New Oil Soluble Polyalkylene Glycols (OSP) for Grease Manufacture

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DOW Lubricant & Fuel Additives

Introduction

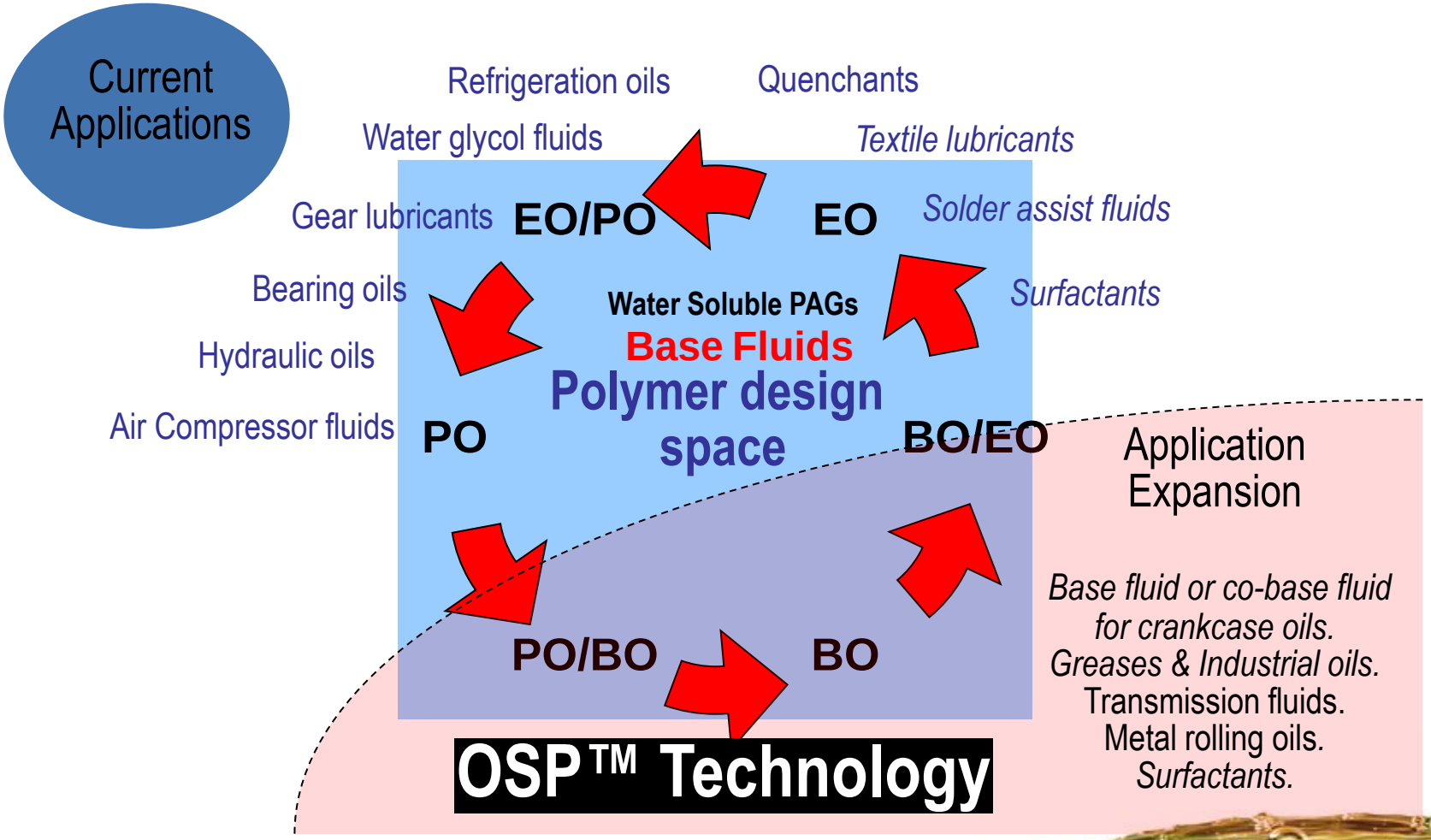
- New OSP technology offers many benefits in grease formulations
- OSPs offer options to upgrade hydrocarbon oils, naphthenic oils and synthetic base fluids to boost solvent power and improve additive compatibility
- **OSP-based Premium Lithium complex Grease provides**

  Significantly higher temperature performance
- The flexibility of PAG chemistry provides a huge amount of space for innovation and providing solutions to specifications and standards of the future

What is Grease?

