CHEMISTRY

From Waste to Wealth

Lignin, Now Mostly Just a Stream-Polluting Nuisance, Shows Promise of Becoming Useful Chemical Citizen

By DR. FRANK THONE

CELLULOSE is a word that has escaped from the cage of technical jargon where scientists once kept it and has become everybody's pet. We all know cellulose now. It is the white shiny stuff in plants that expresses itself in a thousand forms—as cotton and linen and hemp and ramie, as cornstalk pith and thistledown and the walls of cells we peer at through the microscope. We meet it everywhere in articles of daily use. Cellulose shirts and sheets woven out of natural fibers, cellulose paper for reading and writing, cellulose compounded into the thousandfold synthetic things from rayon to artificial leather, into suggestively trade-named substances like Cellophane and Celluloid. We even blow each other to bits with the aid of cellulose, for guncotton is trinitro-cellulose. We might almost call our modern era the Cellulose Age.

Close Partners

Now cellulose, the versatile, the agile, the clever, the Jack of all trades (and master of them, too!) has a chemical brother. Lignin is his name. In nature, lignin and cellulose are almost inseparable, and they work well together. Cellulose forms the cell walls, the fibers, the structural elements generally, and lignin cements them powerfully together. This cellulose-lignin partnership expresses itself most strikingly in wood. Monumental trees, cable-like vines, lowly shrubs, are all products of their joint labors.

Lignin gets its very name from its importance in wood formation: the Latin for wood is *lignum*. We get a derivative in lignite, the fibrous, semi-woody brown coal used to some extent in this country and very widely in Europe. And we get the word straight, in lignum-vitae, an extremely heavy tropical wood highly valued for its hardness and durability.

Chemically Shy

But although these two chemical brothers, cellulose and lignin, are thus almost inseparable as they occur in nature, they are in many ways as different from each other as human brothers often are. Cellulose has proved able to go out into the world and make fame and fortune for himself: as already mentioned, he is in all kinds of businesses, from paper to paint, from explosives to the dainty things on milady's boudoir table. It is not easy to separate cellulose from his brother lignin, but chemists have succeeded in doing so, and have found a multitude of jobs for cellulose.

Lignin, on the other hand, has persistently stuck in the army of the unemployed. Whether he was chemically sulky or merely shy, at any rate he refused to let the scientists know much about his character or capabilities. To speak less figuratively, even yet chemists do not know the structure of the lignin molecule, though they have been trying to find it out for nearly a hundred years. You cannot do much with a chemical compound until you know how it is put together.

However, very recently chemists at the U.S. Forest Products Laboratory in Madison, Wis., have broken down a little of lignin's chemical secretiveness, and with even this partial knowledge in hand they have been able to put him to work at last. Lignin's new job is in one of the occupations his brother cellulose has followed successfully for many years—plastics.

How important it is for American industry, that a job has at last been found for lignin, has been well summed up by Carlile P. Winslow of the U.S. Forest Service, who directs the work of the Forest Products Laboratory. Says Mr. Winslow:

"Lignin makes up twenty to thirty per cent of the weight of the average plant stem. Billions of tons of it are present in the world at any one time, and the supply renews itself indefinitely by natural growth.

