Solving Today’s Lubricant Challenges

with

UCON™ OSP

Brian Goldstein, Product Marketing Manager
goldstein@dow.com
40 Million MT of lubricant sold annually

Dominated by products based on mineral oils

Major applications:
- Auto-engine oils
- Auto-gear/transmission oils
- Hydraulic fluids, process oils
- Metalworking fluids
- Greases
- Compressor oils

Synthetic market is growing at 6% / year

Major chemistries:
- Polyaalphaolefins
- Synthetic Esters
- Polyalkylene Glycols
- Synthetic esters, 24%
- Other, 12%
- Polyisobutylene, 9%
- Polyalkylene glycols, 20%
Why Are PAGs Used?

As primary base oil formulations
- Compressor & refrigeration oils
- Hydraulic fluids
- Textile lubricants
- Gear & bearing oils

As additives
- Viscosity builder in water glycol hydraulic fluids
- Lubricity aid in

Formulated into fluid systems engineered for unique and demanding applications

- Viscosity index
- Oil miscibility
- Pour points
- Elastomer compatibility
- Deposit control
- Biodegradability
- Antiwear
- Oxidation stability
- Hydrolytic stability
- Hygroscopicity

Arbitrary scale but higher values preferred
Why are PAGs Overlooked?

**Recognized positive attributes of PAGs**

- **High viscosity indices**
- **Good low temperature behavior**
- **Good deposit control**
- **Hydrolytic stability**
- **Excellent film forming properties**

**Disadvantages**

- **Oil miscibility**
- **Hygroscopicity**
- **Elastomer compatibility**

**Perceived negative features of some PAGs**

**Dow’s Challenge:**
To develop PAGs which overcome the *perceived* disadvantages but retain the known advantages

**As primary base oil formulations**
- Compressor & refrigeration oils
- Hydraulic fluids
- Textile lubricants
- Gear & bearing oils

**As additives**
- Viscosity builder in water glycol hydraulic fluids
- Lubricity aid in water miscible MWFs

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**Why are PAGs Overlooked?**

Recognized positive attributes of PAGs

- High viscosity indices
- Good low temperature behavior
- Good deposit control
- Hydrolytic stability
- Excellent film forming properties

Disadvantages

- Oil miscibility
- Hygroscopicity
- Elastomer compatibility

Dow’s Challenge: To develop PAGs which overcome the perceived disadvantages but retain the known advantages
Overcoming Objections

- Significant potential for PAG polymer design
- Changes in polymer chemistry can expand functionality & improve performance

![Graph showing various properties of PAGs](image)

**Primary base oil in formulations**
- Engine/transmission oils

**Co-base Oil**
- Upgrade group I-III mineral oils
- Upgrade PAO's

**Additives**
- Deposit control additive
- Friction modifier
- Viscosity builder in mineral oils

Arbitrary scale but higher values preferred
Overcoming Objections

- Significant potential for PAG polymer design
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Primary base oil in formulations
- Engine/transmission oils

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Additives
- Deposit control additive
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- Viscosity builder in mineral oils

Arbitrary scale but higher values preferred

New OSPs

Traditional PAGs
Providing an Emerging Frontier

Performance Attributes of PAGs

... Compatible with Most Mineral Oils & PAOs ...

A Possible Alternative to Esters

“ I doubt if Dow realizes what you have with OSP. This is the first truly new base fluid for the lubricants industry since the introduction of PAO’s! ”

Rick Butler, Technical Manager for Fluids
Chemtool, Inc.
What Are UCON™ OSPs?

UCON™ OSPs are a new API Group V base oil and are also multifunctional performance enhancing additives

As Performance Enhancing Additives in Hydrocarbon Oils they can:

- Improve deposit control, reduce varnish potential (extend oil life and reduce maintenance costs)
- Act as friction modifiers and provide improved energy efficiency
- Provide solvency for additives that are difficult to formulate with

As Base Oils they offer:

- Excellent oxidation stability and low temperature properties
- High viscosity indices
- Availability in all key viscosity grades
## Enhanced Benefits of UCON™ OSPs

<table>
<thead>
<tr>
<th>Benefit</th>
<th>Result</th>
</tr>
</thead>
</table>
| Oil miscibility          | a) Simplifies equipment conversions from a mineral oil to a fully synthetic OSP lubricant  
b) Allows OSPs to be used as performance enhancing additives to upgrade hydrocarbon oils |
| Deposit control          | Protects equipment from varnish formation, ensuring better equipment reliability                                                        |
| Friction control         | Improves energy efficiency when OSPs are used as friction reducer additives                                                             |
| Hydrolytic stability     | Offers an alternative to esters and can extend lubricant life and fluid change over intervals                                            |
| Corrosion Inhibition     | Provide corrosion inhibition while working within the same product family                                                            |

Ongoing R&D has identified additional benefits…
## Additives for Other Synthetics

**Performance Booster**

### Polyalphaolefins

<table>
<thead>
<tr>
<th>Challenge</th>
<th>UCON™ OSP Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. As additives UCON™ OSPs can negate PAO seal shrinkage by mildly swelling some elastomers, enhancing compatibility</td>
<td></td>
</tr>
<tr>
<td>2. Provide higher solvency for difficult to solubilize additives</td>
<td></td>
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<tr>
<td>3. Control deposit</td>
<td></td>
</tr>
<tr>
<td>4. Improve friction control</td>
<td></td>
</tr>
</tbody>
</table>

### Synthetic esters and vegetable oils

<table>
<thead>
<tr>
<th>Challenge</th>
<th>UCON™ OSP Solution</th>
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<tbody>
<tr>
<td>1. As additives UCON OSPs can improve the hydrolytic stability of some natural and synthetic esters</td>
<td></td>
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<tr>
<td>2. Help control deposits by solubilizing ester degradation by-products</td>
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</table>
## Physical Properties of UCON™ OSPs

