RECENT DEVELOPMENTS IN THE CHEMICAL UTILIZATION OF WOOD

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RECENT DEVELOPMENTS IN THE CHEMICAL UTILIZATION OF WOOD[1]

By

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The southern farmer has a big stake in the harvesting of tree crops -- just as he has in taking from the land crops of potatoes, corn, peanuts, cotton or tobacco. In the South, as elsewhere, the largest farm crop in acreage is timber; and timber ranks among the first four southern crops in point of annual dollar value. The development and holding of markets for farm timber is something neither the farmer nor the extension worker can deal with unaided. The market for lumber (which, exclusive of fuelwood constitutes, 70 percent of all forest products cut) has been declining for over 30 years. To extend the marketing and utilization of farm timber we must look to research aimed to find uses for wastes, to improve practices, and to develop new and useful products.

Because of the existing character of farm timber, chemical research must play an increasingly important role in developing its industrial uses. It is perhaps worthwhile also to note in passing that while construction constitutes the present major use for wood, and there is no present justification for minimizing this field, the use of cellulose products is increasing by 200,000 tons per year, and well in the van of industries that have expanded in the very teeth of depression are the chemical and plastic industries. My assignment on this program calls for a report on recent developments in the field of chemical utilization of wood by the Forest Products Laboratory.

Pulpwood Variability a Guide to Future Diversification

Before mentioning specific new chemical products and processes let me say a few words about southern pine pulpwood.

Certain phases of the research at the Forest Products Laboratory apply to pulpwood and pulping. For example, the influence of conditions of growth on pulpwood properties is being examined, and studies of the harvesting and marketing of pulpwood are in progress, particularly with southern species. Some very interesting data relating to pulpwood properties and their influence in the production of pulp has been recently

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developed. As you are probably aware there are inherent physical differences in different batches of pulpwood -- variations in diameter, rate of growth, springwood and summerwood, heartwood and sapwood, knots, crook, and other attributes.

So long as the kraft industry was a sole performer in the southern pulp field there was little reason to take note of the variability -- or perhaps we should say the versatility -- of southern pine pulpwood along lines other than species. With the present tendency toward the development of bleached sulfate, sulfite, and newsprint in the South, however, the versatility of southern pine pulpwood takes on new significance.

Without going into the physical differences in springwood and summerwood fibers which dictate such selection, it is possible to say that material of high springwood content will find its best use in the manufacture of printing and wrapping grades requiring good formation and smooth surface, accompanied by high bursting and tensile strength. High summerwood content material is better adapted to bulkier papers, such as bagging, boards, etc., or in papers where tearing strength is important.

The essential differences in the pulping characteristics of heartwood and sapwood suggest another basis for the segregation of material. Wood which has a large amount of heartwood would necessarily have to go into kraft, but material running low in this dark-colored and sometimes pitchy wood might be properly diverted to bleachable sulfate, light-colored groundwood, or sulfite.

Variability in springwood-summerwood and heartwood-sapwood proportions as affected by height in the tree also opens up possibilities of diversification as between slow-grown wood or butt bolts and young rapid-grown material or bolts from upper portions of the tree.

With increased diversification of the pulping industry, efficient industrial operation, as well as sound conservation, demand that the inherent variations in pulpwood be used to separate and guide both woods production and wood incoming to the mill to the uses to which it is best fitted. The pine trees now growing on southern woodlands and the pulpwood now being handled constitute a source of raw material from which can be made all of the different types of paper used in the United States. I believe this important fact justifies such consideration as we have just given to pulpwood properties and uses.

The most important developments in the chemical utilization of wood, so far as the Forest Products Laboratory is concerned, include some items which are just coming into important commercial production and other items which are still in small-scale laboratory experimentation.

Southern Newsprint From Pine and Gum

As early as 1927, the Laboratory worked out methods for the production of newsprint paper from various combinations of pine sulfite pulp with pine or black gum groundwood. From the standpoint of the forests, however, the sulfite process was undesirable since only the young heart-free pine could be used.

Later the use of bleached sulfate kraft pulp was developed by the Forest Products Laboratory to permit the use of pine of any age. It is this latter process, using a combination of semibleached sulfate pine with pine groundwood, which is being used in the South's first newsprint mill which began operations at Lufkin a few months ago.

As just mentioned, it was also shown how black gum groundwood pulp can be mixed with pine groundwood pulp for the groundwood constituent which makes up 75 to 80 percent of newsprint paper.

Very recently, the Laboratory has further shown how the black and red gums having light-colored heartwood can be cooked by the Laboratory's "semichemical" process to produce a pulp to replace the much more costly semibleached kraft pulp for the chemical pulp constituent which makes up 20 to 25 percent of newsprint.

The semichemical process, which consists essentially in a partial cooking with a reduced amount of chemical followed by mechanical disintegration, gives a 75 percent pulp yield at a cost about the same as for groundwood pulp. With the southern gums, the Laboratory has produced pulps which mixed in a 1 to 4 ratio with southern pine groundwood made a newsprint paper equal to commercial grades.

