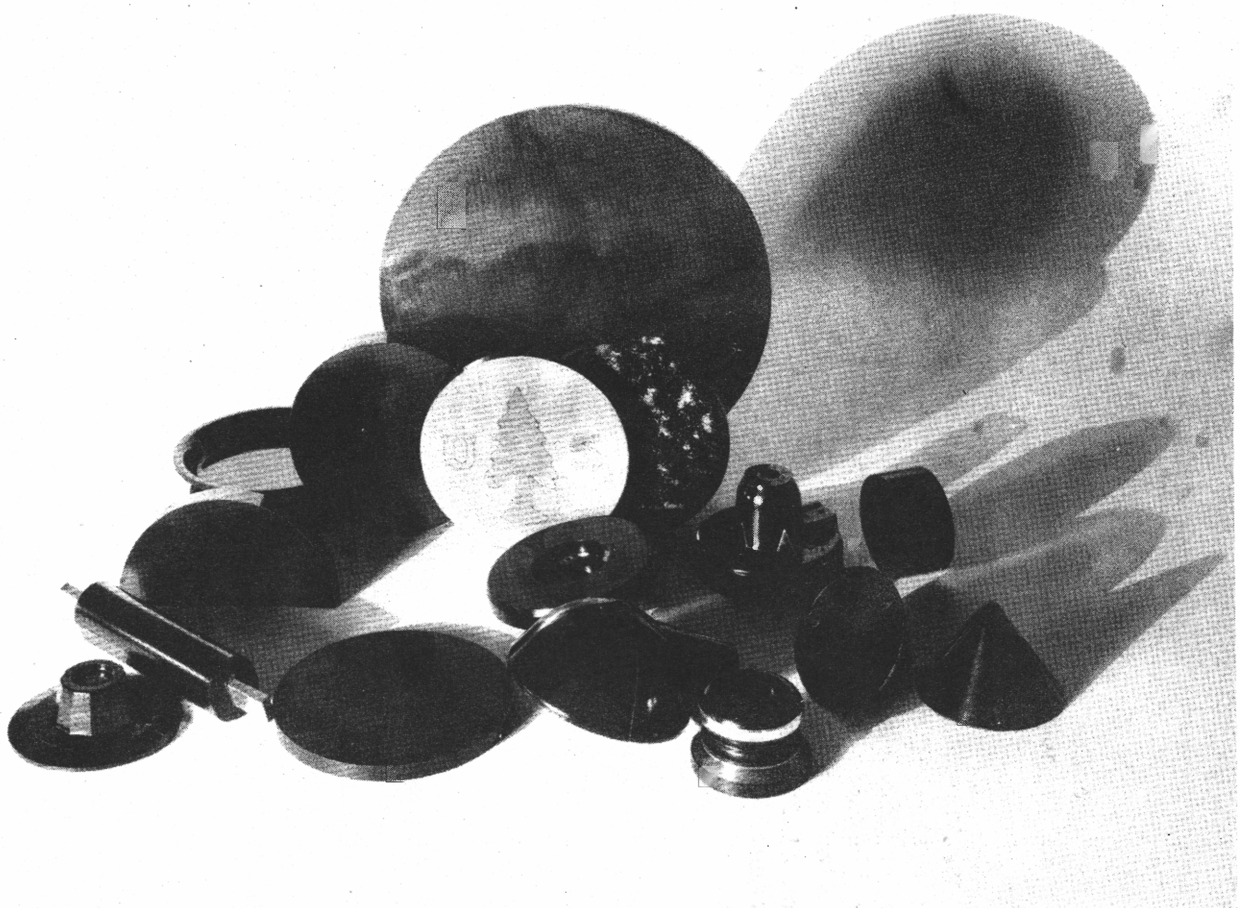
In view of the present shortages of resins for molding compounds, it is interesting to note that savings up to 50 percent in resin content are possible by substituting hydrolyzed wood for the ordinary wood flour filler. A molding powder consisting of 25 percent phenolic resin and 75 percent hydrolyzed wood produced a molding powder comparable to general purpose powders containing 45 percent resin and 55 percent wood flour with respect to flow and strength, and even superior water resistance.

Substitution of hydrolyzed wood for unhydrolyzed wood flour could, therefore, be the means of increasing the amount of molding powder that can be produced from a given amount of phenolic resin by 60 to 100 percent with no sacrifice in quality or molding characteristics.

Where Obtained

Three concerns have recently been active in the commercial development of lignocellulose molding materials produced from hardwood waste.

The Marathon Chemical Company of Rothschild, Wis., produces a material either in the form of sheets suitable for laminating, or as molding powders. Northwood Chemical Company of Phelps, Wis., produces a phenolic resin plasticized lignocellulose said to have excellent flow and curing characteristics. The Burgess Cellulose Corporation of Freeport, Ill., produces modified lignocellulose molding powders of both thermoplastic and thermosetting types.



General character of final material -- adaptable to many forms and products.

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