EXPLORING LUBRICANTS IN MINING

Dr. Lou A. Honary, Environmental Lubricants Manufacturing, USA, highlights the development and availability of biobased and biodegradable lubricants for the mining industry.

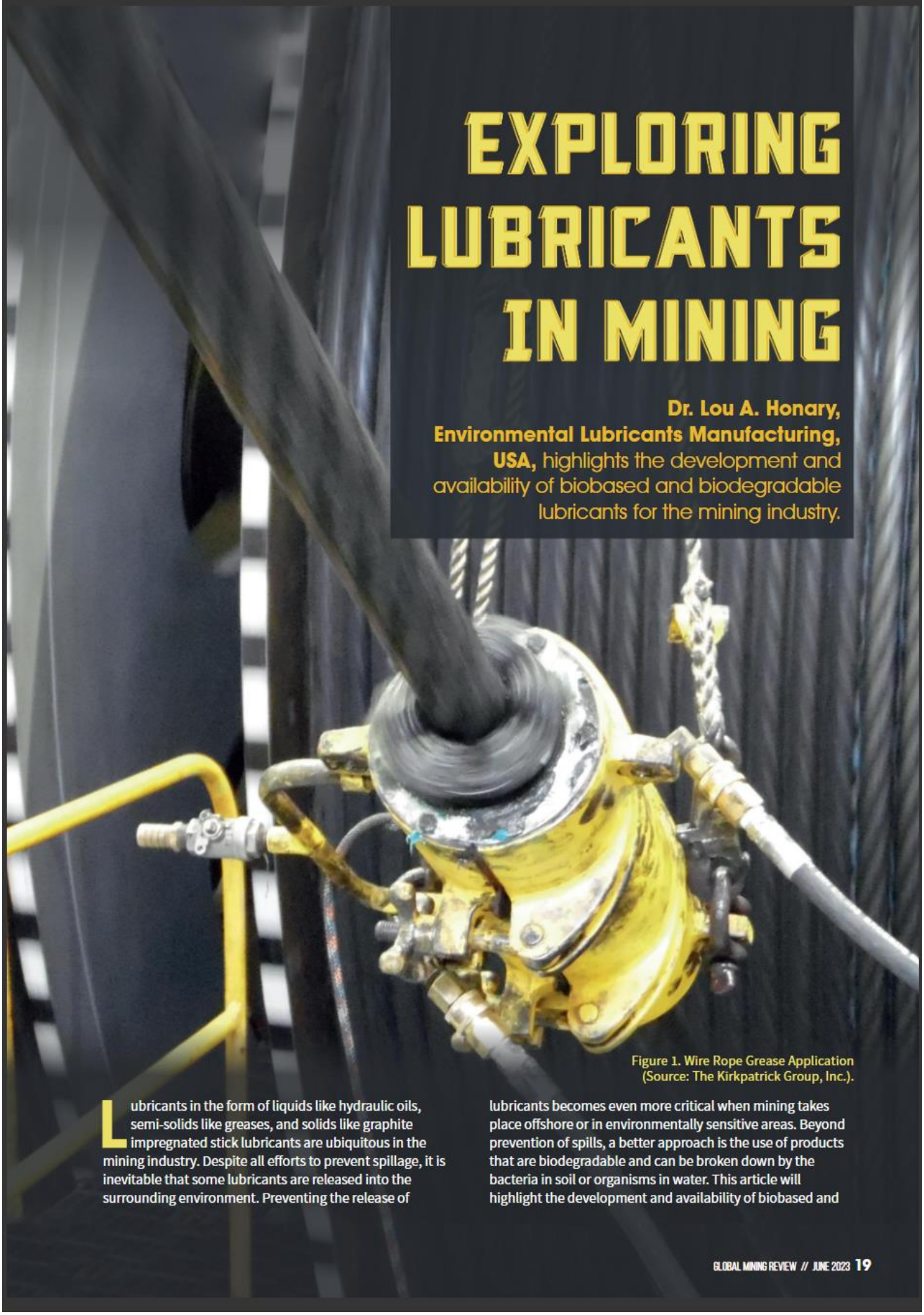

Figure 1. Wire Rope Grease Application (Source: The Kirkpatrick Group, Inc.).

Lubricants in the form of liquids like hydraulic oils, semi-solids like greases, and solids like graphite impregnated stick lubricants are ubiquitous in the mining industry. Despite all efforts to prevent spillage, it is inevitable that some lubricants are released into the surrounding environment. Preventing the release of lubricants becomes even more critical when mining takes place offshore or in environmentally sensitive areas. Beyond prevention of spills, a better approach is the use of products that are biodegradable and can be broken down by the bacteria in soil or organisms in water. This article will highlight the development and availability of biobased and

biodegradable lubricants for the mining industry and start by discussing some key terms.

