

# Soy-Based Thermoset Plastics

## The Product

Building materials, can be end uses for either soy-based polyurethane and polyester thermoset plastics or both. Examples are components of foam insulation and molded mill work; parts for cars, trucks, trains, planes, tractors, tractor trailers and recreational vehicles; furniture, mattresses, carpet pads and carpet binders; insulation for coolers, water heaters and vending machines; packaging and pallets; materials for ships, boats and flotation devices; industrial insulation and sealing; shoe and boot soles.

## Market Size and Value: Polyurethanes

Of all the industrial markets for soy polyol, urethane foams, binders, coatings, adhesives and sealants hold the greatest potential. Annual North American product demand for polyols represents 3.4 billion pounds, with a conservative estimate for soy-oil-based polyols of about 600+ million pounds, or 55 million bushels of soybeans. Specifically, priority markets for soy-based polyurethane are listed in the table below (in millions of pounds of product):

	Polyol Market (mil. lb.)	Possible total soy polyol (mil. lb.)
Foam	2,380	500
Binders & CAS*	595	100
Other:	425	20
<b>Total</b>	<b>3400</b>	<b>620</b>

\*Coatings, Adhesives, Sealants

The North American market represents only a third of the global market for polyurethanes, and the ultimate potential for soy utilization could be tripled from the 650-million-plus-pound level.

## Market Segments

There are six market segments for polyurethane that can be classified as priorities for soy-based products. They include:

- 1) Construction** - Residential and nonresidential buildings insulation, refrigerated buildings, walk-in cooler insulation, molded millwork, laminated insulation board stock, insulated doors and metal panels.
- 2) Transportation** - Automotive vehicle and farm equipment component cushioning.
- 3) Carpet** - Flexible foam underlayment and fiber binder coatings.
- 4) Furniture and Bedding** - Flexible foam cushioning applications.
- 5) Coating, Adhesives, Sealants** - Window seals, industrial adhesives and protective coatings.

## 6) Binders - Rubber and wood products.

Penetration of the six priority polyol end use market segments is estimated to be (in millions of pounds of polyol products):

Segment	Market size ('06 E) (mil. lb.)	Soy polyol Potential ('13 E) (mil. lb.)
Construction:	720	150
Transportation:	880	110
Carpet:	320	80
Furniture, Bedding:	635	100
Other*	845	180
<b>Total</b>	<b>3400</b>	<b>620</b>

\*Other: footwear, marine, packaging, foundry, machinery, and industrial, misc.

## The Construction Market: Rigid Foam

The construction market segment can be divided into several different submarkets, as named above. Rigid foam normally has two functions: insulation (mainly in the appliance, residential and industrial applications) and structural integrity. The foam is made from low-cost, highly functional polyols and isocyanates with many additives to adjust the formulation for specific end-use properties. Soy-oil polyols could compete as a reactive component in quantities of up to 50 percent of the polyol portion of the formulation.

## The Automotive Market: Flexible Foam

Much like the construction industry, the automotive market utilizes both rigid and flexible foams. Soy-based, flexible polyurethane foams are being used in Ford Mustangs, F-150's and Expeditions. Also, Toyota is using similar technology in Corollas and the Lexus RX.

## Relative Economics

To have a driving force for market entry, soy materials must lower the cost of polyurethane foam products. Today soy polyols are priced competitively with petroleum-based polyols.

## Replacement Potential

Because manufacturers typically try to optimize the cost performance of their product, any raw material that can lower the cost of a formulation without affecting properties or processing conditions will readily be accepted. Urethane Soy Systems Company, Inc., of Volga, South Dakota; BioBased Technologies Inc., of Rogers Arkansas; Cargill of Wayzata, Minn., Dow Chemical of Midland, Mich, and Arkema of Bloomington, Minn., have each developed a series of soy-based polyols that are being commercially utilized in polyurethane formulations in the transportation, furnishing and construction industries.

