A natural, renewable feedstock for industry.

Soy-Based Composites Technical Research

Background

Soy-based binders have been used in the manufacturing of common composites, such as plywood, for over 70 years. While soy binders are still used in some specific applications, the introduction of urea-formaldehyde (UF) and phenol-formaldehyde (PF) resins in the late 1930s provided greater water resistance and lower costs than the older soy products. Environmental concerns and the need for binders made from a renewable feedstock have caused a resurgence of interest in developing new soy-based products for the composites industry.

Current Research

Current research funded by the United Soybean Board (USB) is focused on developing soy binder products intended for the larger wood composite market, but may have applications for the alternative agricultural composites. The emphasis of research is in four areas:

1) an improved water-resistant product to replace UF
2) an improved waterproof product to replace PF
3) a soy flour/formaldehyde-free resin for improved economics and worker and consumer safety
4) a phenol-resorcinol-formaldehyde (PRF) soy adhesive system for finger-jointing

Wood Composites

Particleboard and medium-density fiberboard (MDF). The replacement adhesive is modified soy protein or a mixture of hydrolyzed soy protein and PF resins. This is expected to produce a product with reduced formaldehyde emissions, improved water resistance and a longer life span at an equivalent cost.

Oriented strand board (OSB). PF and isocyanates are primary adhesives. Hydrolyzed soy protein co-reacted with PF resins is expected to provide reduced costs, a faster cure rate and reduced emissions. Replacement of a portion of the phenol in the PF resin with soy flour reduces the cost of the resin and reduces reliance on petroleum as a raw material.

Plywood. PF is the principal adhesive used to bind thin wood veneers together or over such products as MDF. USB-sponsored research has developed technology replacing blood meal with soy protein in making foamed glue for plywood production. The product was commercialized in late 2001.

Formaldehyde-Free Adhesives. The use of formaldehyde in resins for wood composite panels has been under attack by environmentalists for years. UF resins degrade over time to liberate small amounts of formaldehyde. PF resins used in OSB production are more stable and do not degrade. However, the presence of formaldehyde in the uncured resin during manufacturing in the plant presents an OSHA hazard. A formaldehyde-free adhesive for manufacturing hardwood plywood based mainly on soy flour is being used commercially, and research is being sponsored by USB to develop a similar resin for use in OSB.

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Alternative Ag Composites

Four types of products have been investigated. The development of soy binders for use in wood composites may apply to these markets and vice versa.

Cellulosic panels. Similar to wood particleboard, these are made from cereal straw, various agricultural byproducts or recycled newspapers. Traditional binders, such as MDI or UF resins in other uses, may be replaced by soy technology coming from wood composite research.

Cementitious/cellulosic building shapes. These may contain Portland cement or fly ash, along with straw or cellulose from other byproduct sources. Binders include inexpensive adhesives such as PVAc.

Cellulosic/foam composites. Two U.S. companies are active in production of automotive headliners and other auto parts based on natural fibers. These may be sandwiched between polyurethane foam layers or polyurethane reinforced with natural fibers.

Extruded composites. Prime or recycled plastics are combined with straw, sawdust or other cellulosic sources, and a binder. These are extruded to make specialty-building shapes, such as window and door parts. The cellulosic component is up to 70 percent, and binders include PF and MDI.

Soy Hydrolyzate Adhesives

Soy hydrolyzate is a colorless, aqueous solution made by reacting soy protein isolate in a 5 percent sodium hydroxide solution under heat (120°C) and pressure (30 psig). The resulting degraded soy protein solution is basic (pH 11) and flowable (approximately 500 cps) at room temperature. In late 1996, mill trials were run using soy hydrolyzate as half of a two-part adhesive system with PRF. The reaction, which begins immediately without the introduction of outside energy, resulted in a millable bond in less than three minutes. The resulting rigid bond develops high tensile strength (estimated at 3,500-5,000 psi) and passes both the six-cycle boil test and the pressure-vacuum soak test for waterproofness.

Soy Flour Adhesives

Soy flour is a finely ground, defatted meal made from soybeans. Various adhesive formulations can be made from soy flour, with the first step usually requiring dissolving the flour in a sodium hydroxide solution. The strength and other properties of the resulting formulation will vary depending on the additives in the formulation. Promising research is under way that combines a basic soy flour adhesive with other commercially available resins, including UF, PF and MDI. Resulting mixtures have been used as binders for OSB, particleboard, MDF and plywood.

The United Soybean Board is made up of 64 farmer-directors who oversee the investments of the soybean checkoff on behalf of all U.S. soybean farmers. Checkoff funds are invested in the areas of animal utilization, human utilization, industrial utilization, industry relations, market access and supply. As stipulated in the Soybean Promotion, Research and Customer Information Act, USDA's Agricultural Marketing Service has oversight responsibilities for USB and the soybean checkoff.