ELECTRON MICROSCOPE EXPANDS HORIZONS IN WOOD RESEARCH

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Synopsis

Microscopy with direct electron image magnifications up to 200,000X will play an invaluable role as a tool in obtaining answers to problems confronting research workers in wood and allied industries. Problems currently being investigated at the U.S. Forest Products Laboratory in which the techniques of modern electron microscopy are being utilized are given.

Expanded horizons in wood research have become possible as direct electron image magnifications up to 200,000X have revealed new orders of exceedingly small structures that up to now were invisible in the composition of wood.

These small structures were revealed by the electron microscope (fig. 1) during investigations at the U.S. Forest Products Laboratory. Laboratory research workers, consequently, now view the techniques of modern electron microscopy as providing an invaluable tool for obtaining answers to problems that must be solved if product improvement is to continue in the wood and allied industries.

From the standpoint of preservative penetration and retention, for example, it is of utmost importance to learn if changes occur during the impregnation process in the ultrastructure of the bordered pits, which are the numerous openings found in the walls of wood cells. These pits encase a thin delicate pit membrane (fig. 2), which serves to route gases and liquids from cell to cell.

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1 Presented at the Symposium on Timber--A Tested Material for the Engineer, held at the Fourth Pacific Area National Meeting, American Society for Testing and Materials, October 3, 1962, at Los Angeles, Calif.

2 Maintained at Madison, Wis., in cooperation with the University of Wisconsin. Report No. 2256
Specifically what must be determined is how moisture or gases pass from cell to cell and the factors that influence their passage when wood is being dried or impregnated with preservatives, as well as the adhesion of these preservatives. Obviously, the question of why some woods are more easily impregnated than other woods is an area currently being studied. This can only be accomplished by acquiring more knowledge of the finer details of the bordered pits and their associated structures (fig. 3). Such information can lead not only to an improvement in preservative techniques but also to a more thorough understanding of wood.

It is also important to determine what changes take place after wood has been subjected to high heat or to learn the effect of mechanical damage, growth characteristics, or decay on wood. Not to be overlooked are the vital questions that confront the pulp and paper industry regarding fiber bonding and the need for more knowledge about cohesion effects in the gluing of wood and wood products.

Among the other problems currently being investigated at the Laboratory, in which the techniques of modern electron microscopy are being utilized, is a study to obtain data indicative of the mechanism of extracellular enzyme action in the decay of wood. Sweetgum sapwood in the sound condition and in various stages of brown- and white-rot degradation, ranging from 2 to 80 percent loss in weight, are being examined. Since the electron microscope provides greater enlargement than the light microscope, it is possible to see the parts of the cell wall that have undergone attack by the organism (figs. 4 and 5).

Studies also are being made aimed at acquiring a better understanding of the chemical structure of lignin. This material is reported to be available in enormous quantities—20 to 30 million tons per year—and is looked upon as a major industrial waste that someday may be converted into a valuable resource. The immediate objective is to learn how or in what manner the lignin braces and reinforces the cellulose fibers of wood. In studies regarding the type of association between lignin and carbohydrate in wood, the lignin in its original position is examined by sectioning the wood that was etched with a carbohydrate-removing chemical. These have revealed details of lignin distribution of the various cell layers in certain softwoods (figs. 6 and 7).

The electron microscope alone will not solve all these problems. However, the use of the electron microscope as one working tool has expanded present horizons in wood research.
Figure 1. -- Electron microscope at U.S. Forest Products Laboratory, which is proving to be an invaluable tool in helping to solve some of the highly technical and complex physical-chemical relationships and architecture of wood structure.

ZM 120 853
Figure 2.--An electron micrograph of a pit membrane of Liquidambar styraciflua (sweetgum) sectioned at 1/40 micron, enlarged to 29,000X.

ZM 120 887
Figure 3. --Electron micrograph of crassula and associated border pit in white spruce; carbon imprint enlarged to 23,000X.

ZM 120 889
Figure 4. -- Electron micrograph of degradation of sweetgum by brown-rot fungus. Sample was sectioned transversely at 1/40 micron, enlarged to 23,800X.

ZM 120 891
Figure 5—Electron micrograph showing degradation of sweetgum by brown-rot fungus. Section was sectioned transversely at 1/40 micron and enlarged to 22,000X. Clearly evident is the differentiation of middle lamella and primary wall.
Figure 6. --Electron micrograph of lignin distribution through cell wall of white spruce after chemical etching. Sample was transversely sectioned at 1/40 micron; enlarged to 10,000X.

ZM 120 892
Figure 7.--Electron micrograph of lignin distribution through cell wall of Pinus taeda (lobolly pine) after chemical etching. Sample was transversely sectioned at 1/40 micron, and enlarged to 20,500X.
SUBJECT LISTS OF PUBLICATIONS ISSUED BY THE
FOREST PRODUCTS LABORATORY

The following are obtainable free on request from the Director, Forest Products Laboratory, Madison 5, Wisconsin.

List of publications on
Box and Crate Construction and Packaging Data

List of publications on
Chemistry of Wood and Derived Products

List of publications on
Fungus Defects in Forest Products and Decay in Trees

List of publications on
Glue, Glued Products, and Veneer

List of publications on
Growth, Structure, and Identification of Wood

List of publications on
Mechanical Properties and Structural Uses of Wood and Wood Products

Partial list of publications for Architects, Builders, Engineers, and Retail Lumbermen

List of publications on
Fire Protection

List of publications on
Logging, Milling, and Utilization of Timber Products

List of publications on
Pulp and Paper

List of publications on
Seasoning of Wood

List of publications on
Structural Sandwich, Plastic Laminates, and Wood-Base Aircraft Components

List of publications on
Wood Finishing

List of publications on
Wood Preservation

Partial list of publications for Furniture Manufacturers, Woodworkers and Teachers of Woodshop Practice

Note: Since Forest Products Laboratory publications are so varied in subject, no single list is issued. Instead a list is made up for each Laboratory division. Twice a year, December 31 and June 30, a list is made up showing new reports for the previous 6 months. This is the only item sent regularly to the Laboratory's mailing list. Anyone who has asked for and received the proper subject lists and who has had his name placed on the mailing list can keep up to date on Forest Products Laboratory publications. Each subject list carries descriptions of all other subject lists.