Maximising Environmental Grease Compounds for Extreme High Pressure High Temperature Applications

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Peter is Technical Manager of Jet-lube (UK) Ltd a market leader in oilfield lubrication. He holds a Bachelor’s Degree in Chemistry from the University of Bath. Before joining Jet-lube Peter spent 4 years working in various technical and formulation roles for Infineum, Akzo Nobel, BP Castrol and Halliburton.

Key words:
Environmental Thread Compound, HPHT, Biodegradable, Vegetable Oil, Calcium Sulfonate Complex grease

Synopsis
Jet-Lube’s patented Environmentally Considered Formula (ECF) technology was developed to comply with the stringent North Sea environmental guidelines for offshore chemicals used on exploration drill rigs while maintaining the required performance standards. This paper explores the environmental properties of the binding grease, the constituent base oils, solid lubricants and additive chemistries to deliver a bio-degradable OSPAR compliant formula.

As conventional sources of oil and gas decline, operators are increasingly turning their attention to unexplored or underdeveloped areas with increasing focus on High Pressure High Temperature (HPHT) wells. Under such extreme conditions many items of equipment and tools simply cease to function. This imposes very real limitations on much of the technology currently available to help develop these reservoirs.

Having developed a range of ECF drill collar and casing joint compounds Jet-Lube set about taking this technology a step further to develop a casing compound for extreme HPHT applications. By highly tuning existing market leading products and reformulating with new specially refined base oils, Jet-Lube had been able to develop a much improved product. This paper will focus on the challenges of delivering a bio-degradable product with such inherent instability for HPHT applications.
Johanna Persson is a Development engineer at Axel Christiernsson International located at the R&D lab in Nol, Sweden. She graduated from the University of Växjö as a Chemical Engineer 2001 and the year after, 2002, she received her Master of Science in Technology at the same University with major subject Environmental and Process Technology. Johanna started working as a Laboratory engineer at Axel Christiernsson in 2004 and during 2008 she took the position as a Development engineer and has since then been working with product development for the Axel Christiernsson. Over the years she has acquired a deep and fundamental knowledge about the art of grease making.

Key words:
Bio-Grease, Anhydrous calcium thickener, EU Ecolabel, water contamination, low temperature

Synopsis
Environmental sustainability can be achieved in several ways and within the field of lubrication, one obvious example includes switching from traditional lubricating greases to more environmentally friendly greases. For example, applications where the grease cannot be easily prevented from coming into contact with the surrounding environment are often referred to as Loss Lubrication systems and represent an increasingly important target market to benefit from Bio-Greases. This paper will present the beneficial properties of anhydrous calcium thickener technology as the basis for an environmentally friendly Bio-Grease developed to meet the EU Flower (ECO Label) Requirements. With Bio-Greases typically being used on components exposed to the elements, testing has focused on performance in relation to water and low temperatures.
Government legislation and policies have placed an emphasis on the future protection of natural resources. Greases with reduced environmental impact are now mandated in many areas such as marine and forestry. These new requirements in Europe and North America have prompted research and development of new technologies. Recent technology developments have enabled bio-based and eco-considerate grease products to be formulated to achieve a high level of performance. These new products can be used in a multitude of total loss applications. For some end users, even when the use of such environmentally considerate lubricants is non-mandatory, their preference is still to use such lubricants.

Developing sustainable components requires careful review of all raw materials used in the manufacture of additives and synthetic base oils. Most oil-soluble performance additives have organic tails attached that facilitate the solubility. One way of improving their sustainability is to select a tail derived from a renewable source such as a vegetable oil instead of petroleum. There has been recent growth in synthetic base fluids derived from sugar and other natural sources. One challenge for some of these fluids, is that although they are made from renewable materials they are however, not readily or inherently biodegradable and cannot be used in applications where significant biodegradability is a requirement. Most commonly supplied renewable vegetable oils have a drawback in that their base oil viscosity is low. To thicken these bio-fluids, polymer and complex esters are being used. Complex esters are made from polyols and a mixture of mono- and di-carboxylic acids, all of which are now available from renewable sources. This paper will discuss technologies that can enable grease producers to improve and enhance their grease making processes. By combining these technology approaches, greases can be developed to meet these and future sustainability requirements.
### Key Points

