Overview

- The constant evolution of automobiles and emissions regulations places a need for constant innovation of engine oil formulations.
- Growing needs for lower viscosities and improved friction properties at wider operating boundaries will require an alternative to traditional petroleum base oils.
- Alternative base oils present an opportunity to improve fuel economy and performance necessary for next generation engines.

Base Oil: Definition

A base oil can be considered as one of the fundamental ingredients that make up all engine oils and lubricant formulations. For engine oils, the base oil makes up around 75% to 80% of an engine oil, which is the vast majority of the product. The figure below shows the typical percentages of the ingredients used to make engine oil. Base oils are typically produced by refining crude oil and are categorized by the API into groups I-V with increasing levels of refinement. Groups I-III are traditional base oils refined from crude oil with increasing levels of refinement and lubricating properties. Group IV consists of polyalphaolefins (PAOs) and represent a class of synthetic base oils. A sub-class of PAOs known as oil-soluble polyalphaolefins (OSPs) possess a similar aspect but in their molecular structure.

Typical Non-Petroleum Based Base Oils

Although the majority of base oil is derived from crude oil, the alternative base oils that fall within the higher API base oil groups IV and V possess a number of properties that often exceed that of their crude oil derived counterparts. As such, numerous alternative base oils are available to manufacturers. The table below summarizes some of the strengths and weaknesses of the classes of common alternative base oils. These typically consider biodegradability, viscosity index (VI), oxidative stability, volatility, wear resistance, and lubricity for engine oils. Many Group V base oils listed on the table are being investigated recently due to their capabilities in lower viscosity/friction engine oils. Esters and PAGs in particular have much lower NOACK evaporation at low viscosities due to their molecular polarity inherent to their molecular structure.

Advantages of Esters and PAGs

Esters and PAGs both possess an oxygen atom within their carbon backbone that gives them unique advantages over traditional petroleum base oils. The additional polarity caused by the presence of the oxygen atom improves lubricity, viscosity index, and reduces NOACK evaporation but simultaneously reduces compatibility with polymeric materials used in additive packages. Esters in particular have strong viscosity index, thermal/oxidative stabilities, and reduced NOACK volatility which has made them promising for high temperature low viscosity engine oils but may suffer from thermal degradation. They also are capable of qualifying as an environmentally acceptable lubricant (EAL) as per the US Vessel General Permit. PAGs on the other hand, possess similar characteristics such as high lubricity, high viscosity index, and low NOACK evaporation, but possess uniquely high heat capacities over both esters and hydrocarbons as shown in the figure above that make them suitable for high temperature low viscosity engine oils with greater viscosity retention and film-forming abilities to reduce wear. They are also capable of blending with other base oils/formulations due to their capability of being water and oil-soluble allowing for greater flexibility in engine oil applications and easier maintenance/cleaning.

Conclusion

- Alternative base oils can improve fuel economy and performance as they can leave the engine oil cleaner for much longer compared to the traditional engine oil and reduce the material footprint.
- This increases vehicle mileage and allows the vehicle to reduce CO2 emissions without having to replace the engine.
- In the near future, it can be expected that there will be more lubricant formulas that incorporate alternative base oils.

References

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Oil-Soluble PAGs and Bio-Olefins

A sub-class of PAGs known as oil-soluble PAGs (OSPs) possess the advantages of PAGs but with significantly greater flexibility in formulation that allows for a wide range of operating applications as shown in the table to the left. Bio-olefins possess a similar aspect but in their feedstocks as bio-olefins can be produced from a wide array of biomass feedstocks. Through processes such as fermentation, distillation, etc., greener algae and sugar from yeast cells can be converted into useful oxygenates/olefins such as ethylene that possess similar advantages as PAGs and Esters.