Meadowfoam Oil and Polyols Expand Vegetable Oil Markets

Meadowfoam, a new oilseed crop grown in Oregon, contains a unique oil that is used in cosmetics and has potential in other applications. Recent plant breeding, agronomic research, and oil-product development are bringing meadowfoam closer to commercial viability. Polyols, which are traditionally derived from petrochemicals, are now being made from vegetable oils.

Meadowfoam Is Commercially Produced in Oregon

Meadowfoam is a low-growing winter annual native to the Pacific Northwest. Seeds collected from wild stands were tested in the late 1950's as part of a USDA-initiated search for plants that could provide industrial raw materials. Research in the early 1960's indicated that the Willamette Valley of Oregon would be a good area for meadowfoam production. In 1967, Oregon State University initiated a crop improvement and agricultural production program for meadowfoam. This program was expanded in 1980 as a result of funding from the Oregon grass-seed industry, which was searching for alternative crops for the poorly drained soils of the Willamette Valley and a way to lessen the pollution resulting from the field burning required after harvesting grass seed. Legislation adopted in 1991 reduces the acreage that may be open-burned from 250,000 to 65,000 in 1998.

Meadowfoam is an oilseed crop planted in the fall and harvested in early summer. Equipment and cultural practices are similar to those used for winter grain and seed crops. Meadowfoam requires insect pollination; honey bees have been the primary pollinator used by farmers and researchers. At maturity, plants are 10 to 18 inches tall. Commercial production began in 1984 with 600 acres planted by the 24 members of the Oregon Meadowfoam Growers Association. Since then, acreage has fluctuated from 0 to 1,000. This fall, 2,200 acres were planted. Yields have varied dramatically, from 600 to 1,300 pounds per acre. The major factors involved in yield variation have not all been identified, but differing levels of insect pollination appears to be part of the cause.

The small seeds average about 30 percent oil. Meadowfoam oil consists primarily of long-chain fatty acids. More than 95 percent are 20 carbons or longer, which is unique among commercial vegetable oils (table 2). Most of the fatty acids also contain one or two double bonds, which are referred to as monounsaturated or polyunsaturated, respectively. This composition imparts considerable oxidative stability, which is required in cosmetics and is potentially useful in lubricants. Another special feature of meadowfoam's dominant fatty acids is the location of the double bond at the unusual delta-5 position. This allows chemists to make products that cannot be derived from other vegetable oils.

The first commercial sale of meadowfoam oil was made in 1985 to a Japanese firm for use in cosmetics, and the Japanese cosmetic industry remains the major purchaser. In 1993, the Oregon Meadowfoam Growers Association signed a contract with Chicago-based Fanning Corporation, which sells lanolin and other products to the cosmetic and pharmaceutical industries, to market the oil. Skin-care products are currently the oil's primary use.

To explore additional uses, a number of meadowfoam oil derivatives have been made in the laboratory by scientists at USDA's National Center for Agricultural Utilization Research (NCAUR). For example, meadowfoam oils has been vulcanized (reacted with sulfur or sulfur mono-

Table 2--Typical compositions of meadowfoam, rapeseed, crambe, and soybean oils

Fatty acid name and formula 1/	Meadowfoam oil	Rapeseed oil	Crambe oil	Soybean oil
		Percent		
Less than C18	0.5	2.5	2.3	10
Stearic (18:0)	--	1	1	4
Oleic (18:1)	1.4	14.5	16	22
Linoleic (18:2)	0.5	15.2	9	54
Linolenic (18:3)	--	10	6	7.2
Eicosanoic (20:0)	0.5	0.6	1	--
cis-5-eicosenoic (5-20:1)	64	--	--	--
cis-11-eicosenoic (11-20:1)	0.2	9.5	3.5	--
cis-5-docosenoic (5-22:1)	3	--	--	--
Erucic (13-22:1)	10	43	55	--
cis-5, cis-13-docosadienoic (5,13-22:2)	19	--	--	--

-- = Not present in significant amounts.
1/ The formula indicates the location of the double bonds, chain length, and number of double bonds.
Source: S.M. Erhan and R. Kleiman, "Vulcanized Meadowfoam Oil," Journal of the American Oil Chemists' Society, Vol. 67, No. 10, October 1990, pp. 671.

chloride) to produce compounds used in rubber formulations. The vulcanized oil, which is called "factice," had properties equivalent to or better than high-quality, rapeseed-oil factice. However, factices are also made from soybean, castor, and other vegetable oils. Meadowfoam factice would have to be cost competitive to enter this market.

Meadowfoam oil has been epoxidized (adding an oxygen atom across a double bond). The resulting derivatives could be used in coatings, polymers, and lubricants and as plasticizer-stabilizers. Some plasticizers currently are made from vegetable oils, primarily soybean oil (see the June 1994 issue of this report). Meadowfoam oil also can be hydrogenated to produce a wax similar to carnauba and candelilla waxes, but a significant market for these materials has not yet developed.

Dimer acids and esters have been made using meadowfoam oil. The meadowfoam compounds were comparable to commercial products, which are used in adhesives, corrosion inhibitors, lubricants, and lubricant additives. Meadowfoam fatty amides have been prepared and purified, which could be used as slip and antiblock agents in polyethylene films.