#### Synthesis

**To what extent do synthetic esters contribute to better sustainability on greases?**

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**Keywords**: environmental impact, renewability, durability, safety

### Synopsis

**Can we agree on the meaning of sustainability for lubricants?**

Sustainability is a very wide and complex notion that needs to be clearly defined and agreed upon by all actors of the product cycle. Whilst current concerns about lubricants revolve mainly around environmental issues, economical and social aspects are clearly gaining visibility.

**How is sustainability supported by standards and legislation?**

There are numerous standards and labeling programs that encourage the development and use of products in a more sustainable approach. In the specific area of lubricating oils and greases, a number of standards and programs attempt to set targets on environmental impact, fossil resources depletion, innocuity of products, performance and durability.

**Synthetic esters may contribute to increased sustainability**
Synthetic esters are well known for their good environmental profile, but they also show other features that should make for more sustainability. More specifically:

- They exhibit excellent environmental profile
- They may be designed from renewable carbon sources
- They increase durability, whilst improving energy efficiency
- They deliver added human safety thanks to their fire resistant properties

**Ester based greases**

Greases produced from synthetic esters will show the benefits described earlier. Thickening technologies and processes may have to be adjusted.

An ISO VG 150 synthetic ester based, general purpose lithium grease was formulated with very good overall features. This grease is European Ecolabel certified.

The biodegradability features of synthetic esters are not limited by their viscosity.

Being conclusive about sustainability of ester based greases requires carrying out a full Life Cycle Assessment. However, the unique combination of excellent biodegradability, high level of renewability, and superior lubricating performance of such greases clearly make a step towards sustainability.
Dr. George S. Dodos has a Diploma and a PhD degree in Chemical Engineering from the National Technical University of Athens in Greece. He is working with ELDON’S S.A., involved mainly in research and development of new innovative products and in technical services. He also holds a Research Associate position in the Laboratory of Fuel Technology and Lubricants in the National Technical University of Athens with his research activities currently being focused in the field of renewable fuels and biobased lubricants. He has several publications in international peer-reviewed journals and conference proceedings on topics such as oxidation stability, tribological behavior and microbial contamination of lubricants and fuels. He is affiliated to a number of international organizations including SAE and ACS. From 2013 he chairs the ELGI Biobased Greases WG.

Key words
Biobased lubricating greases, used cooking/frying oil, sustainability, green chemistry, environmentally acceptable lubricants.

Synopsis
Biobased lubricants are high added value commodities and their market is considered to be one of the most promising universally. The positive perspectives of this product group mainly stem from the increasing environmental concern and the sustainable strategies for conserving natural resources. Biobased greases can be used either for general application or equipment working in areas where biodegradability is required such as in agriculture, forestry and coastal marine. Used cooking oil or used frying oil is actually a waste vegetable oil that is practically a feedstock of low commercial value; therefore its valorization could be beneficial in terms of biolubricants' economics and sustainability. In this study a sustainable lubricating grease for general and environmentally sensitive applications was formulated by employing used cooking oil as feedstock for the base fluid. The prepared biobased grease was assessed regarding its physicochemical and quality characteristics such as dropping point, copper corrosion, oxidation and roll stability The wear preventive and boundary friction characteristics of the biogrease were evaluated by conducting measurements in a Four-Ball and an HFRR apparatus.
Estolides – A High Performance Renewable Base Fluid

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Jakob is a founding member of Biosynthetic Technologies and directs all technical efforts as the company’s Chief Technical Officer. He is named on over 20 issued or filed patent applications in the field of sustainability and performance lubricants. He has helped the company raise millions of dollars in support of biobased lubricants. He has been asked to sit on a review panel as an industry expert to evaluate research projects for the US Government related to biobased products. His responsibilities include the development and commercialization of new innovative technologies.

