Forest Products Laboratory

NewsLine

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Wood and Plastic "Join Forces" To Create High-Tech Materials

By George Couch, FPL public affairs specialist

At first glance, the phrase "wood-plastic composite" suggests an unlikely marriage of dissimilar materials. "Wood" is usually regarded as natural, organic, strong, traditional, and good. "Plastic" carries the connotation of inexpensive, modern, and recyclable.

But composite materials made by mixing a plastic, such as polyethylene, with natural fibers such as wood, hemp or kenaf are proving ideal for a variety of uses. Sit in a late-model European automobile, perhaps a Mercedes Benz, BMW or Audi, and you're likely to be surrounded by composite materials made of plastic and natural biofiber from the hemp-like plant called kenaf. European—and some U.S.—car manufacturers use composite materials in door panels, headliners, seat backs, headrests, and similar components.

Deck lumber made from wood-plastic composites has recently gained consumer acceptance in the United States. Other uses include: picnic tables, park benches and other outdoor furniture, hot tubs and saunas, and industrial uses such as pallets, cable reels and industrial flooring.

Wood-plastic and other wood-based composites constitute a major research area at USDA Forest Service Forest Products Laboratory (FPL).

Composite materials of wood fiber and plastic can be engineered to meet a wide range of requirements—from cosmetic containers to tool handles.

Jerry Winandy, project leader for FPL's Performance Engineered Composites group, believes developing new and expanded uses for wood composites is vital to the Forest Service's efforts to restore forest health.

"Because wood-based composites enable us to use small pieces of wood to create large objects they represent the best opportunity to create high-value uses for the small trees and other vegetation that threaten many forests," Winandy said. "Small-diameter logs, crooked and heavily branched trees as well as species of forest vegetation that have never been used productively before can become a valued resource and help offset the cost of forest-thinning activities. They may enable us to make a silk purse out of a sow's ear."

At FPL, wood-plastic composites research focuses on the inherent characteristics of the materials and how manufacturing processes affect those

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Stop me if you've heard this...

By Gordie Blum, FPL public affairs director

Sometimes researchers are inaccurately portrayed as stuffy intellectuals wearing lab coats and pocket protectors, rarely seeing the light of day. But not the gang at the Forest Products Laboratory (FPL). This fun-loving bunch is recognized nationwide as some of the funniest people in research, and they are in high demand on the banquet circuit. Listen to some of the latest rib ticklers that are making their way around the halls and the water coolers.

FPL's composite-research team examines the engineering performance of chicken-feather and wood fiber composites in a variety of configurations. Shown here, prior to being pressed into medium density fiberboard, is a "sandwich" of chicken-feather fiber between two layers of aspen fiber.

Question: *Why did the chicken cross the road?*

Answer: Because he didn't want to end up in ¾ inch medium density fiberboard!

Wait, there's more!

Question: *Which came first...the chicken, or the highly moisture resistant ¾ inch medium density fiberboard (also known as MDF)?*

O.K., had enough?

What we actually want to tell you about is a new fiber board product being developed at FPL that shows real promise in diminishing and possibly eliminating the effects of moisture on building products. And yes, the answer is related to the string of bad jokes you read above.

Researchers at the FPL and the Agricultural Research Service in Maryland have been testing a MDF product that incorporates chicken feather fiber mixed with Aspen fiber. Why chicken feathers? Chicken feathers are naturally decay resistant (ever seen a moldy chicken?) and we have an abundance of them. Close to 4.5 billion pounds of feather waste is generated each year in the United States. Much of that is sent to a landfill. A small portion is used in animal feed. And since feathers contain keratin (which gives them their moisture resistance) some is also used in hair care components.

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Wood and Plastic "Join Forces"

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properties. Some of it is basic research aimed at increasing understanding of the properties of different wood and similar fibers (generally called biofibers) and plastics and resins.

Winandy expresses confidence in the future of composites.

"Composites are a versatile engineering material and offer a range of desirable qualities. Though each type of biofiber is different, all have a high strength-to-weight ratio. We can develop a formulation and an engineering process to meet almost any performance or production requirements," he said.

