APPLICATIONS AND MARKETS FOR RENEWABLE RESOURCE BASED SHEET MOLDING COMPOUND

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Abstract

Unsaturated polyester resins based on renewable resource raw materials (soy and corn) have been commercially available since the late 1990s. These resins have successfully been formulated into sheet molding compound and are compression molded into parts used by the John Deere Corporation to manufacture farm machinery. This paper will discuss the economics and environmental effects of using renewable resource based composites, describe the current applications where the technology is being used, and consider the future of bio based technology in the composites industry.

Background

Interest in natural products for the automotive industry goes back to the 1920s when Henry Ford dreamed that he would be able to make every part of the automobile, except the chassis and engine, from the soybean. Work on this project was delayed due to World War II and was not restarted after his death in 1947. World War II in fact changed the course of natural products by focusing on synthetic materials such as rubber due to unstable natural rubber supplies. At this time composites were introduced as a material of construction for radar domes and aircraft fuel tank protection.

Not until the late 1990's was an interest in a biobased unsaturated polyester resin seen. In 1999 discussions with John Deere[1] on a soy based resin were initiated. John Deere's focus was to show support for the farmer customer by supplying a product that had the customer's product as part of the construction. Based on new technology, an unsaturated polyester resin marketed by Ashland Inc.[2] as Envirez® 1807 resin and a corresponding SMC formulation was developed. The polyester resin contains 25% biobased materials comprised of both soybean oil and ethanol.

Application Technology

The liquid unsaturated polyester resin is supplied to Continental Structural Plastics[3] where it is compounded into sheet molding compound and supplied to Ashley Industrial Molding, Inc.[4] where the compound is molded into tractor parts painted and supplied to John Deere. The tractor parts are hood enclosure panels, side panels etc. The SMC has a biobased content of 18% per ASTM D6866-05. This SMC is known as BD 842R. CSP makes about 5million lbs/year. The typical physical properties are shown in Table I.

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[1] Deere & Company, One John Deere Place, Moline, Illinois 61265 www.deere.com
[2] Ashland Incorporated, Performance Materials, 5200 Blazer Parkway, Dublin, OH 43017 www.ashland.com
[3] Continental Structural Plastics, 755 West Big Beaver Road, Suite 700, Troy, MI 48084 www.cspplastics.com
[4] Ashley Industrial Molding, Inc., 320 South Wabash, Ashley, IN 46705 www.ashinmold.com

Table I: Physical Properties of the Bio Based SMC BD 842R

Property	ASTM Test Method	Typical Molded Specification	Metric Equivalent
Specific Gravity	D-792-98	1.86 - 1.94	1.86 - 1.94
Water Absorption (24 Hours @ 23°C)	D-570-98	<0.35%	<0.35%
Heat Distortion Temp. °F, 264 PSI	D-648-98	>450°F	>235°C
Barcol Hardness	-	45 – 60	45 - 60
Impact Strength (Izod Ft. Lbs./In. Notched)	D-256-97	12 – 20	640 – 1065 J/m
Flexural Strength, PSI	D-790-98	25,000 – 31,000	170 – 215 MPa
Flexural Modulus (PSI x 10^6)	D-790-98	1.30 – 1.90	8.90 – 13.0 GPa
Tensile Strength, PSI	D-638-98	10,000 – 13,000	68 – 90 MPa
Mold Shrinkage (Cold Piece from Cold Mold, In./In.)	--	-0.0004	-0.0004 cm/cm
Coefficient of Expansion (75°F - 300°F)	D-696-98	7.0E-6 in./in./°F	12.5 E-6 cm/cm/°C
Glass Content	-	25 – 30%	25 – 30%

This compound meets Deere material specifications JDM H22 UP-(GF 28+M44), JDH612, and JDMF11. The compound provides a Class A surface with good paint and bond adhesion properties. Figures 1, 2, and 3 show a variety of parts molded from the SMC for the John Deere applications.

Figure 1: Hornet Hood (Deere)

Figure 2: Different Hoods for Deere Tractors

Figure 3: Combine for Deere

Biobased Market Dynamics

Many factors have currently forced the market acceptance of renewable resource based resins for composite applications. Included, but not limited to, is a better understanding of molecular biology and genetics resulting in the possibility of tailoring natural products with desirable characteristics. The launching of the environmental movement has brought public attention to issues such as carbon footprint and dependency on foreign oil. This has forced industry to include environmental thinking as a business strategy.