This is of two-fold significance. First, owing to its higher yield, the cost of semichemical pulp should be no greater than for groundwood and appreciably lower than that of either sulfite or semibleached kraft pulps. Secondly, gum is one of the most abundant of the southern hardwoods, which as a group occupy half of the southern forest.

Blackjack oak and red gum for "corrugating" container board

The semichemical process was developed at the Forest Products Laboratory about 15 years ago to produce "corrugating" board, as well as "liner" for shipping containers from waste extracted chestnut chips in the tannin industry. Today, 100,000 tons of such board are produced annually from extracted chestnut. The chestnut supply, however, will ultimately be exhausted because all of the chestnut trees have been killed by the blight. Very recently the Laboratory has shown how to use blackjack oak and red gum by the same process and has produced container board of quality superior to that from extracted chestnut.

Development of Bleached Papers from Southern Woods

Around 1910 there was practically no pulp production in the South. The Laboratory showed how satisfactory brown kraft pulp for wrapping paper could be made from southern pines, and upon this work as a basis the great kraft pulp industry was initiated.

One weakness of this southern industry was that it was restricted to one type of product — brown kraft pulp. Laboratory methods were initiated for the development of cooking and bleaching procedure to produce a white pulp. This work had much to do with the present development of bleached pulps and papers in this region. Incidentally, the use of southern gums and other hardwoods was proved entirely feasible for book and similar bleached grades of paper.

Pulp and Chemical Products from Wood by Hydrogenation

Recently, by subjecting wood chips in water to the action of alkali and hydrogen with a nickel catalyst at high pressures, it was found that the hemicellulose and lignin, which constitute together 50 to 60 percent of wood substance, were converted into a variety of alcohols, oils, and an alkali-soluble resin, and at the same time the cellulose was recovered in the form of a pulp. The alcohols include methyl and propyl alcohol and the previously unknown products of this operation include a hard, glassy, amber-colored resin that may prove useful for plastics and lacquers and several derivatives of propyl cyclohexane, some of which are thick viscous oils and others thin and toxic in nature.

The pulp has normal fiber length, average alpha cellulose content, is bleachable, and can be beaten to develop satisfactory sheet-making properties.

While this new discovery has as yet been applied only on a small-scale laboratory basis and is chiefly of immediate scientific interest, it holds forth most interesting industrial potentialities.

Low-cost Plastic from Poor-quality and Waste Wood

About 50 percent of the southern forests are in hardwoods with many species and many defective trees that won't pay their way when manufactured into standard lumber and which should be harvested to make room for a new crop of timber of desirable species; also the aggregate of logging, sawmill, and manufacturing wastes amounts to something like 50 percent of the tree.

In this connection it is possible to report a process by which a high-utility low-cost plastic can be produced from poor-quality and waste wood. As this plastic has been described to other Farm Chemurgic meetings, I will ask those who have heard the story to bear with me briefly.

The essentials of the process are simple. Sawdust or wood chips are "hydrolyzed" by heating with dilute sulfuric acid, certain resulting sugars are washed out of the fibrous mass that is left, and this product is dried, ground fine and mixed with a small amount of aniline and furfural. The result is a molding powder, which when pressed at 150° C. under 3,000 to 4,000 pounds per square inch pressure for a few minutes, becomes a dense, impervious sheet material that offers wide possibilities for use as a floor tile, switchboard panels, and a variety of other pressed and molded products. The powder ready for molding should not cost more than 2 to 3 cents per pound as compared to about 16 cents for the well-known phenolic plastic.

The finished material, which is normally opaque black, receives a high polish in the mold and its appearance may be altered by the use of paint, enamel, metallic powders, or decorative overlays of paper, cloth, or figured veneers.

Commercial production of this plastic is in exploratory stages in the hands of several large companies and one factory, using low-quality wood, is now making the molding powder in pilot-plant quantities for trial by responsible manufacturers.

Another pleasing development is the discovery that hydrolyzed wood (that is sawdust or chips partially processed in the plastic process) makes an excellent filler for use in the production of phenolic resins. Plastics of this type have a greater flow with hydrolyzed wood than with wood-flour filler and a greater moisture resistance, 25 to 30 percent more hydrolyzed wood than wood flour can be used, and it is estimated that by this means a saving of 1 to 2 cents per pound can be effected in the production of a filled bakelite molding product.

Let me point out again the possible application of the plastic process to a wide range of low-grade woodland species and defective timber. Experiments have so far been confined largely to a few hardwoods and the process has developed in such a way as to accommodate the properties of these species. There is no present reason to believe that the process could not be extended to a wide range of hardwoods and further modified for conversion of softwood species. It appears from preliminary experiments that Ozark blackjack oak, which is perhaps the archetype of neglected species crying for markets in a depressed rural region, promises to be adaptable to the process.