Key Words: Sustainability, Renewable, Baseoil, Green Lubricants, Biobased

Synopsis
Estolides are an environmentally acceptable base oil that is sometimes referred to as a “biosynthetic.” Over the last few years, they have gained recognition for their performance and environmental qualities, allowing lubricant companies to formulate quality products that are seen as environmentally friendly. They are synthesized from vegetable oils so they have high renewable content. They are also biodegradable and nontoxic, yet have strong performance characteristics. Estolides are an exciting new technology and many large companies are now evaluating the use of estolides in a number of applications including marine, metalworking, automotive, and various industrial products.

Advancements in equipment design are requiring more from today’s lubricants. In addition, there’s a desire to reduce the environmental impact of products in the market. Being able to formulate a product that both performs well and reduces the lubricant’s environmental impact has been a great challenge. However, new technologies like estolides are now offering more options to formulators and helping close the gap traditionally found between performance and sustainability.
After having BSc. from METU (Turkey), I completed my MSc. thesis at Bilkent University under the supervision of Ass. Prof. Emrah Özensoy. At Bilkent, I studied ternary mixed oxide systems as catalysts in the form of BaO/FeOx/Al2O3 with varying compositions as an alternative to the conventional NOx storage materials (BaO/Al2O3). In the existence of iron, the structural characterization of the poisoned NOx storage materials and the performance and sulfur tolerance of these materials upon SOx adsorption were analyzed with the help of FTIR, Mass Spectrometry, TPD, Raman Spectrometry, XRD, XPS, SEM-EDX to understand the effect of iron addition to these systems. I have been working as Laboratory Engineer at OMV Petrol Ofisi A.Ş. for two and a half year. I prepare formulations for lubricants and greases in conjuction with Product Management Department ; enhanced the products and processes; evaluate alternative raw materials; follow the literature and trends; coordinate with universities and related organizations to start R&D projects;and back the Quality Control Department up.

**Key Words:** biodegradable, non-toxic, eco-friendly, grease, cellulose, castor oil, ester

**Synopsis**

Renewable resources have gained great interest for the past few years, because of being alternative to finite sources and their environment friendly characteristics. Beside the increasing public concerns for a clean environment, regulations such as REACH and ecolabelling and governments prompt lube industry to search for biodegradable, non-toxic and eco-friendly products. This study aims to fabricate two types of almost 100% biodegradable greases consisting of ethyl cellulose/methyl cellulose binary system as thickener, and differing from each other by base fluids one of which is castor oil and the other is synthetic ester. Specifically, methyl cellulose will be added to the kettle after ethyl cellulose is melted in the base fluid. Then, the mixture will be heated up to a certain temperature followed by mixing at this temperature for a required time and finally mixture will be cooled down to room temperature by natural convection. Comparison of these products to the conventional soap based greases will be done by means of consistency, mechanical stability, oxidation stability, thermal resistance and water resistance in order to evaluate their potential industrial use.
Calcium Sulfonate Complex Greases:
A Solution to Wheel Flange Lubrication

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Dabo Liu is a Product Development Engineer for grease at Wuxi PetroChina Lubricating Grease Company. Responsibilities include the oversight of fundamental research, new grease product and process development, enhancement of existing technology, R&D management, and technology transfer within the Wuxi PetroChina company. Prior to joining the PetroChina, he received a Master's Degree in Material Engineering from Lanzhou Institute of Chemical Physics, Chinese Academy of Sciences and has been in the Industrial R&D area with a primary focus on grease since 2009.