### Typical Physical Properties*

<table>
<thead>
<tr>
<th>OSP</th>
<th>KV40 cSt</th>
<th>KV100 cSt</th>
<th>Viscosity Index</th>
<th>Pour Point °C</th>
<th>Flash Point, °C</th>
<th>Aniline Point, °C</th>
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<tr>
<td>UCON™</td>
<td>ASTM D445</td>
<td>ASTM D445</td>
<td>ASTM D2270</td>
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<td>OSP-68</td>
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<td>171</td>
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<td>OSP-150</td>
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<td>243</td>
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* Typical properties not to be construed as specifications.
## Ideal Applications & Uses for UCON™ OSPs

### Base Oil Uses

<table>
<thead>
<tr>
<th></th>
<th>OSP-18</th>
<th>OSP-32</th>
<th>OSP-46</th>
<th>OSP-68</th>
<th>OSP-150</th>
<th>OSP-220</th>
<th>OSP-320</th>
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<tr>
<td>Industrial Gears</td>
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<tr>
<td>Auto Engine Oils</td>
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<td>Metal Deformation</td>
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<tr>
<td>Greases</td>
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<td>X</td>
<td></td>
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</table>

### Additive Uses

<table>
<thead>
<tr>
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<th>OSP-18</th>
<th>OSP-32</th>
<th>OSP-46</th>
<th>OSP-68</th>
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<th>OSP-320</th>
<th>OSP-460</th>
<th>OSP-680</th>
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<tr>
<td>Viscosity Modifier</td>
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<td></td>
<td></td>
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<td>X</td>
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<tr>
<td>Deposit Control Additive</td>
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<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

OSP@dow.com
www.dowOSP.com
UCON™ OSP Applications

Hydrocarbon based Hydraulic, Compressor or Turbine Oil
- Deposit control and equipment reliability

Hydrocarbon based Auto-engine and Transmission oils
- Friction control and fuel economy
- Deposit control and extended lube life

Hydrocarbon based gear oil (especially PAO gear oils)
- Deposit control and extended lube life
- Seal swell and hydrolytic stability if replacing an ester

Metalworking Fluids
- Friction control and reduced tool life
- Fluid and equipment cleanliness
UCON™ OSP Applications

OSP Synthetic Hydraulic Oil
- Excellent air release – may reduce equipment design costs
- Deposit control and equipment reliability

OSP Synthetic Compressor Oil
- Friction control and energy efficiency
- Deposit control and extended lube life

OSP Synthetic Gear oil
- Lower frictional losses – energy efficiency
- Lower fluid temperatures – higher heat capacities – better oxidation stability
Here’s some of the data...
Boost Corrosion Inhibitors

Traditional corrosion inhibitors are often ineffective in passing the salt water corrosion test in conventional EO/PO PAG formulated lubricants

<table>
<thead>
<tr>
<th></th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>PAG (EO/PO random copolymer)</td>
<td>97.0</td>
</tr>
<tr>
<td>Additive package</td>
<td>2.75</td>
</tr>
<tr>
<td>Sodium dialkynaphthalene sulphonate*</td>
<td>0.25</td>
</tr>
</tbody>
</table>

Inclusion of an OSP base oil improves performance

<table>
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<tr>
<th></th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>PAG (EO/PO random copolymer)</td>
<td>92.0</td>
</tr>
<tr>
<td><strong>UCON OSP</strong></td>
<td><strong>5.0</strong></td>
</tr>
<tr>
<td>Additive package</td>
<td>2.75</td>
</tr>
<tr>
<td>Sodium dialkynaphthalene sulphonate*</td>
<td>0.25</td>
</tr>
</tbody>
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* Corrosion inhibitor; ** e.g. UCON OSP-46

24 hours ASTM D665 A and B
De-ionised Water
Synthetic sea water
Reduced Hygroscopicity

Hygroscopicity of ISO-VG46 PAG base oil chemistries
Relative humidity 80% and temperature 50°C

Water absorbing characteristics lower for OSPs than traditional PAGs
PAGs act as polymeric sponges binding water within the structures (water is not free at levels of several thousand ppm)
Typical values - Aniline points using ASTM D611-01

Additive technologies used to boost solvency in hydrocarbon oils

Oil Soluble PAGs can provide formulators another option for adding back some solvency power to Group II, III and IV base oils
Deposit Control Study
Concentration Effect of UCON™ OSPs

Group I Mineral Oil

Group I Mineral Oil + OSP-46 (1%) Deposit formation

Group I Mineral Oil + OSP-46 (5%) Deposit free

Group I Mineral Oil + OSP-46 (10%) Deposit free

Modified ASTM D2893B at 120°C Minor deposit

OSP@dow.com
www.dowOSP.com
Deposit Control Study
UCON™ OSP versus Esters and Alkylated Naphthalenes

**Group I Mineral Oil**

- 0 day: Clear oil
- 14d: Oil with visible deposit
- 50d: Oil with heavy deposit

**Group I Mineral Oil + OSP-46 (10%)**

- 0 day: Clear oil
- 14d: Deposit-free oil
- 50d: Deposit-free oil

**Group I Mineral Oil + Synthetic Ester (10%)**

- 0 day: Clear oil
- 13d: Oil with deposit
- 41d: Oil with heavy deposit

**Group I Mineral Oil + Alkylated Naphthalene (10%)**

- 0 day: Clear oil
- 13d: Deposit-free oil
- 41d: Deposit-free oil
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