Thinking ahead

Research at Forest Products Lab sets sights on the year 2000

By R. Sam Williams

R. Sam Williams is project leader, wood suface chemistry, at the. U.S. Department of Agriculture Forest Service's Forest Products Laboratory, One Gifford Pinchot Dr., Madison, Wis. 53705-2398. Phone: (608) 231-9465.

Introduction

WOOD FINISHING research at the Forest Products Laboratory (FPL) in Madison, Wis., began about 1920, and a program has been continuously maintained since that time. Much of the knowledge on moisture, species and weathering effects with regard to finishing was discovered through work at the FPL.

Recently, a new five-year program in wood surface chemistry was approved. The description of this program is the subject of this article.

The new program will continue to include both fundamental and applied research on wood surfaces, and much of the research will focus on surface treatments such as wood finishing. Surface treatment of wood (e.g. paints, stains, etc.), adhesion of wood composites and chemical reactions with wood depend on understanding the surface chemistry of wood. This chemistry often differs for each wood/non-wood interface.

Wood composite materials, paints and stains and chemical treatments have been developed empirically, over many years, without a thorough understanding of the interracial chemistry. These products have served the consumer well, but traditional wood products and materials are being replaced with alternate chemicals due to environmental considerations. Environmentally driven legislation is causing rapid change, and there is little time for trial-and-error development of replacement products.

The success of these replacements will depend on basic research focused on surface chemistry of wood to ensure that compatible materials are used with the wood.

The wood resource is also changing. Properties of wood from second-and third-growth forests are not identical to wood from old-growth forests. This is particularly true for the durability of wood used as exterior siding, roofing, decking, and fencing.

In addition, there may be large differences in the performance of substitute and alternate species compared to the more traditionally used wood species. Supplies of second- and third-growth timber and alternate species are abundant, but the grades of siding available are changing because of the different properties of these materials.

There are greater amounts of available flat-grained wood compared to vertical-grained material, thinner cuts of siding, and siding boards comprised of a series of end-glued (finger-jointed) pieces. Problems of substrate and finish durability often result with these second- and third-growth materials and with wood composites.

Forest Products Laboratory research will focus on evaluating the surfaces and interfaces of wood/non-wood materials — including paints and other finishes. The technology is available to drastically change the surface properties of wood and to chemically bond a wide variety of organic and organometallic compounds to the wood surface.

Finish durability

Finish durability problems on wood products are further compounded by many restrictions on traditional paint and stain systems, as well as by restrictions on some paint additives such as mildewcides and preservatives. The changes in wood-based substrates, the use of VOC-conlpliant wood finishes, the effect of pollutants on weathering, and the continued trend away from heavily pigmented paints to less-pigmented stains and clear finishes act in concert to make finished wood vulnerable to premature failure.

To meet VOC requirements, new finishes are being formulated that have high solids, reactive diluents, new types of solvents and/or cosolvents, or other non-traditional substituents. To date, no information is available on how these new finishes interact with the substrate to protect the wood or degradation mechanisms when wood is exposed to various outdoor conditions. Changes in surface characteristics (chemical, physical and biological) for both normal weathering conditions and aggressive environments with air pollution and/or acid rain must be understood.

Basic research on weathering mechanisms and modes of finish failure is essential to evaluate the effectiveness of new VOC-compliant finishes in protecting wood and wood-based substrates. Research will focus on fundamental principles necessary to determine the chemical, physical and environmental factors that affect the surface/subsurface interactions and occur on different wood species, composites, treated wood, and new modified wood products.

Liquid/wood interactions

The changing nature of wood and wood-based materials intended for exterior use presents a challenge for developing processes and formulating treatments that enhance wood-surface properties. These chemical and physical properties determine the interaction of the solid wood surface with liquids, both penetrating and film-forming finishes. This interaction is important whether the material is placed in service as is, or is subjected to further processing.

In further processing, surface properties are important because good wetting of the wood surface by the treating liquid leads to optimum performance of the finished wood product.

