DESCRIPTION OF THE FOREST PRODUCTS LABORATORY'S WORK ON WOOD LIGNIN AND PLASTICS

Next to cellulose, lignin is the most abundant and most widely distributed organic substance. The chemistry of lignin has been of importance to the chemist working on the pulping of wood since that industry began. Lignin is found to be the substance which cements together the cells of the tree or plant and also reinforces the cellulose within the cell. It must be removed before white paper, rayon, or many of the other cellulose products can be produced.

After almost 100 years of study the chemical nature of lignin still is a matter of controversy. Some have suggested that lignin is aromatic in nature on the grounds that it yields some small amounts of aromatic compounds, as vanillin and pyrocatechol, by alkali fusion, and aromatic tars when it is destroyed by the action of heat. The many attempts, however, to obtain intermediate aromatic products by less drastic treatments have failed. One must therefore conclude that the aromatic compounds are formed as a result of chemical decomposition.

Unlike cellulose, lignin does not exist in long chains of simple sugar groups connected through oxygen linkages which may be split by hydrolysis. Instead it seems to be a comparatively short chain of hydroxy-furan groups joined together by carbon-to-carbon linkages. Theoretically, this may be explained by assuming a condensation of pentoses or furanoses and methylation of some of the hydroxyl groups. Such an arrangement would account for its extreme stability toward hydrolytic reagents. This relationship of lignin to the furans is shown by a similarity of many of their reactions: oxidation of lignin with dilute nitric gives oxalic acid and carbon dioxide; it can be nitrated and coupled with other organic compounds to form dyes; it polymerizes easily and combines with other compounds to form resinous or plastic material.

In these days of labor-saving devices and processes, any material which promises to produce finished articles by casting, stamping, pressing, or molding is of great interest. The plastic properties of lignin and its associated materials displayed under certain chemical reactions make raw materials containing lignin of particular interest in the field of plastics.

The supply of sawdust suitable for this purpose runs into millions of tons, much of it now wasted or used for fuel or other minor uses. Simple hydrolysis of sawdust with dilute acid at the proper temperature and pressure is sufficient to produce a powder which will mold to a hard, black, dense material not far different in appearance and properties from other well-known molding materials at only a fraction of their cost. A much better material can be obtained by incorporating 6 to 8 percent aniline and 6 to 8 percent furfural in the mixture before pressing. This plastic causes less trouble in sticking to the mold and can be pressed at a lower temperature. It has a density of approximately 1.35 to 1.41 and a machinability very much like hard rubber. Its modulus of rupture, as determined by static bending, is approximately 6,000 pounds at 4 percent moisture content, an equilibrium moisture content acquired at 30 percent relative humidity. The electrical resistance varies with the moisture content; at 30 percent humidity it is of the order of 5×10^{11} ohms per square centimeter. After 24 hours' soaking in water it will take up between 1 and 2 percent of its weight, but only 0.2 to 0.4 percent in 60 percent atmospheric humidity for the same time. The maximum swelling in length and width, after soaking for 100 days, is less than 1.5 percent.

Preliminary estimates indicate that this molding powder can be made for 2 to 3 cents a pound, the increase in cost over that of sawdust being due to added chemicals.

A third modification is made by digesting sawdust with aniline and compounding the finished material with furfural. This material flows better in the mold and has a better finish than the previously described plastics. It appears to be somewhat weaker, but strong enough for the purposes for which plastics are generally used. It would cost about 5 cents per pound.

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