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Keywords: Wheel flange lubrication, Calcium sulfonate complex grease, Boundary lubrication, Wear

Synopsis
In this article, a wheel flange grease based on calcium sulfonate complex grease was synthesized with the highly refining mineral oil as the base oil. Selections of antioxidant and anticorrosion additives were added into the base grease. Owing to the comprehensive properties and the specific structure of the calcium sulfonate complex grease, the prepared grease exhibited excellent extreme pressure and antiwear properties and better water resistance. This new kind of wheel flange grease is well suitable to the wheel flange lubrication system for rail vehicles. The grease reduces the friction and wear at the interface between the side of rail and the wheel flanges where it experiences in high loads, high temperature, high running speed and shock load conditions commonly known as boundary lubrication. The prepared calcium sulfonate complex grease is a good solution to wheel flange lubrication.
An Application Study on the Calcium Sulfonate Complex Greases in the Roll Neck Bearings of Hot Rolling Mills

李纪委 <lijiw.lube@sinopec.com>

Key Words

Synopsis
The roll neck bearings of hot rolling mills are consistently working under severe service conditions, such as: exposure to significant amounts of water and dusty environments, heavy-duty and the demand for high-reliability. So, the performances of grease in the roll neck bearings become a key factor for the successful operation. The greases in roll neck bearings must have good water-resistance and Extreme Pressure (EP) properties. The traditional grease thickeners are lithium-calcium, lithium-complex or lithium-calcium complex. In the recent years, Calcium Sulfonate Complex Grease with its excellent overall performance became a preferred selection for roll neck bearings. The author has conducted a field study on some commercially available greases through monitoring the grease performance changes including the penetration, EP property, anti-wear property and the temperature increase. This paper will give a thorough performance change comparison between the Calcium Sulfonate Complex Grease with other traditional thickened greases in the lubrication of roll neck bearings before and after the grease usage. Field tests show that compared with a traditional bearing lithium complex grease, Calcium Sulfonate Complex Grease has obvious advantages. Calcium Sulfonate Complex Grease lowers not only the cost of grease, but also the costs of waste water treatment and labor.
The Evaluation of Oxidation Resistance of Lubricating Greases using the Rapid Small Scale Oxidation Test (RSSOT)

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Steve started working as a grease Chemist at Ironsides Lubricants (UK) in 1978, moving to Lubrizol as a Product Development Chemist in 1989 until 2009, and has been doing a similar role with RS Clare since 2012.

He has a BSc in Applied Chemistry and an MSc in Lubricant Technology. He has been awarded patents in UK and USA. But his greatest achievement in the grease world is to have won both the NLGI and ELGI best paper awards with different papers in the same year (2008) J

Ron Savin is an instrumentation engineer who has been with Anton Paar since 2002. He is currently Product Manager for their specialist petrochemical testing range (formerly branded as Petrotest). His previous experience has been split between roles in technical support, systems engineering or sales & marketing for Yorkshire Water, RS Components and Testo.

Key words: Rapid, Small Scale, Oxidation, Testing, RSVOT, Grease

Synopsis
ASTM D7525 is an established fuel industry test that measures the Oxidation Stability of Spark Ignition Fuel using the Rapid Small Scale Oxidation Test (RSSOT). This test equipment was recently evaluated in Round Robin studies carried out by the ELGI Bio-lubricants Working Group on various biodegradable greases. Samples were also evaluated using other recognised oxidation tests, such as the traditional ASTM D942 test, Pressure Differential Scanning Calorimetry (PDSC) and a Modified Rotary Pressure Vessel Oxidation Test (RPVOT). However, ASTM D942 requires carefully preparation of the apparatus to ensure that the measured pressure loss is not compromised by oxygen leakage, and it takes 100 hours to complete the test. This paper shows that the RSSOT apparatus delivers accurate and repeatable results for lubricating greases in a time-efficient manner, (minutes rather than days) yet discriminates their oxidation performance in line with traditional and other oxidation tests.
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Jon is the Vice President of Technical Development at the Savant Group, Midland, Michigan. He has a BS in chemistry from Ithaca College, Ithaca, New York and a Ph.D. in Organic Chemistry from Wayne State University, Detroit, Michigan. His responsibilities include the oversight of fundamental research, concept development, development and enhancement of existing technology, new product development, process development, prototyping, R&D portfolio management, and technology transfer within the Savant Group of companies. The Savant Group of companies provide innovative solutions to customer and industry needs, improve current products and services, and generate ideas for new products and services.

