Market Opportunity Summary

Soy-Based Building Composites

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Composites Containing Soy

A useful definition for a composite is two or more materials brought together to make a new product "better" than the individual components. Better may mean improved properties or performance or, in some cases, improved economics. Two areas remain a focus for the United Soybean Board (USB): traditional wood composites, such as plywood, oriented strand board and particleboard, and alternative agricultural composites composed of agricultural byproducts, recycled materials and binders.

Current research is focused on developing soy binder products that are intended for the larger wood composite market but may have application for the alternative ag composites. The research covers four areas:

1) An improved water-resistant product to replace urea-formaldehyde (UF)
2) An improved waterproof product to replace phenol-formaldehyde (PF)
3) The partial replacement of phenol with soy flour in PF resins for improved economics
4) A soy-based phenol-resorcinol-formaldehyde (PRF) adhesive system for finger-jointing

Wood Composites

An estimated 230 North American mills annually produce approximately 40 billion square feet of combined particleboard, medium-density fiberboard (MDF), plywood and oriented strand board (OSB).

Particleboard and MDF are composed of low-value wood byproducts such as sawdust bound with UF resins. The replacement adhesive is a modified soy protein or a mixture of hydrolyzed soy protein and UF resins. This is expected to produce a product with reduced formaldehyde emissions, improved water resistance and a longer life span.

OSB is made of layered wood strands oriented at right angles to develop maximum strength and stability. OSB competes with plywood and has seen significant growth due to a lower price and competitive performance in many uses. PF and isocyanates are primary adhesives. Hydrolyzed soy proteins added to PF resins provide reduced costs, a faster cure rate and expected reduced emissions. As an alternative, a soy-based formaldehyde-free resin is being developed for use in plywood and OSB.

Plywood is the largest of the panel products but has experienced market share decline since the introduction of OSB. PF is the principal adhesive used to bind thin wood veneers together or on top of such products as MDF.

In late 2001, USB-sponsored research led to the commercialization of a product using soy protein to replace blood meal in making foaming glues for plywood production. Foamed glues expand adhesive volume to realize equal bond performance with a 20 percent to 30 percent reduction in adhesive use.

Replacement of traditional adhesives in these markets has a long-term potential to utilize tremendous quantities of soybeans:

Soybean Potential in the Year 2000

Market Segment	Million Bushels
Particleboard	30-60*
Medium-density fiberboard	15-25*
Plywood	15
Oriented strand board	15
Total Soy Bushels	**75–115***

*The range is based on 50 percent or 100 percent substitution of UF in these markets.

Alternative Ag Composites

For the purpose of this summary, alternative ag composites are products in which the wood component has been replaced with a nonwood cellulose source (straw, bagasse, hemp) or recycled materials (newspaper, plastics). Other filler material such as Portland cement or fly ash may be added.

Use of soy straw as a component in composite materials has been researched by some companies. The use is controversial, although it would undoubtedly open a new source of revenue to soybean farmers. The value of straw left on the field as a mulch for conserving soil and moisture, as well as the nutrients straw adds to the soil, may outweigh the economic value of its sale.

Four types of products have been investigated:

Cellulosic panels – similar to wood particleboard, the panels are made from cereal straw, various agricultural byproducts or recycled newspapers. In some systems, binder use is limited or eliminated.

Traditional binders, such as MDI or UF resins, may be replaced by soy technology coming from wood composite research.
One product, Environ from Phenix Biocomposites, already uses soy flour and a proprietary soy adhesive to make decorative panels.

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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. With the appearance of cement blocks, these products can typically be processed like wood.

Cellulosic/foam composites – two U.S. companies are actively producing molded automotive parts out of fiber mat. 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 source and a binder. These are extruded to make specialty building shapes such as window and door parts. The cellulosic component is as much as 70 percent, and binders include PF and MDI.

At current production levels for alternative composites, the substitution of soy products for current resins and binders would consume only 2 million bushels annually. Growth is expected, however, since the availability of wood for making wood composites is limited in many areas. The use of alternative composites will continue to be fragmented by the location of small plants near locally available materials. Niche uses, such as decorative materials, should continue to grow. The development of soy binders for use in wood composites may apply to these markets, and vice versa.

State of the Art

Most USB-sponsored research has concentrated on the use of hydrolyzed soy protein (soy hydrolyzate), used either as a direct substitute or in a mixture with PF and UF. Soy hydrolyzate is made from soy isolate at a yield of 12 pounds/bushel of soybeans.

Other research has investigated the use of a lower-cost soy flour at a yield of 39 pounds/bushel of soybeans. This product, in combination with MDI, has been successfully used to make OSB in early trials.

A two-part system of soy hydrolyzate and PRF adhesive has been commercialized. The PRF/Soy 2000 adhesive system is a hydrolyzate-based, finger-joint adhesive intended for uses requiring either a nonstructural or structural, wet-use, exterior-exposure end joint. The adhesive was developed with funding provided by USB and specifically allows green lumber to be finger-jointed.

Typical adhesives in use today can only bond wood that is dry. PRF/Soy 2000 is a honeymoon system (different adhesive components are applied to each end of the finger joint – the PRF adhesive to one end and the soy-based resin adhesive to the other end). The final adhesive is formed as the two opposing sides of the finger joint are mated, causing a mixing reaction at the interface. PRF/Soy 2000 is in commercial use today for the manufacture of finger-jointed studs.

PRF/Soy 2000 is accepted by the Western Wood Products Association (WWPA) as an exterior-type adhesive meeting the requirements of ASTM D2559, or equivalent. The adhesive is suitable for the bonding of wood, including finger-jointed lumber of all structural grades.

Relative Economics/Supplies

Phenol and urea wood adhesive pricing and availability are both subject to the vagaries of the petrochemical industry. Phenol demand is driven by bisphenol A (used for polycarbonate plastics) and caprolactum (for nylon 6 used in carpeting). Phenol capacity is expected to become very tight as demand in these areas grows.

UF is derived from natural gas, with only about 5 percent of capacity going into adhesives. Agricultural uses for fertilizer and feed additives utilize more than 90 percent of U.S. urea capacity. Urea prices fluctuate significantly with agricultural demand, and supplies are seasonally tight.

Formaldehyde pricing is dependent on methanol supply and demand. Methanol prices were relatively stable for a number of years before spiking in 1994. The United States is a net methanol importer. Soy adhesives, in contrast, are based on a renewable resource. Soy prices fluctuate with world supplies of feed grains and oilseeds. The United States is the world's leading producer and exporter of soy, with annual production of about 3 billion bushels.

Advantages and the Path Forward

New soy adhesives promise both improved performance and economics to the wood products and ag composites industries. They also are expected to be safer to handle and to reduce volatile organic compound emissions.

To assist in the commercialization of these products, USB is supporting research and testing to ensure these products meet relevant industry standards. Working with industry partners, USB will help develop standard industry practices, an infrastructure to supply the products and acceptance of the resulting end products at all levels.

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.

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