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Effect of Organic Friction Modifiers on the Tribological Performance of Engine Oils

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ABSTRACT

A commercial engine lubricant is composed of base oil(s) and additives for enhanced engine performance. The viscosity of the base oil mainly determines the friction in the EHL regime. However, under boundary and mixed regime the tribological behavior mostly depends on the friction modifiers (FMs) and Anti wear (AW) additives and therefore has a decisive role to play in reducing friction and wear of moving mechanical components[1]. One of the important class of FMs that are key additives for engine oil performance optimization is organic friction modifiers (OFMs)[2]. OFMs are amphiphilic surfactants where the polar head is anchored on the metal surface thereby forming a low shear strength plane that facilitates low friction [3]. As there will be a marked increase in the contribution of piston to engine friction in the future, OFMs mostly based on straight saturated alkyl chain with small polar head groups may not meet the performance demands. Therefore, new OFMs that can operate effectively under harsher conditions that are more prevalent in IC engines are needed for the future. To develop novel systems, a deeper understanding of the functional mechanism of model OFMs is needed.

In this study, the influence of OFM types, chain length and levels of unsaturation of model OFMs (*Table 1*) on the tribological performance was investigated using a Mini Traction Machine under a wide range of sliding/rolling conditions. Model base oils with different polarity were selected for investigation.

As the surface-active molecules has an affinity for steel, understanding the nature of adsorption is vital to develop friction modifiers for next generation engine lubricants. Quartz Crystal Microbalance with Dissipation monitoring (QCM-D) is a convenient tool to study the physical and chemical interactions that occur on the surface. Here QCM-D was employed to study in-*situ* the kinetics of adsorption and structural changes on a stainless steel (SS2343) coated quartz crystal. Sauerbrey equation and Voigt model were utilized to study the mass of adsorption and kinetics of adsorption was obtained using Langmuir Isotherm model.

The QCM-D results were related to the effectiveness of OFMs in reducing friction at macroscale. The difference in tribological performance as a function of the type of oil and additives is also presented.

Table 1: Different types of OFMs employed in the study.

OFM Chemistry	Research objective
An amide, amine and acid	To investigate the influence of OFM types on tribological performance
Acids with different chain lengths (C_{18}, C_{20} and C_{22})	To study the influence of chain length on frictional response
A saturated and unsaturated acid with 18 carbon atoms	To examine the influence of levels of unsaturation on the observed friction

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