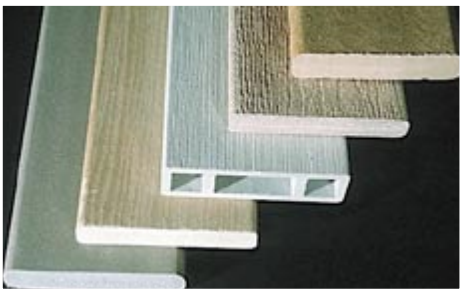
Broadly defined, wood-based composites include engineered lumber such as plywood or oriented strand board. These products are made using a thermoset resin (i.e., glue) that, once hardened, cannot be melted by reheating.

Wood-based composites made with a thermoset resin date back to the early part of the last century. A product trade named Bakelite combined wood flour with phenol-formaldehyde and had a wide variety of uses.

Interest in wood-plastic composites got a boost in the recycling movement of the 1960s, sparked in part by the growing use of plastic packaging for food and other household goods. Those plastics, such as polyethylene and polyvinyl chloride, were thermoplastics, meaning they could be repeatedly melted and reshaped. Thus it was relatively simple to melt used milk jugs, etc., and make new jugs—or something completely different.

Early thermoplastic composites also used powdered wood fiber, which lowered the cost and weight. Later, with the introduction of longer fibers, composites gained increased strength. The combination of reduced weight and cost with increased strength makes composites suitable for a variety of applications. And the thermoplastics could be easily recycled, making them attractive to car makers in Europe, where regulations require automotive components to be recyclable.

FPL's composites research leads in several directions. One major challenge affecting formulations, manufacturing processes and applications of wood-plastic composites is the need to ensure that moisture is kept away from the fiber. *(go to page 4)*



. . .and from deck and porch lumber to roofing.

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If a bio fiber gets wet, it's going to expand. One promising approach Winandy's team is studying is the use of keratin, a strong, hydrophobic protein derived from feathers, to limit the effect of moisture *(see "Stop me ..." in this issue of NewsLine).*

Winandy's group also looks for new or improved uses for composites. Once installation of a new extruder is complete, FPL will have the capacity for both lab and pilot-plant experiments using injection-molding or extrusion processes. The new extruder will be used for pilot-scale studies of products like composite house siding and roofing.

"We'd like to develop products and processes that could be adapted by small entrepreneurs near forested areas to manufacture composite products for their local markets that would consume great quantities of fiber," Winandy said. "That would help cover the cost of forest thinning while stimulating rural economies."

For Winandy, developing wood-based composites will be a long-term project. It takes time for new technologies like these to really take hold.

"In the 1920s and '30s, for example, researchers at FPL helped developed glulam beams and floor and roof trusses, which became widely used in the 1950s. During the '40s, FPL helped develop improved plywood and laminated veneer lumber, both of which became widely used in home construction in the 1960s. Meanwhile, in the '60s, researchers developed OSB, which is now the premier sheathing material," Winandy said.

FPL's new extruder permits pilot-scale production of composite products such as lumber for performance testing.

"Research into wood-plastic composites conducted in the 1980s and '90s is now showing up as decking lumber. Thus we might expect the work we're doing now to show up in standard products in 10 to 20 years or so," he said.

And, still looking for more high-value applications for wood fiber, FPL researchers have begun to look at making wood–mineral composites, combining wood fiber and materials such as cement, silicates and ceramics.

Burn Wood, Not Oil

National Fire Plan Recognizes School Heating Project

FPL's Technology Marketing Unit (TMU) and four other organizations—the Darby Public School System, the Bitterroot National Forest, the Bitter Root Resource Conservation Development Area, Inc., and Krueger and Sons, Forestry Consultants—that worked together to design and finance a wood-burning heating system for three Darby, Mont., schools were named to receive the first Innovation in Utilization of Biomass award from the National Fire Plan. The Darby project, part of a pilot program called Fuels for Schools, is intended to reduce fuel costs while finding a use for biomass from forest-restoration projects around the Bitterroot Valley. The new heating system will use some 500 tons of wood fuel per year, reducing the schools' annual fuel bill by 50 percent.

