SOY-BASED LUBRICANTS

Soybean oils have a higher viscosity index, lower evaporation loss and potential to enhance lubricity.

DRIVING ISSUES

The market for soybean oil in lubricants will be driven by a combination of environmental concerns, economics and performance issues. Petroleum or mineral-based oils have historically been, and will likely continue to be, the economical choice for many manufacturers to satisfy performance, logistic and cost targets in many applications. Soy, especially enhanced varieties, and other vegetable oils show the ability to compete in significant segments of this market.

The need for readily biodegradable and low-toxicity lubricants in environmentally sensitive areas has been recognized in Europe. Regulations have been adopted in some European regions, and both synthetic ester and rapeseed oil lubricants have been developed to meet these needs.

The combination of growing regulatory pressure to reduce or eliminate certain emissions of petroleum lubricants and U.S. Presidential Executive Order 13101, which instructs federal agencies to use environmentally preferable biobased products, should encourage increased use of renewable oils. Soybean-based lubricants have the potential to capture a significant share of this emerging market segment and are a research priority of the United Soybean Board (USB).

Regardless, products containing biobased components must compete head to head with conventional products in the purchase decision.

COMPETING PRODUCTS

Soybean oil will compete for a share of the emerging environmentally sensitive and renewable lubricant markets with other vegetable oils and with synthetic lubricants. Vegetable oils, including soy, cost less than synthetics and will be the product of choice when they meet customer performance requirements.

When compared with mineral-oil-lubricant basestocks, vegetable oils have the following advantages: higher viscosity index, lower evaporation loss and a potential to enhance lubricity, which could lead to improved energy efficiency.

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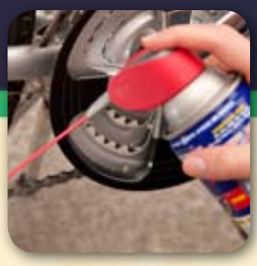


SOY-BASED LUBRICANTS

Vegetable oils have performance limitations, particularly in thermal, oxidative and hydrolytic stability. These problems can be alleviated by modifying the oil. This has in part been done with rapeseed oil, which has been widely used in Europe since the late 1980s and is available in the United States today.

Soybean oil is less expensive than rapeseed oil and can have an advantage if the base oil can be modified to improve stability. Developing a cost-effective, commercially viable source of economical and stable basestock is the key to wider commercialization of soy-based lubricants.

MARKET POTENTIAL

Nine areas were investigated to determine the potential acceptance of soybean oil as a commercial alternative to mineral-based oils.

SOYBEAN OIL OPPORTUNITIES

Application Prob.	Potential Acceptance (%)	Mkt. Share Potential (%)	Mkt. Share (Mil. Bu.)
Hydraulic Fluid	40	5	8.0
Two-Cycle	20	10	1.5
Bar/Chain	60	50	1.0
Crankcase	10/80*	10	87.3
Drip Oil	65	80	0.8
Rail & Flange	55	50	0.4
Wire Rope	70	70	1.1
Metal Cutting	30	10	2.8
Dedusting	50	50	0.4

* Automotive water-cooled-engine use/air-cooled-engine use.

Potential soybean market share is an estimate of the potential penetration once a technically and economically competitive product is developed and introduced. In the crankcase market, a distinction is made between the larger automotive sector and the smaller air-cooled-engine sector.

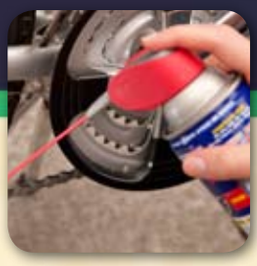
SOY VS. RAPESEED

The chemical composition of rapeseed oil proves to be different from soybean oil, and processes for modification of rapeseed oil to improve stability in lubricant use already have been developed. These advantages and the current political support and infrastructure will make it difficult to replace rapeseed oil in the European lubricant market.