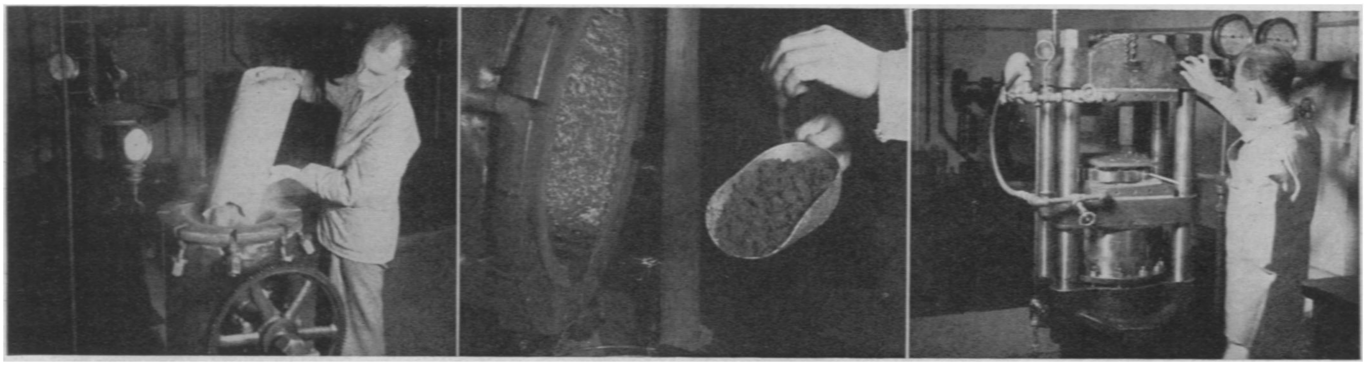
Waste and Pollution

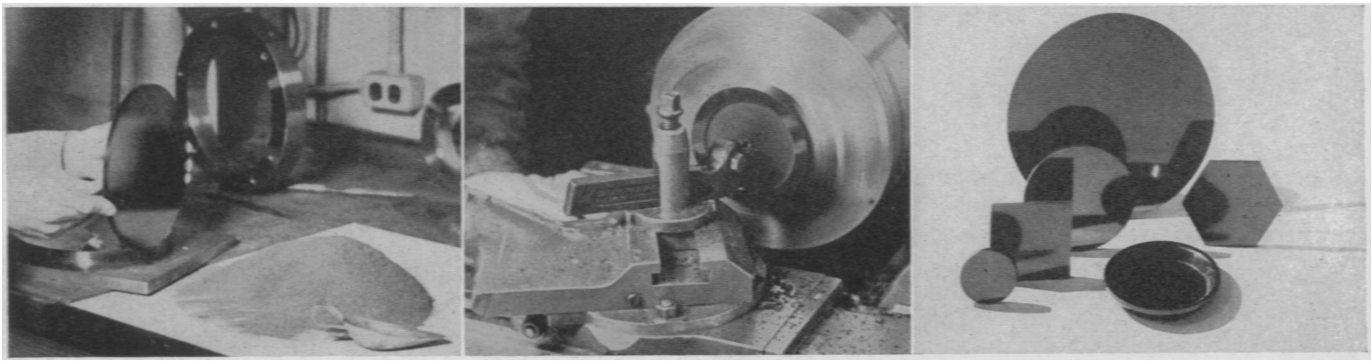
"Limiting our view to present facts in the United States, we find the lignin problem pressing for attention in two forms: a million tons of it are dumped into our streams annually as waste liquor from pulping mills; in the background, fifteen million tons more, contained in four times that tonnage of waste wood.

"The question that faces the chemist and the inventor is, how can we change

MAKING LIGNIN USEFUL

The first step in the process (left): pouring sawdust into the digester. After digestion in the heavy kettle the sawdust emerges in the form of "hydrolized" wood. Then the powdery dough-like substance is put into powerful presses to be shaped into solid forms.





PRODUCING BEAUTY

Out of the press comes a hard disk ready to be machined. It can be turned on a lathe (center) like metal or wood. At the right are shown stock shapes of lignin plastic and, in front, a molded ash tray.

lignin from a source of stream pollution and a waste to a source of wealth and usefulness?"

Mr. Winslow and his fellow workers at Madison have found a large part of the answer to his own question, in qualifying lignin for the plastics job. There seems to be no limit to the world's demand for things that can be made out of those synthetic gummy stuffs that harden and polish and work up beautifully into everything from such trifles as ash trays and vanity cases and buttons to larger objects opening up possibilities of big quantity uses, like floor tiles, wall panels, auto instrument boards, electrical insulators, and acid-resisting containers for chemicals. Plastics, all the way from the old-fashioned hard rubber to the newer ones made of cellulose, phenol, formaldehyde, etc., are taking over hundreds of jobs that used to be given to wood, metal, pottery, glass, leather; sometimes because increasing scarcity has made the old things too expensive, but often too because the new synthetic stuffs can do the work better. So lignin plastics are entering a field that offers limitless possibilities which even its numerous predecessor plastics have not yet been able to exploit to the full.

