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Editorial

Vegetable Oils as Bio-lubricants

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Editorial

Vegetable oils can and have been used as lubricants in their natural forms. They have several advantages and disadvantages when considered for industrial and machinery lubrication. On the positive side, vegetable oils can have excellent lubricity, far superior than that of mineral oil. Lubricity is so potent that in some applications, such as tractor transmissions, friction materials need to be added to reduce clutch slippage. Some crude vegetable oils tested at UNI-ABIL have passed hydraulic pump/wear tests, such as ASTM D2882 and ASTM D2271, in their natural form.

Vegetable oils also have a very high Viscosity Index (VI); for example, 223 for soybean oil *vs.* 90 to 100 for most petroleum oils. Restated, the viscosity of a high VI oil changes less than that of low VI oil for a given temperature change. The oil's viscosity does not reduce as much when exposed to high temperatures, and does not increase as much as petroleum oils when exposed to cool temperatures.

Another important property of vegetable oils is their high flash/fire points; 610°F (326°C) is the flash point of soybean oil compared to a flash point of approximately 392°F (200°C) for mineral oils.

Most importantly, vegetable oils are biodegradable, in general are less toxic, are renewable and reduce dependency on imported petroleum oils. Additionally, using lubricants and greases made of soybean oil helps reduce soybean surpluses and helps stabilize soy prices for American farmers. For most industrial machinery users these products offer considerable public relations benefits and goodwill within the agricultural community.

On the negative side, vegetable oils in their natural form lack sufficient oxidative stability for lubricant use. Low oxidative stability means, if untreated, the oil will oxidize rather quickly during use, becoming thick and polymerizing to a plastic-like consistency. Chemical modification of vegetable oils and/or the use of antioxidants can address this problem, but increase the cost. Chemical modification could involve partial hydrogenation of the vegetable oil and a shifting of its fatty acids. The challenge with hydrogenation is to determine at what point the process is to cease. Full hydrogenation of oil can lead to solid products like margarine. Depending on the needed liquidity and pour point of the oil, optimum hydrogenation is determined.

Recent advances in biotechnology have led to the development of genetically enhanced oilseeds that are naturally stable and do not require chemical modification and/or use of antioxidants. A soybean seed developed through DuPont technology, for example, presents more than 83 percent oleic acid as compared to only 20 percent oleic acid content in conventional soybean oil. Originally developed for frying applications, this oil has shown about 30 times more oxidative stability and viscosity stability in hydraulic pump tests conducted at the UNI-ABIL Research Program. High oleic varieties of canola oil, rapeseed, sunflower and soybean are now becoming standard base oils for biodegradable lubricants and greases. The primary advantage of soybean is that it is U.S.-grown and has a well-established infrastructure to deliver the quality, quantity and economy for these alternative products.

All conventional, chemically modified or genetically modified oils tested at UNI-ABIL have shown the same levels of biodegradability. Using tests developed by American Standard for Testing and Materials (ASTM) and Organization for Economic Cooperation and Development (OECD), the oil is inoculated with bacteria and is kept under controlled conditions for 28 days. The percentage of oxygen consumption or CO^2 evolution is monitored to determine the degree of biodegradability. Most vegetable oils tested have shown to biodegrade over 70 percent within that period as compared to petroleum oils biodegrading at about 15 to 35 percent. For a test to be considered readily biodegradable, there must be > 60 percent degradation in 28 days. Similarly, using a variety of tests involving fish, daphnia and other organisms, the toxicity of the vegetable oils are tested. In this case, in their pure form, both mineral oil and vegetable oils show little toxicity, but when additives are included, toxicity increases.

Another negative to vegetable oils is their high pour point (the temperature at which oil loses fluidity and does not flow). This problem too can be addressed by winterization, addition of chemical additives (pour point suppressants) and/or blending with other fluids possessing lower pour points. Various synthetic oils can be used for this purpose. With a combination of these techniques, UNI-ABIL has developed hydraulic fluids with pour points of -32.8°F (-36°C) for use in snow blowers used by the Iowa Department of Transportation. Another experimental hydraulic fluid using genetically enhanced oils meets military specifications for pour points of -65.2°F (-54°C). While the use of genetically modified seed oils alleviates the problem of oxidation stability, the cold temperature properties must be enhanced by the addition of chemical pour point depressants and/or the addition of other liquids with much lower pour points.

If a high degree of biodegradability is required, then biodegradable synthetic esters are added to improve cold temperature properties. On the other hand, if the attempt is to maintain the so-called biobased property, where at least 51 percent is of natural biomaterials, then a portion of the blend could be light mineral oil with low pour points. The latter will show a higher degree of toxicity and a lower degree of biodegradability.

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