Providing performance superior to rapeseed-based oils will likely facilitate penetrating this market segment and should be a priority for soybean-oil-lubricant formulators. Soybean oil is significantly cheaper in the United States than rapeseed/canola oil. This economic advantage makes it possible for soybean oil to capture a large share of an emerging U.S. market for renewable lubricants if performance can be enhanced to meet or exceed the rapeseed standard. Thus rapeseed or canola oil represents the base for lubricant performance that soybean oil must meet or exceed. Approaching the performance of mineral-oil basestocks would be a definite plus.

SOYBEAN OIL VS. SYNTHETICS

Biodegradable synthetic oils have been developed for environmentally sensitive segments of the lubricants market. They offer improved performance over mineral-oil-based lubricants and rapeseed-based oils, but at a significantly higher price. Most of the synthetics in this market segment are polyalphaolefins or synthetic esters and offer superior thermal and oxidative stability. Prices for these niche-use products are higher than those for vegetable oils and significantly higher than those for petroleum-based lubricants. The synthetic lubricants represent the ceiling in price and performance, and an easier economic target against which soy oil can compete.



SOY-BASED LUBRICANTS

HYDRAULIC FLUIDS

Industrial hydraulic fluids represent a 222-million-gallon market in the United States. In Europe, environmental regulations and consumer pressure already have forced the conversion to more environmentally acceptable hydraulic fluids in sensitive areas such as waterways, farms and forests. These are either rapeseed-based lubricants or synthetic fluids that have been used successfully for a decade. Caterpillar, Inc., estimates this constitutes 12 percent of the European hydraulic fluid market. While such environmental regulations and pressures do not exist in the United States, manufacturers expect a shift may emerge in five to 10 years. Some manufacturers now market environmentally acceptable hydraulic fluids in the United States.

Exxon Mobil, Chevron, and E.F. Houghton, a supplier of industrial hydraulic fluids, offer rapeseed-based products. Pennzoil offers a hydraulic fluid made with sunflower oil. The outlook for soy-based hydraulic fluids remains positive if soy can meet performance specifications and any emerging regulatory requirements, while remaining lower in cost. Penetration in this market will be limited to niches where environmental and safety concerns are high.

CRANKCASE OILS

There is no significant pressure from regulatory agencies or environmental groups to force a change away from the use of mineral oils such as crankcase lubricants. In normal use, the potential contact of crankcase oils with the environment is limited to disposal of used products. Recycling and energy recovery are the preferred alternatives to limit environmental exposure.

The industry continues to adopt new crankcase-oil standards for which further decreases in volatility and increases in viscosity index (VI) of oil are stressed. These new standards are already causing crankcase-oil manufacturers to reformulate engine oils and substitute more expensive API Group II+ and Group III hydrocracked base stocks and API Group IV synthetics for standard API Group I and II solvent refined oils.

The very high VIs and extremely low volatility of vegetable oils, including soybean oil, may prove useful in formulations meeting these new standards if other characteristics, such as oxidative stability, can be improved. This could be important for lubricant manufacturers that wish to continue their use, for economic or logistics reasons, of lower-cost Group I & II mineral oils.

The performance requirements for crankcase lubricants are severe. While bench-scale tests of higher-oleic vegetable oil by several formulators have shown results comparable to current mineral-based oils in oxidative stability, "conventional wisdom rejects vegetable-based oils as engine lubricants." (*Lubes 'N' Greases*, August 1995, p. 20.) Furthermore, major automakers will likely have limited interest in biobased oils as crankcase lubricants unless cost-saving performance benefits can be documented.

Despite this attitude, some manufacturers are developing and testing vegetable-oil-based crankcase oils. AgroManagement Group of Colorado has developed an oil composed of canola, sunflower and soy oils that is usable in air-cooled engines (lawnmowers, chain saws, etc.).

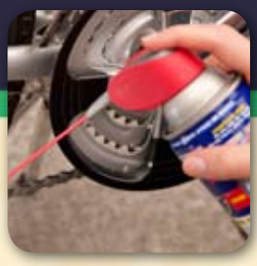
Renewable Lubricants of Ohio has developed a crankcase oil using additives aimed at bringing higher-oleic vegetable oils up to mineral-oil standards. Valvoline continues to evaluate mid-oleic soybean oil from the Better Bean Initiative for potential crankcase applications.