Finally. the surface properties of the finished wood product and the subsequent changes in these properties resulting from exposure in service need to be measured so that the processes that yield the best-performing products may be selected.

Basic studies of the interaction of liquids on the surface of solid wood or wood-based products and the relationship of these interactions will provide the key to developing compatible finishes, adhesives and other surface treatments for wood.

The solutions to these problems will be beneficial to many user groups, including those involved in the wood, wood-preservation and wood-finishing industries, research and industry associations, federal and state agencies, architects, builders, highway engineers, scientists, and the general public. The general public will be a significant beneficiary because more durable wood allows less replacement of materials and longer periods between maintenance, resulting in reduced costs. This could save millions of dollars annually in maintenance and replacement costs.

Billions of square feet of wood siding are in use today. In new construction alone, more than 1 billion square feet of plywood siding and 1 billion square feet of hardboard siding are used annually in the United States. Greater durability of these old and new wood siding products would make a sizable impact on our forest resource. In addition, there could be better and broader use of alternative wood species because they could be substituted or made into composite products.

Potential benefits of this research are difficult to estimate because the exact dollar amounts for replacement costs of wood lost due to deterioration are unknown. It has been estimated, however, that replacement costs could approach the $2 billion mark annually.

Studies

Research in these problem areas is expected to result in a better understanding of the chemical and physical aspects of the deterioration of wood and wood surfaces and the interaction of wood with other materials (coatings, fire retardants, biocides, water repellents, and others), absorbed or bonded, and the performance of preservatives in wood.

Additional information and procedures are vital to improve wood-finish performance and to modify wood and wood surfaces for greater stability and durability in harsh exterior exposure environments. The following research areas will be studied:

1. The exterior weathering performance of finished wood, including flat- and vertical-grained wood, alternate species, preservative-treated wood, modified wood, and wood-based materials for siding, millwork and other outdoor uses such as fencing, decking and roofing, using both traditional and new wood finishes. Emphasis will be on VOC-compliant coatings.

2. An understanding of the role of finish removal, surface preparation, pretreatments, and application methods in the exterior performance of refinished wood and wood composites using VOC-compliant coatings for refinishing.

3. Development of a database and assembly of fundamental information on the mechanisms of weathering of wood, modified wood and treated wood. New characterization techniques, such as electron spin resonance spectroscopy, Fourier transform IR (FTIR), x-ray photoelectron spectroscopy (XPS), and others will be investigated for these studies.

4. Development of information on the effect of substrate surface roughness on paint adhesion.

5. Determination of the effect of wood moisture content on the adhesion of VOC-compliant finishes.

6. Determination of the effect of acid rain on the weathering and performance of finished wood surfaces.

7. Determination of the effect of various fastener types on iron staining and their interactions with new VOC-compliant finishes.

8. Evaluation of the performance of VOC-compliant finishes on wood exposed under severe conditions, such as wood decks.

9. Continued development of media (technology-transfer materials) to support the transfer of knowledge in these study areas (e.g. practical publications, slide/tape and videotape shows, lecture series).

10. Development of a database on fundamental surface properties of wood and wood-based materials and their relationship with chemical structure and interaction with liquids, especially VOC-compliant coatings.

11. Determination of the quantitative significance of extrinsic factors on fundamental liquid-related properties of wood and wood-based materials, including age, temperature, UV light, previous liquid contact, and chemical modification.

12. Determination of the correlation between liquid-related fundamental surface properties of wood and the performance of VOC-compliant finishes.

13. Preparation of a wide variety of wood-based materials for these studies, including wood-polymer composites, chemically modified, surface-treated, and UV-irradiated wood.

To accomplish this research, the Wood Surface Chemistry Project at the FPL anticipates the formation of two post-doctoral positions. For one position, we will consider applicants with strong backgrounds in instrumental techniques, such as solid-state NMR, XPS and FTIR, and plasma technology. The other position requires a background in microemulsion technology. ■

on recycled paper