Stop me if *(continued from page 2)*

Jerry Winandy, head of FPL's composites research group, is excited about the prospect of chicken feathers. "We have only just begun exploring this. We've only made about a few dozen boards. But we believe this can significantly improve composites. I know the whole thing sounds funny, but this really has potential."

Composites such as oriented strand board and MDF are truly sustainable building products. They allow us to build highly durable buildings using material that used to be thought of as waste. Winandy says that most moisture problems are intermittent (increased bathroom humidity, watering some flowers, boiling food in the kitchen, etc.) and therefore the moisture resistant composite would only have to be placed in a few key areas in the house. And even slowing the absorption of water for a couple of hours would solve many moisture problems. An added bonus is that preliminary results indicate that the feathers increase mold resistance as well.

And the chicken, of course, came before the 3/4 in. MDF.

Questions?

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ASK FPL

In attempting to identify possible uses for a new material or technology, consumers and manufacturers sometimes try to use it in unsuitable applications or environments. If the product fails to perform up to expectations, the new material can get a bad reputation even though it was put to a use never intended by its developer. FPL's researchers urge users to learn as much as possible about a material before using it in an unproven way.

Can I use wood-plastic composite deck boards to repair my lakefront pier?

You should be able to use wood-plastic composite deck boards for a pier, but there are some things to watch out for. If the boards were sold as deck boards, they probably were formulated with chemical ingredients to resist damage from sunlight. Some thermoplastics are significantly degraded by the ultraviolet (UV) radiation in sunlight, but deck board manufacturers normally add UV-blocking chemicals and colorants to the composite to reduce or eliminate the effects of sunlight. (In fact, FPL research shows that some colorants and UV blockers can actually strengthen the composite material.) The board's labeling should indicate whether or not it is suitable for prolonged exposure to direct sunlight.

The other main concern with using wood-plastic lumber on pier is water. Wood fibers love water. And when they absorb just a little bit, they want to expand. Repeated cycles of damp and dry, expansion and contraction, can lead to deterioration of the boards. We'd strongly advise against using a wood-plastic composite board in any part of the pier that is immersed in water. You might want to consider some kind of sealant, especially on the sawn ends of the boards and around screw heads or any drilled holes. The recommended sealant would depend on the type of plastic used in manufacturing the boards. If directions for sealing don't come with the boards, contact the manufacturer.

You might be interested to note that the U.S. Navy and U.S. Coast Guard are conducting tests of wood-plastic composite materials in waterfront structures, including piers.

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New Electron Microscope Provides Researchers with Super Eye

FPL's new electron microscope can reveal three-dimensional surface texture of biological specimens without the distortion caused by sample-preparation measures required by older instruments.

FPL scientists are able to get a more accurate, three-dimensional look into the microscopic cellular world of wood fiber, leaves, and fungi thanks to a new electron microscope.

FPL's new Environmental Scanning Electron Microscope (ESEM) allows examination of objects at a low vacuum—or "high" pressure—permitting specimens to be examined without being dried out or coated with gold or some other metallic conductor. This makes it possible to obtain more accurate and detailed images, particularly of shape and surface texture of biological specimens.

Older scanning electron microscopes require samples to be in a vacuum, necessitating that they be dehydrated and coated with metal to dissipate the electrical charge. With the ESEM, enough gas remains in the sample chamber to dissipate the electrons.

The ESEM's magnification power is about 50 times greater than the best optical microscopes and permits imaging of details as small as 4 billionths of a meter—or about one 40-thousandth the thickness of a human hair.

The ESEM's images are created and stored digitally, allowing for quantitative analysis and for immediate viewing and transmission to any computer connected to the Internet.

This capability will be especially valuable as we provide microscopy services for other Forest Service research units, said Jim Beecher, supervisory chemist of FPL's Analytical Chemistry and Microscopy Laboratory.