TOTAL-LOSS OILS

Lubricants may be lost directly into the environment in a number of applications, including two-cycle engines, bar and chain oils, drip oils, rail and flange oils, wire-rope lubricants and dust-suppressant oils. While there is a strong need for viable, low-toxicity, readily biodegradable oils in these uses, the performance needs are significant.

Combustion properties, shelf stability and other issues are all obstacles to a near-term entry into this market.

Increasing commercial acceptance of properly formulated soy-based products in total-loss lubricants is ongoing. Originally, vegetable-oil formulations generally were based on rapeseed oil, but soybean oil is making definite inroads. The markets are relatively small compared with crankcase oils, but collectively they represent significant potential.



SOY-BASED LUBRICANTS

METAL-CUTTING OILS AND METALWORKING FLUIDS

Several new metalworking fluids have been introduced, many of which are based on methyl soyate. Methyl soyate has many advantages, including use by the Food and Drug Administration as an incidental food-contact product when used in rolling metal foils. USB-sponsored research has focused on formulating soybean oil or methyl soyate for more technically challenging areas, such as extreme-pressure metalworking. Research has also led to water-miscible metalworking formulas that are both effective and stable.

MODIFYING SOYBEAN OIL

As previously stated, the key to lubricant acceptance is the development of a means to provide a commercial-scale, economical and more stable source of soybean oil. Four possible avenues for an improved soybean oil basestock have been or are being investigated:

- Biotechnology to produce seed that provides more stable oil. DuPont/Pioneer has developed a genetically modified soybean that produces high levels of oleic acid (18:1). This may overcome the first hurdle of developing a base oil with monosaturated levels superior to rapeseed/canola. Pricing and supply issues have prevented high-oleic canola oil from gaining wide market acceptance in lubricants. Other high-oleic-acid soybean varieties have been developed through USB-supported research at the University of Nebraska and elsewhere. Potential entry of this oil into the market could provide a needed source of high-oleic product.
- Non-biotech modification to produce more stable oil. USB-sponsored work by the USDA (Agricultural Research Service) and multiple university cooperators has resulted in new varieties with superior oil traits using genes from wild and commercial soy varieties. Among the new varieties being developed are those with higher levels of oleic acid (18:1) and lower levels of saturates.
- Modification of the oil through chemical or mechanical processing to improve oxidative stability, while maintaining good oil properties, is under investigation by Archer Daniels Midland Company and others.
- Chemical additives that improve stability offer the most rapid and cost-effective route to commercialization. USB-sponsored researchers studying potential additive combinations to overcome performance limitations. Additives may offer a low-cost route to commercialization. Renewable Lubricants, the AgroManagement Group and Valvoline have made strides in the uses of additives.

A combination of several of these areas offers the greatest opportunity for achieving significant levels of soybean oil in finished lubricant formulations. Coordinating the efforts of diverse groups is the challenge of commercialization.

USED OIL DISPOSAL

Testing by Safety Kleen has shown soybean-based lubricants can be disposed and re-refined along with conventional mineral-oil-based lubricants.

REGULATORY CHANGES

Growing regulatory impacts on lubricants should result in more use of biobased lubricants in the United States during the next five to 10 years. The vegetable-oil industry should follow this effort, providing information on the availability and performance of renewable vegetable-based lubricants that can facilitate their use. With an annual U.S. crop of over 3 billion bushels, the potential supply of soybean oil could surpass 31 billion pounds if the entire crop were crushed domestically. No other oilseed crop has a current availability of this magnitude. If renewable oils are desired as lubricants, the availability of an enhanced soybean oil, coupled with its price advantage over other vegetable oils and synthetics, will make it a logical substitute for mineral oils in appropriate market segments.

ABOUT USB

USB is made up of 68 U.S. farmer-directors who oversee the investments of the soybean checkoff, a U.S. soybean research and promotion program, 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.

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