Wood–Plastic Composites

To convert low-value wood resources into high-value products, researchers at the Forest Products Laboratory (FPL) are combining wood fiber with thermoplastic resin, resulting in wood–plastic composites (WPCs). To optimize composite performance, researchers are exploring material options, investigating processing effects, and improving engineering performance and durability.

Thermoplastic resins, such as polypropylene, polyethylene, polystyrene, and polyvinyl chloride, soften when heated and harden when cooled. This property allows other materials, such as wood, to be mixed with the plastic to form a composite product. The resulting WPCs can be easily processed into various shapes and can be recycled.

WPCs are typically made using 30% to 60% wood filler or reinforcements. Most composites research at FPL has used wood flour as a filler in plastics. Wood flour is made commercially by grinding postindustrial material, such as planer shavings, chips, and sawdust, into a fine, flour-like consistency. Wood fiber, although more difficult to process than wood flour, can lead to superior composite properties and act more as a reinforcement than as a filler. Wood fiber is available from both virgin and recycled sources. Recycled sources include pallets, demolition lumber, and old newsprint. Wood from small-diameter trees and underutilized species can also be used.

Additives are also often used in WPCs. Additives are materials that are added in small amounts to enhance properties. For example, lubricants improve surface appearance and processing; coupling agents improve adhesion between the wood and plastic components. Other possible additives include colorants, light stabilizers, foaming agents, and thermosetting resins.

The first step in producing a WPC is to determine what raw materials, and in what amounts, will produce a WPC that meets the processing and performance requirements. Manufacturing melt-blended composites is usually a two-step process consisting of compounding and forming. In the compounding step, wood flour or wood fiber and additives are combined with molten thermoplastic to produce a homogeneous composite material. Three common forming methods for WPCs are extrusion (forcing molten composite through a die), injection molding (forcing molten composite into a cold mold), and compression molding (pressing molten composite between mold halves).

Clockwise from top left: virgin polyethylene pellets, wood flour, and wood–plastic composite pellets.

Several factors influence processing WPCs. Moisture can disrupt many thermoplastic processes, resulting in poor surface quality and voids. The wood material must be predried or vented equipment used. Also, melt temperatures should be kept below 200°C (392°F) because prolonged exposure to high temperatures can result in release of volatiles, discoloration, odor, and degradation of the wood component.

Mechanical and physical properties, such as strength, stiffness, impact resistance, density, and color, are important considerations in many WPC applications. Different applications take advantage of properties that WPCs offer. For example, automotive applications take advantage of a lower specific gravity, compared with inorganic filled thermoplastics. Household products, such as paintbrush handles, scissor handles, and flowerpots, take advantage of the aesthetics, resulting in a product that can look like wood but can be processed like a plastic. Non- or semi-structural building applications, such as decking, roof tiles, and window trim, also take advantage of the wood look and offer improved thermal and creep performance compared with unfilled plastics.

To better understand and influence how WPCs behave, FPL researchers are examining underlying attributes, such as microstructure, formulation (appropriate wood, plastic, and additive types and quantities), and surface chemistry,

Forest Products Laboratory • Performance Engineered Composites
One Gifford Pinchot Dr. • Madison, WI 53726–2398 • 608–231–9200 • 608–231–9592 (fax)
mailroom_forest_products_laboratory@fs.fed.us • www.fpl.fs.fed.us
COM–1
Issued 01/04

that affect composite performance. Because many WPCs must perform well in adverse environments, researchers are also investigating durability issues, such as resistance to moisture, ultraviolet light, decay, fire, and creep, that impact service life.

References

Clemons, Craig. 2002. Wood-plastic composites in the United States: the interfacing of two industries. Forest Prod. J. 52(6): 10–18.

English, Brent; Clemons, Craig M.; Stark, Nicole; Schneider, James P. 1996. Waste-wood-derived fillers for plastics. Gen. Tech. Rep. FPL–GTR–91. Madison. WI: U.S. Department of Agriculture, Forest Service, Forest Products Laboratory. 15 p.

Stark, Nicole M.; Rowlands, Robert E. 2003. Effects of wood fiber characteristics on the mechanical properties of polypropylene composites. Wood Fiber Sci. 35(2): 167–174.

Clemons, Craig M.; Ibach, Rebecca E. 2002. Laboratory tests on fungal resistance of wood filled polyethylene composites. *In:* ANTEC 2002. Vol. 2–Materials. Annual technical conference; 2002 May 5–9; San Francisco, CA. Brookfield, CT: Society of Plastics Engineers: 2219–2222.

Stark, Nicole M.; Matuana, Laurent M. 2003. Ultraviolet weathering of photostabilized wood-flour-filled high-density polyethylene composites. J. of Applied Polymer Sci. 901(1): 2609–2617.

Stark, Nicole. 2001. Influence of moisture absorption on mechanical properties of woodflour-polypropylene composites. J. of Thermoplastic Composites 14(5): 421–432.

Additional Information

Visit the Performance-Engineered Composites website (http://www.fpl.fs.fed.us/PDComp) for more information.