

## Friction Modifiers for Next Generation Engine Oils

### Introduction

Legislation on improving fuel economy and reducing emissions continues to drive innovation throughout the automotive industry, throughout the world. OEMs have adopted numerous technologies to achieve these targets; for example engine downsizing and turbo-charging, hybridisation, improving aerodynamics, light weighting the vehicle, stop-start technology, and a whole host of other technologies.

OEMs and lubricant formulators are also actively working together, seeking new ways to formulate engine oils to minimise parasitic energy losses.

Lubricants can contribute to reducing frictional losses in two ways:

1. reduce the friction associated with churning and pumping of the lubricant (hydrodynamic conditions) by modifying the rheological properties of the oil, achievable by using low viscosity engine oils (which require high quality, low viscosity base oils) and viscosity modifiers
2. reduce friction in the boundary and mixed lubrication regimes through the use of friction modifiers.

### Friction Modifiers

Friction modifiers are typically split into two categories; organic and inorganic.

Traditional organic friction modifiers (OFMs) include partial esters and fatty amides such as glycerol mono-oleate and oleyl amide. Following the successful development of a new range of products, Croda can now add polymeric friction modifiers to the range of organic friction modifiers. OFMs typically have a polar head-group which enables the OFM to adsorb onto the metal surface, and a non-polar hydrocarbon backbone which is required to maintain oil solubility and to enable film formation between contacting surfaces.

Inorganic friction modifiers also contain non-organic elements, such as sulphur, phosphorus and molybdenum. Inorganic FMs chemically break down to form products able to chemisorb onto metal surfaces, forming low shear strength films. An example of an inorganic friction modifier that is widely used in Japanese engine oils in particular is molybdenum dithiocarbamate (MoDTC).

### Polymeric Friction Modifiers

Over the past 5 years Croda has developed and commercialised a range of organic polymeric friction modifiers (PFMs) that offer exceptional benefits in reducing friction in the boundary and mixed lubrication regimes. Due to their polymeric nature, PFMs effectively have more anchoring points available to adsorb onto the metal surface than conventional organic friction modifiers, which typically have only one or two anchoring points. This alone however isn't the answer to achieving exceptionally low friction; to achieve this requires a unique combination of novel polar head groups with novel oil soluble backbones.

Croda has developed three polymeric friction modifiers, their typical physical properties are shown below:

	Perfad 3000	Perfad 3006	Perfad 3050
Physical Form	Viscous liquid	Viscous liquid	Viscous liquid
Colour	Dark brown	Dark brown	Dark brown
Dynamic viscosity @ 40 °C (mPa.s)	10640	6400	114000
Dynamic viscosity @ 60 °C (mPa.s)	2730	2000	23300
Dynamic viscosity @ 80 °C (mPa.s)	990	800	6690
Dynamic viscosity @ 100 °C (mPa.s)	440	360	2700
Iodine Value (g/100g)	25	1.1	6.5
Acid Value (mgKOH/g)	7.5	1.2	4
Density @ 20 °C (g/ml)	0.97	0.98	0.97
Flash Point (°C)	270	269	280
Pour Point (°C)	>21	4	>21

### Testing Friction Modifier Performance

Historically friction modifier performance has been demonstrated in relatively simple systems; base oil + FM and base oil + zinc dialkyldithiophosphate (ZDDP) + FM. This method has proved very successful in understanding the performance of FMs in combination with such a universally used anti-wear additive. The issue with this type of testing has been that ZDDP is not the only surface active additive in engine oils, one must also evaluate how FMs perform in combination with a range of surface active additives such as detergents and dispersants, viscosity modifiers etc., as well as considering how they perform in different base stocks.