Chemical Plasticization of Wood and Hogged Waste

It appears that even cheaper plastics from low-quality woods may be in the offing. Very recently the Laboratory has found that green swamp oak and blackjack oak, after soaking in a water solution of a single chemical and drying, becomes thermoplastic. The swamp oak while hot and dry has been bent and twisted to very sharp curvatures which are retained on cooling; further, the hot material has been pressed into dense molded or flat shapes with several pieces in the press fusing together into a solid mass. These are true plastic characteristics. The fact that the bent material can be recurved or straightened on reheating may be altered by later developments or it may prove advantageous in possible use of the material.

Although financial limitations have permitted this process to be tried with small-sized hogged material or sawdust only on blackjack oak, a sawdust plastic has been made from this species and it is reasonable to expect that it will work with some other species and with hogged wood or sawdust as well as with boards. This process would be simple and cheap; it offers a possibility of a plastic of even lower cost, and probably somewhat different properties than the one produced from hydrolyzed wood. Its development would be of the utmost significance to southern hardwood utilization.

High Alpha Cellulose Yield from Holocellulose

Any development which tends to diversify the demand for southern pulpwoods reacts to the general good of the southern woodlands. Of interest in this connection is the discovery that wood contains about 50 percent of alpha cellulose having high-viscosity characteristics similar to cotton instead of the 38 percent obtained by the usual pulping processes. Alpha cellulose is required for the production of rayon and similar cellulosic products calling for cellulose that has not been degraded in pulping. The higher fraction recently obtained experimentally -- which was less degraded than alpha cellulose obtained from the ordinary run of pulps -- was derived from holocellulose. The problem now is to modify the method to reduce costs of preparing the 50 percent of alpha cellulose which we know definitely can be realized from this procedure.

Other Accomplishments Affecting Farm Timber Utilization

Research at the Forest Products Laboratory is not, of course, confined to chemical investigations. So far as the utilization of southern farm woodland timber is concerned there are numerous other activities of equal significance.

Logging cost and value studies have shown that, for lumber, it is unprofitable to cut trees below certain diameter limits, and it is also bad for the development of the future forest. These findings form the basis for "selective logging" practice, now increasingly being applied to southern forest lands as well as elsewhere.

Principles have been developed for log grades, and for similar pulpwood grades, to the end that the timber owner and particularly the farm woodland owner can properly select and grade his trees and logs so that they can be more advantageously sold.

A truly portable band sawmill (still in the experimental stages) is under development. It can be moved and operated by a tractor, will not require costly "resetup" expense, and will cut even thickness boards without the loss resulting from the wasteful circular saw.

It has been recognized for years that the development of uses for many of the so-called little-used hardwood species in the southern forest has been greatly handicapped by lack of information on the machinability of these woods. Work on the turning, planing, and shaping of 24 southern species has shown that good results can be obtained if the wood is at the right moisture content and if the speeds, feeds, and cutting angles of the machines are properly controlled toaccommodate the species being used.

Glued, laminated structural beams and arches have been developed to make large structural members from cheap, low-grade, small-sized boards. The laminated arch has recently been used in 200 buildings which otherwise would have used some other material.

Engineering data has been worked out for the use of metal connectors to increase the strength of joints in wooden construction. As a result of this new construction method, since 1933 there have been 18,000 structures put up with these fittings in 44 states, and using over 563,000,000 feet of lumber valued at more than $11,000,000. More than half of this lumber was from the South.

A system of low-cost prefabricated house construction has been developed, using plywood glued to light framing for the construction of unit panels for walls, floors, roofs, and other members. The engineering features have proved sound and the unit panels well adapted to factory construction. Four companies are now using the main principles, and one of them has sold so far about 1,000 houses.

Importance and Present Status of Research on Farm Timber Use

The market needs of the farm woodlands will be especially acute during the transition period between past neglect and the period of thrifty and skilled woodland management. Also, the farm group will be especially affected by any shrinkage of forest products consumption. Standing in the way of woodland improvement is a vast acreage of timber of low-utility species and knotty and malformed character that must be thinned out or in many cases removed once and for all to build up timber production on farm woodlands. A general program of farm forestry improvement cannot be advanced without sound economic incentives to marketing of the thinnings and of the accumulation of low-quality timber that has resulted from past neglect. In view of the present ailing condition of agriculture there is no phase of timber utilization more deserving of attention that that devoted to developing uses for farm timber.

The present scope of Federal research in the farm woodland utilization field is entirely inadequate in relation to the magnitude and importance of the problems involved. This becomes evident on examination of similar work on other crops, for example research to extend the use of farm products other than wood. The Federal government is spending over 20 million dollars a year on food-crop research, and is now building four new laboratories to develop new scientific and technical uses for farm products and byproducts at a cost of from 3 to 4 million dollars annually. In contrast to this, for research on utilization of the tree crop, which occupies more land than all farm food crops put together, there is set aside the sum of only $664,000. This sum covers all types of forest products research, chemical research receiving only its proportionate share.

I believe that the research accomplishments I have cited indicate that forest products research, if properly encouraged, can measure up to its present obligations and to the opportunities for serving pressing economic needs that lie ahead.