Outline

• Who are Infineum and what do we do?
• Engine oil and engine function
  – Destructive processes in the engine environment
• Overview of oil additives
• Collaborations with UK Universities
  – Criteria for selection
  – What would we like to work with Warwick on
Infineum in our everyday life

Infineum additives are in over 200 million motorcycles worldwide

Infineum additives are inside 1 in 3 vehicles

We operate in every continent

Our fuel additives treat more than 150 million tons of diesel fuel/year

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Business Profile

- Independent additives company with an annual revenue in excess of $3 billion
- Worldwide resourcing of approximately 1,600 colleagues in multicultural and multifunctional teams
- Globally positioned
  - Global Corporate HQ in UK with regional business centres in the UK, USA, China and Singapore
  - Sales and Marketing representation in more than 70 countries
  - R&D facilities in the UK, USA, China, Japan and Singapore
  - Global manufacturing facilities strategically located
A truly global company
Destructive processes in the engine

What destructive process are present in the engine?

1. Combustion
2. Oxidation
3. Friction and Wear
4. Rust and Corrosion
5. Shear
   - Mechanical degradation
   - ‘Tearing apart’
Destructive processes in the engine

Fuel combustion

- **Ideal situation** – Complete combustion of fuel with oxygen
  
  \[
  \text{Fuel + Air} \rightarrow \text{Energy} + \text{CO}_2 + \text{H}_2\text{O}
  \]

- **What actually happens** – Incomplete combustion of fuel produces undesirable by-products
  
  \[
  \text{Fuel + Air} \rightarrow \text{Energy} + \text{CO}_2 + \text{H}_2\text{O} + \text{NO}_x + \text{SO}_x + \text{CO} + \text{HC} + \text{Particulate Matter (PM-Soot)} + \text{Radicals}
  \]

- **Result** – Accelerate the oxidation and degradation of engine oil, viscosity increase, acid build-up, corrosive wear and deposits
Balance of additives and base oil
what’s in a typical oil formulation

Key is balancing the additives for the application.
Dispersants

- **Functions**
  - Suspend soot (carbonaceous particles)
  - Inhibit and disperse sludge
  - Reduce formation of deposits
  - Keep things clean
  - Typical composition
  - Metal free (ashless)
  - Polyisobutene succinimide (PIBSA PAM)

![Polyisobutylene Oleophile (oil-loving)](image)

**Polyisobutylene**

![Succinic Acid](image)

**Succinic Acid**

![Polyalkylene Amine](image)

**Polyalkylene Amine**

= PIBSA/PAM
Detergents

- Functions:
  - Neutralise acidic species (sulfur oxides and organic acids)
  - Reduce lacquer, carbon and varnish deposits on the engine’s pistons
  - Prevent ring sticking under severe high-temperature operating conditions

- Typical compositions – colloidal
  - Alkylated metal sulfonates, sulfurised phenates, salicylates
  - Neutral or overbased (Excess base)
Antiwear Agents and Friction Modifiers

General function and types

• Function
  – Reduce metal-metal wear

• Types
  – Zinc-based: zinc dialkyldithiophosphates (ZDDP)
    • Engine oils
  – Molybdenum-based: molybdenum dithiocarbamates (MoDTC)
  – Phosphorus-based: tri-cresyl phosphate
    • ATF, gear, aviation
  – Extreme pressure: highly reactive sulfur-phosphorus compounds
    • Gear oils
  – Friction modifiers
    • Organic molecules like GMO
Friction modifiers organic

- Molecular geometry is similar to detergents (surfactant)
- Act “intact” (not chemically transformed at the surface)
- Examples include oleic acid and glycerol mono oleate (GMO)

![Diagram of Friction modifiers organic](image-url)

**Glycerol monooleate**

Performance you can rely on.
Friction modifiers inorganic

Solid friction modifiers
- Molecular geometry describes a “flat plate”
- Act after chemical transformation at the surface
- Examples include molybdenum disulphide (MoS$_2$) from molybdenum trimer (MoDTC)
Antioxidants

- Primary antioxidants (chain stopping, radical traps)
  - Hindered Phenols
  - Alkylated DiPhenyl Amines (DPA)

\[
R\bullet + \text{In-H} \quad \xrightarrow{\text{Reactive}} \quad R-H + \text{In}\bullet \quad \xrightarrow{\text{Stable}}
\]

Where: In-H = inhibitor

- Secondary antioxidants (peroxide decomposers)
  - Zinc Dialkyl Dithiophosphates (ZDDP)
  - Molybdenum Dialkyldithiocarbamates (MoDTC)
  - Thioethers

\[
\text{ROOH} + \text{PD} \quad \rightarrow \quad \text{ROH} + \text{PD}[O]
\]

Where:
- ROOH = Peroxide
- PD = Peroxide decomposer
- ROH = Alcohol
- PD[O] = Oxidised peroxide decomposer
Viscosity modifiers

- **Ethylene-Propylene Co-polymer (OCP)**
  - Can be semi-crystalline or amorphous depending on structural details

- **Polymethacrylate: (PMA)**

- **Hydrogenated Styrene-Diene: Linear Polymer**

- **Hydrogenated Styrene-Diene: Star Polymer**
  - Chemically bonded together
  - Loose physical association due to polarity differences
Criteria for selection of a university/department

Infineum targets external projects in a limited number of areas at key universities based on:

1. Appropriate Skills of the department/academic
2. Ease of working with (e.g. contract/IP negotiations, previous experiences)
3. Partner University
4. Ongoing relationship with key academics
5. Connections with other programmes
6. Other Possible benefits, idea generation etc.
7. Cost
Working with Warwick

- **Areas for potential collaboration with Warwick University**
  - Identification of trace contaminants in complex sample mixtures
  - High end analytical techniques (high end for the lubricant industry)
  - Custom synthesis (we are already working with Peter Scott’s group on this)
  - Process development, continuous processing etc.
  - NAIC, Engine understanding, lubricant development/formulation work
  - More work with chemistry and physics into calcium carbonate based detergents
  - Work on fuels additives in conjunction with Warwick Chemistry
  - Potential for collaboration with non-competing industries
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