Meadowfoam's fatty acids have also been used to make estolides, which have potential uses in lubricants, plasticizers, cosmetics, and printing inks. Traditionally, estolides are formed by esterifying the double bond in an unsaturated fatty acid to the hydroxyl group of a hydroxy fatty acid, thus linking the two fatty acids together. However, a new procedure developed by NCAUR chemists produces estolides directly from monounsaturated fatty acids. The reaction has a particularly high yield when using meadowfoam oil because of its high concentration of monounsaturated fatty acids. A patent has been allowed for this process, and it will be granted in mid-January. Patents are pending on other products based on the chemistry of the delta-5 double bond.

The meal remaining after the oil is extracted contains 21 percent crude protein and 27 percent acid detergent fiber. The amino acid profile of meadowfoam meal closely resembles those of industrial rapeseed and crambe meals. It has been evaluated as a feed for chickens, rabbits, sheep, goats, and beef cattle. Because of the glucosinolates present in the meal, nonruminant animals gained less weight than with a standard ration. However, lambs and beef cattle responded satisfactorily when fed meadowfoam meal.

According to David Nelson, executive secretary of the growers association, commercial development of meadowfoam has been a break-even proposition for the growers thus far. However, meadowfoam is becoming an important crop for grass-seed growers, enabling them to clean up fields infected with grassy-type weeds. A informal consortium has come together to further commercialize meadowfoam and its products. Participants include the Oregon Meadowfoam Growers Association, Fanning Corporation, Oregon State University, and NCAUR. Plant breeding, agronomic research, and oil-product development is progressing rapidly--bringing meadowfoam closer to commercial viability.

Vegetable-Oil-Based Polyols Hit the Market

Polyol is the basic compound used in the production of polyurethane and several other classes of plastic products. Traditionally derived from petrochemicals, polyol is now being made from vegetable oils. For example, Natural Resources Group, a British research company, operates eight vegetable-oil-based polyol plants throughout the world. The company has two plants in Canada, two in northern China, and one each in northern India, Zimbabwe, the United Arab Emirates, and Poland.

Biobased polyol production can utilize a variety of raw material sources--both virgin and waste vegetable oils. The list includes canola, castor, peanut, sunflowerseed, olive, cottonseed, palm kernel, coconut, and fish oils. This raw material flexibility not only protects against feedstock shortages, it also makes polyol production suitable for developing countries that produce surplus quantities of vegetable oils.

Not only can vegetable-oil-derived polyol be used in the manufacture of polyurethane and related products, it also has exceptional blending properties. To date, biobased polyols have been tested as inputs in the production of foams, elastomers, marine coatings, adhesives, polymer concretes, and housing components. Polyol could be a useful feedstock in developing new end-product applications, as well as producing environmentally improved versions of existing products, such as electrical cord coatings and nontoxic fire retardant foams.

Currently, vegetable-oil-based polyol is being produced in small-scale plants in multiple batches of 4 tons each. Such small-scale facilities allow producers to adapt to seasonal feedstock changes and to minimize capital costs. Ecotek Holdings, Ltd., of Lions Bay, British Columbia, has constructed a standard size polyol plant on a 40-foot truck that is capable of processing any vegetable oil into polyol. It also is equipped with a quality control laboratory.

International Polyol Chemicals, Inc., of Redmond, WA, has develop a patented new technology for turning cornstarch into polyols, such as propylene glycol, glycerine, and ethylene glycol. The company currently processes 5,000 tons of cornstarch per year in a pilot-scale facility. Plans are underway to develop a commercial-scale plant, with the goal of processing

100,000 tons per year. USDA's Alternative Agricultural Research and Commercialization Center invested $300,000 in the venture to support additional research. The U.S. Department of Energy's Alternative Feedstocks Program also contributed $300,000 to help transfer expertise in catalysis operations from Pacific Northwest Laboratory to the company.

Polyol from canola oil and polymerized with fuel ash from coal-fired power stations is being used to produce polyconcrete, a construction material produced in different strengths for applications ranging from construction-grade building blocks to household appliance shells. This process has two environmental benefits. First, it replaces nonrenewable fossil fuel feedstocks with renewable vegetable oil. Second, it utilizes fuel ash that is otherwise dumped in a landfill or at sea.

According to industry sources, production costs for vegetable-oil-based polyol average 15- to 20-percent higher than for polyol made from petrochemicals. However, the manufacturing process for vegetable-oil-based polyol is more environmentally friendly than comparable petroleum-based processes and such benefits may compensate for some of the cost differential. Furthermore, production costs could decrease in the future as the technology improves. Currently, a gallon of high-grade polyol derived from vegetable oil costs $15 a gallon.

Production costs also differ depending on the end product. For example, vegetable-oil-based polyol used to coat electrical cords is 10 to 15 percent cheaper than electrical-cord coatings derived from petrochemical feedstocks. In comparison, biobased polyol used to produce fire-retardant foams tends to cost 15 to 20 percent more than similar products made from fossil fuels. However, most of the current fire-retardant foams are petroleum derived and based on toluene 2,4-diisocyanate (TDI), which is a carcinogen. When these foams are sprayed on high-temperature fires, they produce toxic fumes. Fire-retardant foams made from vegetable-oil-derived polyol can replace TDI-based foams. The biobased-polyol foams emit harmless water vapors when applied to high-temperature flames. [Lewrene Glaser, (202) 219-0091; Irshad Ahmed, (301) 951-2060, and Harry Parker, (806) 742-3553]