Prior to joining the Savant Group, he spent 25 years with the Dow Chemical Company directing technical development and research in the areas of Advanced Materials and Polymer Synthesis, Pharmaceuticals and Drug Delivery. He is the co-author of more 70 papers/presentations and has more that 20 US and European patents.

Key Words: Oxidation, Wear

Synopsis
The ability of a grease to sustain its lubricating performance under operational stress and temperature is critical to its ability to minimize friction, increase system efficiency and extend operating life. The present paper will describe the development of a new technique for assessing wear properties of grease by the use of a modified Pin and Vee Block technique developed by the authors. For this study both mineral based and renewable bio-based greases were evaluated.

Since oxidation is one of the primary causes of degradation of a lubricant, both fresh and oxidized grease wear properties were compared using this new technique. The greases were first exposed to a modified version of ASTM D942 grease oxidation test utilizing a recently available isothermal, high pressure, high temperature bench test instrument. The oxidized greases were also evaluated by Fourier Transform Infrared (FTIR) analysis.
# Sustainability in the Grease Industry: Principle – Process – Product

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<td>Diplom-Kaufmann / MBA</td>
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| Born in Mannheim (Germany) in 1971 |
| MBA, Western Illinois University (USA) in 1996/1997 |
| Diplom-Kaufmann, University of Mannheim in 1999 |
| Successful completion of certified study program “Competitive Intelligence Engineer”, Graduate School Rhein-Neckar, 2009 |
| Successful completion of certified qualification course “Sustainability Manager (SME)”, European Institute for Labour Relations, 2012 |
| Since more than 15 years different positions in the FUCHS PETROLUB Group, the world’s leading independent manufacturer of lubricants and related specialties (joined in 1999) |
| Promoted to Vice President of Sustainability & Global Competitive Intelligence as of 1 January 2016, reporting to the Executive Board |

**Responsibilities/Duties:**

- Corporate Sustainability Management (KPI analyses, reporting & targets, corporate citizenship, carbon footprint management, life cycle analyses)
- Global Competitive intelligence (product & customer portfolio analyses, production plants analyses, scanning/screening competitive landscape for potential acquisition targets, market intelligence)

**Key Words**

**Synopsis**

The trend towards greater sustainability will reduce the demand for lubricants and greases, especially in Europe. To compensate for the negative volume effect, lube manufacturers need to continuously adapt and re-define themselves. This requires more active involvement in lubricants and greases product and system innovation, deeper integration in the customers’ value chain and global availability of raw materials as well as of finished lubes and greases with consistent quality.
# Modeling and Experimental Validation of Grease Flow

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Lars is Associate Professor in Fluid Mechanics at Luleå University of Technology (LTU), Sweden. He has a M.Sc. in Space Engineering and a PhD in Fluid Mechanics from LTU. Lars has research- and educational experience from many engineering- and science areas from electromagnetism and space physics, to fluid mechanics, rheology and lubrication. Current research has a strong focus on lubricating greases and the relation between grease composition, rheology, and flow dynamics. Lars has over 60 scientific publications and have received the Edmond E. Bisson Award (2012) and Frank P. Bussick Award (2013) by the Society of Tribologists and Lubrication Engineers (STLE).

In addition to research and education, Lars has a couple of central leadership assignments at the university as Faculty Programme Director for the Master Programme in Space Engineering, and vice chairman for the Board of Employment.

## Key words
Lubrication, rheology, flow visualizations, grease flow

## Synopsis
Grease and oils are used as lubricants in many mechanical systems such as rolling bearings and gears. In such systems, the energy efficiency, reliability, life time, and maintenance costs are determined by the quality of the lubrication of contacting surfaces. In order to increase the understanding of the lubrication mechanisms and thereby increase the efficiency and quality of the lubrication an enhanced knowledge in how the grease flows is of high importance. The goal with our work within this area is to obtain a better understanding of the correlation between grease rheology and grease flow which is fundamental for the understanding of the lubrication mechanism. Of specific interest is the development of new analytical/numerical flow- and rheology models which together with validating flow visualizations seek to resolve the flow properties of grease. Special attention is given to fresh versus mechanically aged greases, green greases (since they will replace many of today's conventional greases, especially in total loss applications), dispersed particles in grease, and influence of temperature on flow.
New greases based on partially fluorinated lubricants (PFPE-PAGs)

