The Future of Lubricant Formulations

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Introduction

The lubricant industry has always relied heavily on fossil resources such as crude oil and natural gas; however, as the global market makes a concerted effort to shift away from fossil fuels due to CO_2 & climate policies, lubricants must adjust. Environmentally acceptable lubricants [EAL's] synthesized from animal fats, vegetable oils and biomasses have emerged as the front-runner to lead the lubricant industry into this new era.

Sustainability is Key

It is important for the lubricants industry to ensure sustainability during this push for ready/ultimate biodegradability as if the ideal product proves to be too costly, the products will not benefit either the producer or the client. Furthermore, if the product is derived from biomass too difficult to replenish, it could be problematic in the future as production would halt due to lack of resources. Fortunately, EAL's such as synthesized esters and polyalkylene glycols are replenishable, are becoming increasingly cost efficient, have high performance, and can be designed for a variety of functions.

Market Analysis

Moving forward, the lubricants industry has been placed in a very advantageous position. Shown below in figure 3 is a list of the largest consumers of lubricants in the world. Among those, Europe and the United States are among the world leaders in environmental reforms/regulations and have been gradually pushing towards more environmentally friendly products. This bodes well for the lubricants industry as the two leading consumers of lubricants will be moving in the same direction as the industry. This means there is no fear of losing a consistent consumer base as the lubricants industry moves towards a more environmentally acceptable product.

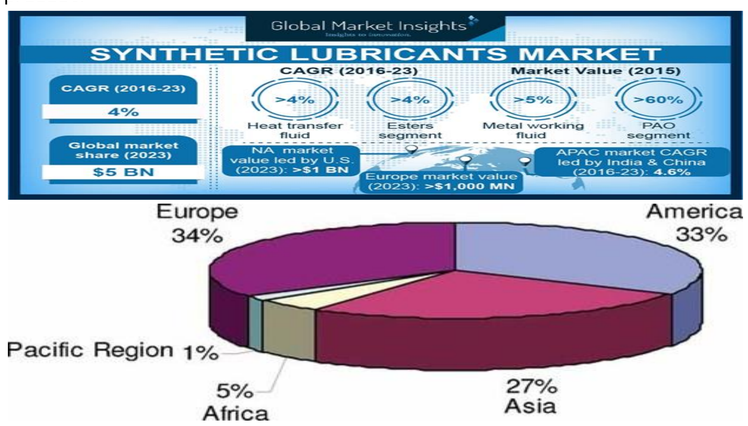

Figure 3. Salimon, J., et al., "Biolubricants: raw materials, chemical modifications, and environmental benefits," Eur. J. Lipid Sci. Technol. 1

Biolubricants: Raw materials, chemical modifications and environmental benefits

Striving for Biodegradability

Factors such as environmental toxicity certainly play a large role in developing EAL's, but the chief concern lays in biodegradability. Ready/ultimate Biodegradability, the measure of the breakdown of a chemical, occurs in two phases. Primary Biodegradation, the first phase, occurs in the intermediate portion of the overall degradation reaction where one or more of the active groups is lost resulting in an inactive compound. Ultimate biodegradation [or total mineralisation], the final phase, is where the leftover biomass is fully reduced into carbon dioxide and water. Moving forward, the lubricant industry should look to prioritize R&D in maximizing primary biodegradation as it minimizes the amount of time the chemical spends in the environment which results in a more desirable product.

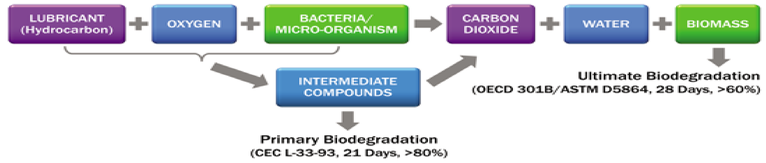

Figure 1. Simplified Representation of the Biodegradation Process for Lubricants. Dr. Kumar, R, *Machinery Lubricants*, 2012, What You Should Know About Environmentally Friendly Lubricants

Emergence of Electric Vehicles (EV's)

Another very important factor to consider for the lubricants market is the recent explosion in popularity of EV's. With the advent of Tesla along with luxury car brands like BMW, Cadillac, and Mercedes Benz slowly transitioning to EV's the lubricants industry must respond to this change. Generally, EV's require much less liquid lubrication than internal combustion engines and the lubrication it does need must be highly specialized to fit this unique purpose. EVs will consume much more greases and call for functionalized fluids/lubricants due to the cooling needs and electrostatic fields created from magnetic fields.

Figure 4. Electric Car Charging. theconversation.com, *Millions of electric cars will need charging in future – but how?*, 2020, Millions of electric cars will need charging in future – but how?

Tests for Biodegradability

There are many biodegradation tests in place, of which some are interchangeable. For the future, much more precision statements for lubricants and formulations must be established. ASTM disposes of few data and EN17181 published the first precision data dedicated to lubricants. Shown below are some of these tests and the aspect of biodegradability they are testing.

Test Type	Test Name	Measured Parameter	Pass Level	Method
Ready Biodegradability	DORT	DOC	>70%	OECD 301A
	Strum test	CO_2	>60%	OECD 301B
	MITI test	DOC	>70%	OECD 301C
	Closed bottle test	BOD/COD	>60%	OECD 301D
	MOST	DOC	>70%	OECD 301E
	Sapromat	BOD/COD	>60%	OECD 301F
	Strum test	CO_2	>60%	ASTM D-5864
	Shake flask test	CO_2	>60%	EPA 560/6-82-003
	BODIS test	BOD/COD	>60%	ISO 10708
Hydrocarbon degradability	CEC Test	Infrared Spectrum	>80%	CEC L-33-A-93A
Screening tests	CO_2 headspace test	CO_2	>60%	ISO 14593

Figure 2. Internationally Standardized Test Methods for Measuring Biodegradability. US EPA, *Environmentally Acceptable Lubricants*, 2011. Environmentally Acceptable Lubricants.

It should be noted that lubricants derived from biomass such as vegetable oils, animal fats, or algae performed excellently in all of these tests, particularly most Polyalkylene Glycols [PAG's] and esters performed well in these tests. Considering that they; can be readily synthesized, are based on renewables, have very high viscosity indices and low pour points resulting in much less friction in the system, they are very good option as an alternative. Moving forward, the lubricants industry should consider investing more R&D into polyalkylene glycols. All lubricants could be fully sourced from biomasses, because the 0.040 gigatons are little in comparison to the global streams of 24 gigatons of biomasses of any kind.

Conclusion

The lubricants industry, while currently in a good position, is approaching a rather tumultuous time as the market shifts both towards EAL's and EV's. They are not without hope however, as many readily available options such as synthesized PAG's and esters have proven to be very promising in the market. Furthermore, as long as the lubricants industry continues to invest R&D into these EAL's for more diverse applications, no consumer base will be lost.

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