Simple Now

Chemists had to put in many hours of hard brainwork before the rather simple-looking process for producing lignin plastics could be called a success. But the very fact that they made it simple, finally, is one factor that should make for its further success on a large commercial scale.

To prepare lignin for its job in the plastics business, sawdust is shoveled into a heavy iron kettle with a lid that can be clamped down tight, called a digester. Dilute acid is added, the lid is closed, and the digester is heated for a while. This raises steam and acid vapor inside, and changes the chemical nature of the sawdust—"hydrolizes" it, the chemist says.

When the digester is opened again, the sawdust as such is gone and in its place there is a dark powder swimming in a bath of dark syrup. The acid has changed part of the sawdust into a mixture of several different kinds of sugar—that accounts for the syrup. This has its own chemical possibilities, but for the moment it is the dark powder we are interested in. So the syrup is drained off, leaving us the powder.

Hard and Strong

This can be put by itself into moulds of suitable shape and subjected to the grip of powerful hydraulic presses. It comes out no longer a powder but as slabs, disks, other shapes, very dense, hard, strong, and black as ebony. By using dies of suitable shape, it can be formed directly into trays, knobs, handles, bowls—what you will. Or it can be pressed into flat "blanks" which can then be turned on a lathe, sawed, bored, otherwise machined, about as you would work hard rubber.

Thus far, it has not been possible to prepare the lignin plastic in the beautiful transparent and light-colored forms in which the phenol-formaldehyde and cellulose plastics can be had. This handicap, however, can be largely overcome by enameling, painting, lacquering and other surface treatments, for it accepts them all very well. An especially interesting facing can be given it by sifting powdered metal into the mould before the plastic-powder is filled in. The metal then becomes an integral part of the finished product.

The great advantage of the wood-waste moulding powder is its very low cost. Preliminary estimates by Mr. Winslow indicate that it can be made in bulk for two or three cents a pound. Other types of plastic materials cost very much more than that. It is not improbable that lignin plastics will take over much of the field now occupied by its predecessors, on price competition alone, and that it will also open up new fields of usefulness that the others can not enter now because of their too high cost.

One advantage lignin plastic shares with other materials in its class: it has high electrical resistivity, and so will make a good insulating material. It is also resistant to acid and its waterproof qualities are very good. It is a poor conductor of heat, so that it feels warm and comfortable to the touch—something like its parent substance, wood, in this respect. This quality should give it advantage in bidding for use as wall paneling and floor tile. The bathroom floor will seem much less chilly underfoot, when it has been done over in "Lignitile." (That isn't a trade name yet, but it probably will be some day—or something like it will be coined and boosted with all the arts of modern advertising.)

Add More Waste

The lignite-containing powder may be used just as it comes from the digester, but the chemists of the Forest Products Laboratory have found it advantageous to add from six to eight per cent each of aniline and furfural—both of these, incidentally, are valued industrial materials made from what once was troublesome waste: aniline from coal tar, furfural from oat hulls, corncobs, straw and other farm by-products. With these additions, the material works up better. It is less likely to stick to the hot metal of the mould, and can be pressed and shaped at lower temperature.

Well, there stands lignin, taught by Uncle Sam's chemists and technicians how to do a big job in a big industrial field. His sleeves are rolled up and he is ready to go to work. It probably won't be long now until plastics manufacturers will be clamoring for his services.

Odd Jobs

As a matter of justice to lignin, he wasn't altogether a loafer before his present big chance came. He picked up what odd jobs he could get.

One has been holding down linoleum. Waste liquor from paper mills contains the lignin from the wood pulp, rudely torn away from Brother Cellulose by chemical means. Turned out of the factory as a bum, lignin long was an undesirable waterfront character, polluting rivers, destroying fish, and in general making a nuisance of himself. Then someone discovered that if you boiled most of the water out of the waste liquor, what was left made a good adhesive for sticking linoleum to floors. So there was at least a small job for lignin.

Lignin in the same waste liquor from pulping mills has been used to some extent on unpaved roads, to make the dirt stick together better and raise less dust. Odd job number two.