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**Key Words:** fluorinated additive, fluorinated grease

**Synopsis**

A new family of greases based on partially fluorinated lubricants, named PFPE-PAGs, was prepared and characterized in comparison with conventional perfluoropolyether (PFPE) greases. PFPE-PAGs were also evaluated as additives for perfluorinated greases showing improved anti-wear properties. An overview of the typical properties and the tribological behavior of the grease formulations will be presented.
Rust Never Sleeps: An Investigation of Corrosion in Grease Lubrication

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Joe Kaperick is a R&D Advisor for Greases at Afton Chemical Corporation. Joe began working for Afton in their St. Louis manufacturing facility as an Analytical Chemist in 1991 and moved to their Richmond, Virginia headquarters in 1994. Joe received a Master’s Degree in Analytical Chemistry from St. Louis University as well as undergraduate degrees in Chemistry, Fine Arts and Classical Humanities. He has been in the Industrial R&D area with a primary focus on Grease since 1999.

Joe is currently serving as Treasurer for the Executive Committee of NLGI, and has been recognized as a Certified Lubricating Grease Specialist by NLGI. He is also a member of STLE, the chair of the joint NLGI/ELGI Working Group on Grease Particle Evaluation, and the Chair of Section G.01 Chemical and Laboratory Tests for ASTM.

Key Words:

Synopsis

Corrosion of steel or iron doesn't just happen "out of the blue". Rust causes damage to untold numbers of machine components not only through direct electrochemical erosion of the metal but through incidental increase in pitting and wear caused by the iron oxide particles. Properly designed rust protection strategies can extend the life of equipment as well as extend lubricating intervals. While grease itself can inhibit some corrosion by reducing ingress of moisture, the addition of rust or corrosion inhibitors is often needed to give additional protection. There is as wide a variety of additive solutions as there are different corrosion tests to screen their effectiveness. An overview of the mechanism of corrosion along with case studies examining additive solutions to the prevention of corrosion in various grease-lubricated applications will be presented.
# Spherical Molybdenum Disulfide (SMD) in friction applications

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**Dr. Yakov Epshteyn** is a Chief Lubrication Engineer in the Climax and is active in the development and optimization of Climax molybdenum disulfide products. Previously, he worked at Rohm and Haas (now Dow Chemical) as a Chemical – Mechanical Polishing (CMP) technologist and technical manager. Additionally, he held CMP engineering positions at Novellus and Atmel. Dr. Epshteyn has published extensively and holds several patents in the area of tribology, lubrication and CMP. He received a PhD in friction and wear of materials (tribology) from the Don State Technical University in Rostov-on-Don, Russia.

**Authors:** Dr. Yakov Epshteyn, 
**Co-authors:** Dr. Manfred Jungk - Dow Corning GmbH; Alejandra Banda, Barbara Buck - Climax Molybdenum, A Freeport-McMoRan Company

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**Key words**
Molybdenum disulfide, spherical molybdenum disulfide, lubrication, friction, wear, brake pads

**Synopsis**

Molybdenum disulfide (MoS$_2$) is one of the best known solid lubricants and is commonly found in a variety of lubrication and friction applications. In automotive brake pads, MoS$_2$ is commonly used as a friction modifier to adjust and stabilize the friction coefficient, to eliminate squeaking noise, and for better uniformity of the distribution of friction forces across the brake pad surface.

Climax Molybdenum has recently developed and patented a new form of MoS$_2$ - Spherical Molybdenum Disulfide (SMD).

This presentation reviews the lubrication properties of brake pads containing Spherical Molybdenum Disulfide (SMD) made by Dow Corning Co. It was established that brake pads containing novel SMD material demonstrated significantly improved coefficient of friction and wear resistance properties when compared to brake pads with conventional MoS$_2$ powder.