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## Market Size and Value: Plastic Composites

The use of fiber-reinforced composites is estimated to be 4.4 billion pounds by the end of 2008. Unsaturated polyester resin (33%), epoxy resin (5%), and polyurethane (2%) account for the majority of the resins. Reinforcements (50%) and fillers (10%) account for the rest. Another 0.5 billion pounds of unsaturated polyester resins are used in color sensitive applications with no reinforcement, but highly mineral filled for marble or granite appearing countertops or sinks.

The total amount of resin in reinforced thermoset composites is 1.7 billion pounds. Assuming the total replacement of the portion of the thermoset resin that could be replaced with soy based ingredients; the total amount would be 1.1 billion pounds (in 2008) which would represent soy oil from 100 million bushels of soybeans. The thermoset composites market is forecast to grow at 2 percent annually over the next five years. Major markets for thermoset composites are transportation, construction and marine, representing 70 percent of the total consumption.

**Initial Market Entry And Future Outlook** - A collaborative effort has led to a commercial introduction of soy-derived composite products. Collaborators are Ashland Performance Materials (resin), Continental Structural Plastics (sheet molding compound), Ashley Industrial Molding (molded parts), Deere & Company (buyer) and the United Soybean Board. The result is a series of molded parts for the Model 9750 John Deere Harvester™ combine, introduced in August 2003. Deere & Company have further specified soy-derived composite products made from SMC in most of their SMC parts including tractor hoods. Some soy based composites are also found on Case New Holland equipment.

The basic process consists of a soy-based polyester resin that is converted into sheet molding compound (SMC) using industry accepted techniques and meeting Deere & Company specifications. More than 285 pounds of soy composite are installed on each combine. The composite material contains the equivalent of 2 bushels of soybeans

Ashland and its collaborators are working to expand the product offerings into other markets, including construction and transportation. Higher productivity through alternate processes, such as vacuum bag, resin transfer molding and pultrusion, is being examined through potential industrial partners.

Meanwhile, basic product research continues on soy-oil-based resins to improve adaptability to key manufacturing processes that are efficient and economical. Interfacing with other composite raw material suppliers is important so that optimal cure conditions and mechanical properties in the final resins are obtained.

Increasing interest in LEED (Leadership in Energy and Environmental Design) in the construction industry gives the opportunity for soy-derived resins from renewable resources to be used in construction applications. The interest in using renewable resources also enhances the potential for soy-based unsaturated polyester resins in other market areas such as transportation. Polyurethane composites fabricated by the pultrusion process are also being evaluated in the construction industry.

Solvay and Dow Chemical have both announced making epichlorohydrin for thermoset epoxy from glycerin, and Ashland, Inc. and Cargill have announced a joint venture for making propylene glycol used in thermoset unsaturated polyester resin. Most of these announcements are for overseas plants. Glycerin is of interest as a low cost ingredient from biodiesel manufacture.

## Issues Affecting Commercial Success

Soy oil containing unsaturated polyester resins is being produced by one major chemical company. Other chemical companies have reported developing these soy containing resins but no commercial activity by others has been announced. Improved reactivity of the resin system containing soy oil is a sought-after property.

Soy based thermoset composites continue to slowly gain market penetration. Interest in renewable resources drive the interest, but cost parity is a must. Aggressive marketing of the benefits of these resins helps to drive the market penetration.

Another route to producing thermoset unsaturated polyester and epoxy resins from soy oil is from glycerin which is a byproduct of the biodiesel manufacturing process. The amount of biodiesel produced in the United States will dictate the supply of glycerin and new found uses will determine its value. The conversion of glycerin for materials to be used in thermoset composites will be driven by the economics of glycerin feedstock and the technology to find economical conversion processes. Other routes of producing feedstock for thermoset resins from soy meal are being investigated.

USB is made up of 68 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 Consumer Information Act, USDA's Agricultural Marketing Service has oversight responsibilities for USB and the soybean checkoff.