Soil Aid

Recently some rather promising experiments with lignin as a soil conditioner have been made. Lignin has little if any direct fertilizer value, but does help to make certain heavy soils lighter and more tillable, serving as a sort of artificial humus. With this lignin soil treatment, direct fertilization with nitrates is usually also added.

Nor are the chemists by any means through with their ambitions for this hitherto neglected brother of the wood family. As they overcome lignin's reticence and learn more about his inner nature, they can find new jobs for him. Some aptitudes in the direction of oxalic acid, a valuable bleaching agent, and possibly dyestuffs also, have been discovered. They'll make a useful citizen of lignin yet.

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Steel varies in hardness from material hard enough to scratch glass to material soft enough to be scratched with a needle.

PUBLIC HEALTH

Flood Forces Destruction Of Vast Quantities of Food

"Tragic but Necessary" Condemnation of Trainloads Supervised by Men From Food and Drug Administration

AS FLOOD waters subside on the Ohio, the greatest destruction of foodstuffs and medicine in history is being carried out in all cities and towns in the inundated region. How much, it is uncertain as yet, but there is no doubt that the quantity condemned and destroyed after the 1936 flc , estimated at 50,000 tons, will be greatly exceeded —perhaps doubled or trebled.

The destruction of flood-damaged food and drugs is being carried out by a cooperative arrangement between Federal food and drug authorities and state, county, and municipal public health officers. The Food and Drug Administration of the U. S. Department of Agriculture has thirty inspectors in the field, and the various states concerned have supplied the services of sixty or seventy of their own men. Flood-spoiled commodities condemned by them are carted away and destroyed by workers of the W.P.A. and the C.C.C., and by volunteer labor of private trucking and merchandising firms.

The wholesale destruction of whole trainloads of food was described by George Larrick of the Food and Drug Administration as "tragic, but necessary." Whatever the polluted water touched it ruined, so far as possibility of safe human consumption is concerned. Even if it were thoroughly heat-sterilized, so that the danger of typhoid and dysentery were removed, there would still be so much filth in it that it could not with any decency be offered to even the neediest of flood refugees.

Individual items in the holocaust are shockingly impressive. In the Cincinnati yards the inspectors found 139 carloads of fresh fruits and vegetables that had been under water. With the exception of some cars of bananas and strawberries, all looked fair and appetizing. Yet the inspectors could not dare to release the contaminated food, and ordered it all destroyed.

In a Cincinnati warehouse there were 132 tons of coffee that the water had reached; in a Louisville dairy, 100,000 pounds of butter. All had to be destroyed.

Typically, the work was divided by assigning inspection of wholesale warehouses and railroad freight concentrations to the Federal officers, while municipal and county officers took over the retail establishments. First scouting trips of the inspectors were made in boats, while the water was still high in the streets. As the river went down, trucks and railroad cars were loaded with the commodities marked for destruction.

Disposal of the condemned goods was not easy. Most of the regular city dumps were flooded, and municipal incinerators are still out of commission. New dumping sites had to be selected, and wherever the damaged materials could be hauled by rail the railroad dumps were used. Glass containers were smashed, kerosene sprayed on such foodstuffs as flour and sugar to "denature" them, and wherever practicable the destroyed food and drugs were buried deep under the trainloads of mud and debris shoveled up out of the city streets.

Only two classes of packages were permitted to be salvaged: canned goods, and food and drug products hermetically sealed in glass. Screw-top glass jars could not qualify. The permissible salvaged cans and bottles were scraped clean of their labels, washed, chlorine-treated, and then passed for use. Many firms contributed large quantities of such salvaged foods for relief.

Whisky in Louisville's famous warehouses is probably safe, said Mr. Larrick; though inspectors, with the more important problems of food and drugs to deal with first, have not got round to that yet. Both bottles and barrels are well sealed, he explained, and if they are thoroughly washed and chlorinated outside the contents will doubtless be all right.

"Besides," he added, "any germ that might get through and tackle the contents would probably find straight Kentucky liquor a bit too strong for it."

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