Key terms

Biodegradable

Refers to products that meet the OECD 301 series of tests. These tests are based on respirometry and rely on the respiration of standards bacteria. Simply described, a sample of the product is placed in a temperature-controlled water chamber with a standard quantity of bacteria. Another chamber with bacteria and 'food' is used as the control for comparison. If the bacteria can consume the sample product and survive or thrive, then the product will likely degrade in the environment also. The test instrument can monitor and record the amount of oxygen the bacteria are consuming, or the amount of carbon dioxide they put out, in both the control and test samples. The tests are 28 days in duration and for a product to be considered biodegradable, the test sample should show at least 60% of the control sample in oxygen consumption or carbon dioxide evolution to pass the test.

Figure 2. Biodegradability test instrument showing chambers in two separate water baths (Source: Environmental Lubricants Manufacturing Inc.).

Figure 3. Biobased drill rod grease (Source: Environmental Lubricants Manufacturing Inc.).

Figure 4. A lubricant applicator uses a drum pump to apply biobased grease to a fast moving wire rope via a lubricant disperser (Source: The Kirkpatrick Group, Inc.).

Biobased

This term was introduced by the US Department of Agriculture (USDA) to encourage the replacement of fossilised hydrocarbons with renewable hydrocarbons. The USDA has established the 'Biopreferred' programme in conjunction with major US agriculture groups such as the United Soybean Board (USB) to promote the use of biobased products. The US federal purchasers are required to give purchase preference to products that meet the USDA biobased criteria. To be considered biobased, a product is sent to a USDA sanctioned laboratory for carbon dating according to the ASTM D6866 test method. This test simply shows the percentage of fossilised hydrocarbon vs renewable hydrocarbon. Plant or crop oils show to be majority renewable hydrocarbons. The USDA has a list of labeled products and their required minimum amount of biobased content.

Biobased and biodegradable

Since some petroleum materials can actually pass the OECD 301 series test of biodegradability, a product can be synthesised from fossilised hydrocarbons to be biodegradable. An example would be some light polyalphaolefins (PAOs) or synthetic oils. Although biodegradable, a PAO oil would fail the ASTM D6866 test for biobased content because it would not be seen to contain any renewable carbon. In conclusion, most biobased oils are also biodegradable, so they are called biobased and biodegradable. However, biodegradable products that are petroleum based cannot be called biobased and biodegradable, they can only be called biodegradable. In Europe in general, regulations are focused on biodegradability regardless of renewability; whereas, in the US, the emphasis is on renewability and replacement of fossilised oils.

Extreme pressure property of lubricants

An important property of lubricants in mining applications is the extreme pressure (EP) performance. EP property can be enhanced naturally by using oils that are dipolar in nature and form strong bonds to metal surfaces (most vegetable oils fall in this category), and/or by using solids like molybdenum disulfide (Moly), graphite, and sulfur. Vegetable oils have some built in properties including a high Viscosity Index, meaning they do not thin down as much as petroleum oils do at high temperatures. Additionally, they have a high thin film strength for better metal to metal separation at high loads, and they

form a stronger bond to metal surfaces due to their polarity. Extreme pressure property is measured using the Four Ball Test (ASTM D2596) and Timken OK Load test (ASTM D-2509 procedure for testing greases and ASTM D-2782 for testing oils).

Water washout resistance property

This property applies to many of the lubricants that are used on or near water. Wire rope grease, jack-up grease, and drill rod grease require resistance to water washout. This property can be improved by proper selection of base oils and or use of tackifiers. Aluminium complex greases exhibit a natural resistance to water washout and are often used in food production facilities, where they are frequently exposed to pressure washers. This property is tested according to the ASTM D1264 or IP 215.

Undesirable metal contents

Understanding the impact of metal-based additives in lubricants is important. Hazardous metals, such as lead, that were prevalent in gasoline as octane booster have been eliminated. In lubricants, zinc in zinc dialkyl dithiophosphate (ZDDP) is still commonly used, but changes are underway to eliminate its use. In greases, especially in drilling, barium has been the most prevalent thickener. Barium greases resist water washout and are fibrous in texture, forming a wrap around the rod during drilling. However, the heavy metal content of this grease is becoming an environmental concern for drillers and regulators alike.

Challenges with barium grease

Based on the available literature, more attention is given to the presence of barium in drinking water in the US and Canada than in Europe. In the US, the Agency for Toxic Substances and Disease Registry (2007) published the Toxicological profile of barium and barium compounds.

According to this report, barium compounds – including barium hydroxide, which is used in the manufacture of barium drill rod grease – dissolve easily in water and do not last in their natural forms for long, but they quickly combine with sulfate or carbonate that are naturally found in water and become longer lasting compounds, such as barium sulfate and barium carbonate. These are the compounds most found in the soil and water. Since 2020, due to the increasing health concerns of barium or compounds of barium in soil and water, Canada has tightened its regulations for release of barium into the environment, an indication that all heavy metals used in lubricants are on their way out in North America.

Vessel General Permit (VGP)

The US Environmental Protection Agency (EPA) introduced the VGP in December 2013. It requires all ships larger than a certain length entering US waters to report the release of any lubricants into US waters. Alternatively, the vessel could be issued a VGP if the lubricants used on the vessel are certified as environmentally friendly based on the VGP specifications. This has led to an increased use of biobased and biodegradable turbine oil, hydraulic oils, gear oils, wire rope, and drill rod greases. The US EPA has a history of retroactively

pursuing those considered as polluters even when some materials are not considered as pollutants at the time of release.