Figure 4 shows the increase in the price of petroleum based chemicals over the last 10 years. A two fold increase in price has been seen in just the last three years. With these increases in petroleum based chemical prices, biobased feedstocks have become economically attractive.

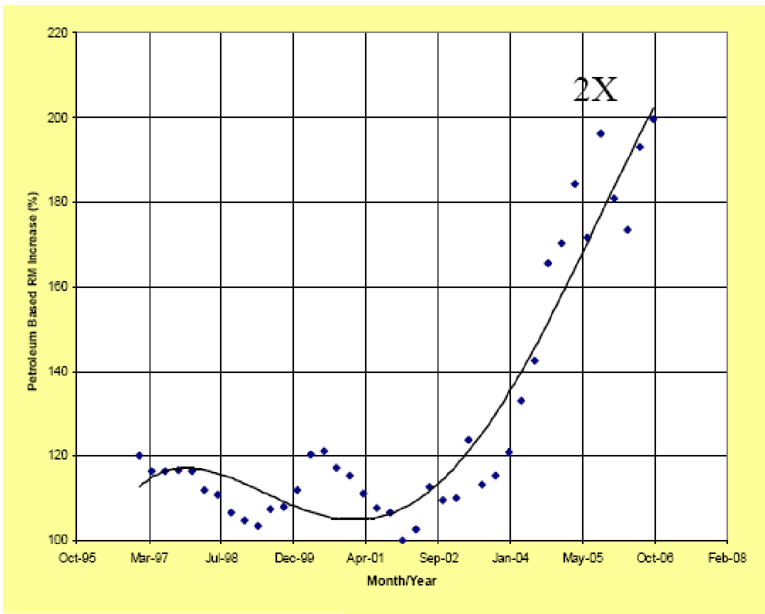

Figure 4. Petroleum Based Chemical Price Increases

Figure 5 shows the bulk price and cents per pound of crude oil, soybeans, and corn. While soybean and corn feedstock prices are lower than crude oil there still remain issues around conversion costs, supply and demand, and the technology to convert the natural materials to usable chemicals.

Feedstock	Cost	Cents/lb
Crude Oil	**$66.36 /barrel**	**23.1**
Soybeans	**$7.38 /bushel**	**12.3**
Corn	**$3.74 /bushel**	**6.7**

Figure 5. Feedstock Prices

As petroleum becomes more expensive, biomass is being used as a key raw material for the chemical industry. Currently 8% of the products generated by the chemical industry are derived from biomass. This amount is projected to grow to 20% by 2015-2020. At that time bioproducts are projected to be a $300B part of the chemical industry. These growths are accelerated by advancements in biocatalysts, computer modeling, and new developments in genomics.

Biobased products also save energy as compared to petroleum based products. One calculation shows that one batch (38,000 lbs) of Envirez® 1807 resin saves 10 barrels of crude oil as compared to a batch of standard PG maleate resin. This savings is based on the net energy consumed in manufacturing as well as farming and processing soy and corn into oil and ethanol respectively. The same 38,000 lb batch of Envirez® 1807 resin is also estimated to remove 34,000 lbs of carbon dioxide from the atmosphere. For each pound of soy oil produced, 2.67 pounds of carbon dioxide are removed from the air and for each pound of ethanol produced, 1.5 – 2.0 pounds of carbon dioxide are removed.

Future of Biobased Thermoset Composites

The future of biobased unsaturated polyester resins as used in thermoset composite applications appears to be one of growth. Case studies such as John Deere show that biobased thermoset composites can perform equal to petroleum based composites in specific applications. Work to broaden the application base and improve performance is being conducted throughout the industry. Continued interest in alternatives to petroleum based feedstock drive the industry to find materials that are biobased. Technology is evolving to bring biobased content of composites even higher to meet the demands of the market. Currently laws exist that provide incentives to use biobased materials. The Farm Security and Rural Investment Act of 2002 provide that federal agencies must give purchasing preference to biobased products designated by this program. Finally businesses are finding that making renewable resources a part of their strategic plans are appealing to the market and may provide a competitive advantage. Partnerships and cooperation throughout the entire value chain will benefit all involved.