Sustainability and lubricants

The attempt to create a more sustainable operation in mining requires more than just the use of a lubricant that is considered biobased or biodegradable. In support of the USDA Biobased initiatives, the National Institute of Standard and Technology (NIST) established guidelines and tools for performing life cycle analysis on products. Data from the entire journey of the product are entered into an analysis program called BEES. It is designed to measure the environmental performance of a product based on the ISO 14040 series of standards and perform the lifecycle assessment. All stages in the life of a product from raw material acquisition, manufacture, transportation, installation, use, recycling, and waste management are analysed.

Figure 5. Reuseable jumbo totes containing biobased biodegradable rail curve grease (Source: Petron Plus Global, Inc.).

Figure 6. Example of biobased-biodegradable lubricant-penetrant (Source: Environmental Lubricants Manufacturing Inc.).

Grease and lubricant products for mining

There are several environmentally friendly lubricants and greases available that could help to reduce the use of mineral oil-based lubricants in mining applications.

Biobased jack-up grease

Biobased jack-up greases are primarily aluminium complex greases, but also available in mineral oil-based calcium sulfonate and offer natural water repellant properties and extreme pressure performance. Most such greases contain molybdenum disulfide and or graphite for an improved extreme pressure property. Using a combination of tackifiers that impart adhesion and cohesion properties, these greases can be used for jack-up and all open gear applications – including cranes, draw bridges, and the like.

Biobased wire rope grease

Biobased-biodegradable wire rope greases are mostly made of vegetable oil or vegetable oil derived synthetic esters that are thickened with aluminum complex thickeners. These greases are often tested for aquatic toxicity using the OECD 202 test method. In July 2022, after two decades, an update to the military specifications for wire rope grease MIL-PRF-18458D was released. This update now contains specifications for two types of wire rope greases (Type 1 being for conventional mineral oil-based grease and Type 2 for biodegradable versions). To meet the requirements of Type 2, the grease has to pass biodegradability tests according to OECD 301B or 301F and aquatic toxicity according to OECD 202. One US original equipment manufacturer (OEM) and supplier of grease has already announced meeting the requirements of both Type 1 and Type 2 wire rope greases.

Biobased drill rod grease

These greases are made of aluminum complex, lithium or organo-clay thickeners, and vegetable or biobased synthetic ester base oils to replace barium greases. Greases with inherent water repellant properties – such as aluminium complex fortified with tackifiers for a balance of adhesion to wire ropes and cohesion to fight water washout – have shown to perform well as a replacement for conventional barium greases. Vegetable oils have nearly 200 °F (93 °C) higher flash/fire points than equivalent mineral base oils, and thus offer added safety when used as base oil in making grease.

Biobased multi-pupose drill floor grease (NLGI GC-LB Rating)

These are biobased greases that are thickened as lithium complex and offer extreme pressure and

anti-wear properties. Such greases should meet the highest performance rating of the National Lubricating Grease Institute (NLGI) with a performance rating of GC-LB – suitable for use in bearings and high-speed moving parts. They could replace all miscellaneous greases used in mining or offshore platforms without compromising performance.

Key liquid lubricants products could be considered

Biobased hydraulic oils

Biobased derived synthetic esters, made from natural vegetable oils, offer superior oxidation stability and improved cold temperature performance. Biobased hydraulic oils reduce energy consumption observed as lower current draw on drive motors, cooler pump temperatures, and quieter operation. Beyond the oxidation stability and cold temperature performance, consideration should be given to seal compatibility. Some elastomeric seals and O-rings are not compatible with biobased oils and could cause excessive seal swell, however manufacturers have developed additives that counter the seal swell that could be present in otherwise poorly formulated products. The ASTM D4289 is a test of Elastomer Compatibility NBR L and CR with grease.

Biobased multi-purpose lubricant penetrant

Biodegradable lubricating oils are combined with wetting agents to prepare products that outperform conventional lubricant-penetrant products. Simple applications – such as pipe threading, metal drilling, honing, reaming, etc. – could benefit from the superior lubricity and other benefits of bio-oils without compromising performance.

Biobased rust and corrosion inhibitor

These products contain biodegradable heavy-duty base oils combined with wetting agents and a rust and corrosion inhibitor package for on and offshore use. They have the same benefits of mineral oil-based rust and corrosion inhibitors, but are also biodegradable and safe to use.

Conclusions

The current attention to sustainability is deep rooted within the industry, and a genuine attempt is underway to bring about change with limited impact on performance. To the younger generation of mining personnel, climate change and environmental stewardship have taken on a different meaning and a higher sense of urgency. The lubricants industry too has been actively searching for novel approaches to meeting the needs of the mining industry, in terms of performance and offering reliability in supplies. As the end user becomes more educated about biobased products, the increased demand and the economy of scale should make these products mainstream. GMR