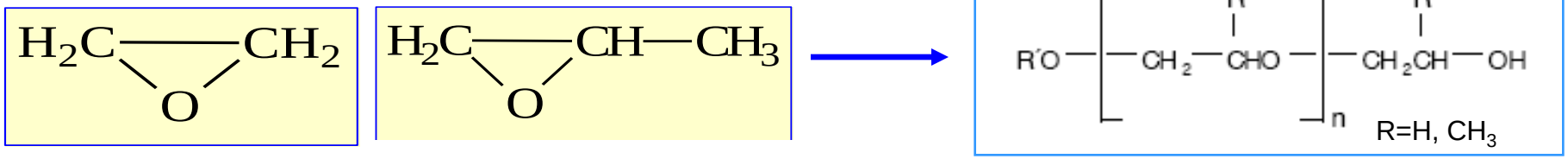
- Grease is a combination of oil, additives and a thickener
- The oil and additives serve the same function as in a lubricating oil
- The thickener converts the liquid lubricant to a semi-solid lubricant
- A grease can't be any better than its base oil

Evolution to OSP™ Technology

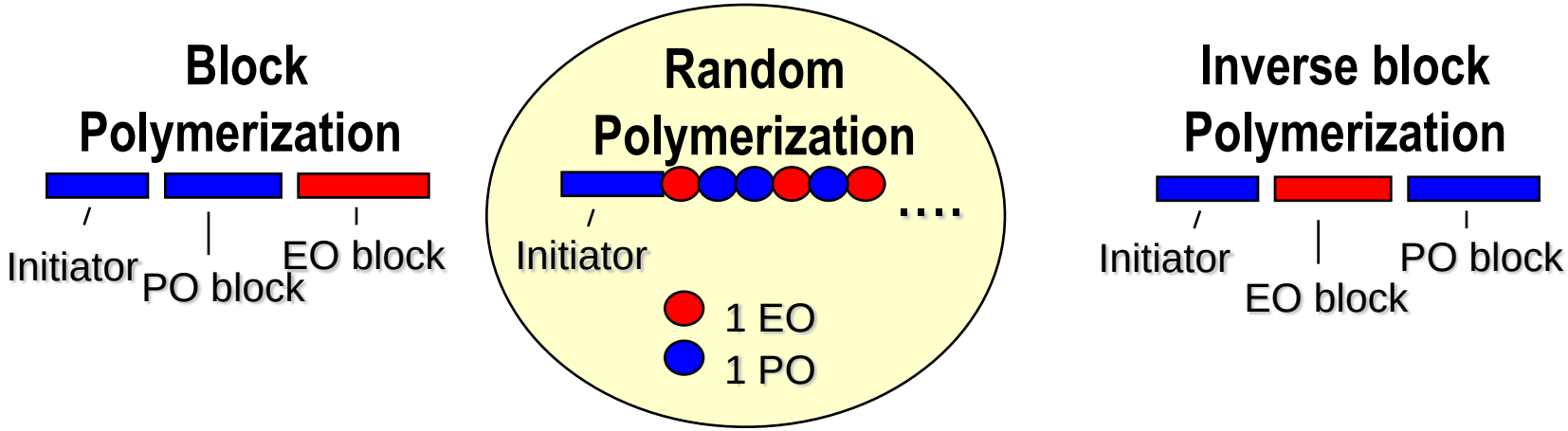


Traditional PAG Polymerization Technologies

Ethylene oxide (EO) **Propylene oxide (PO)**



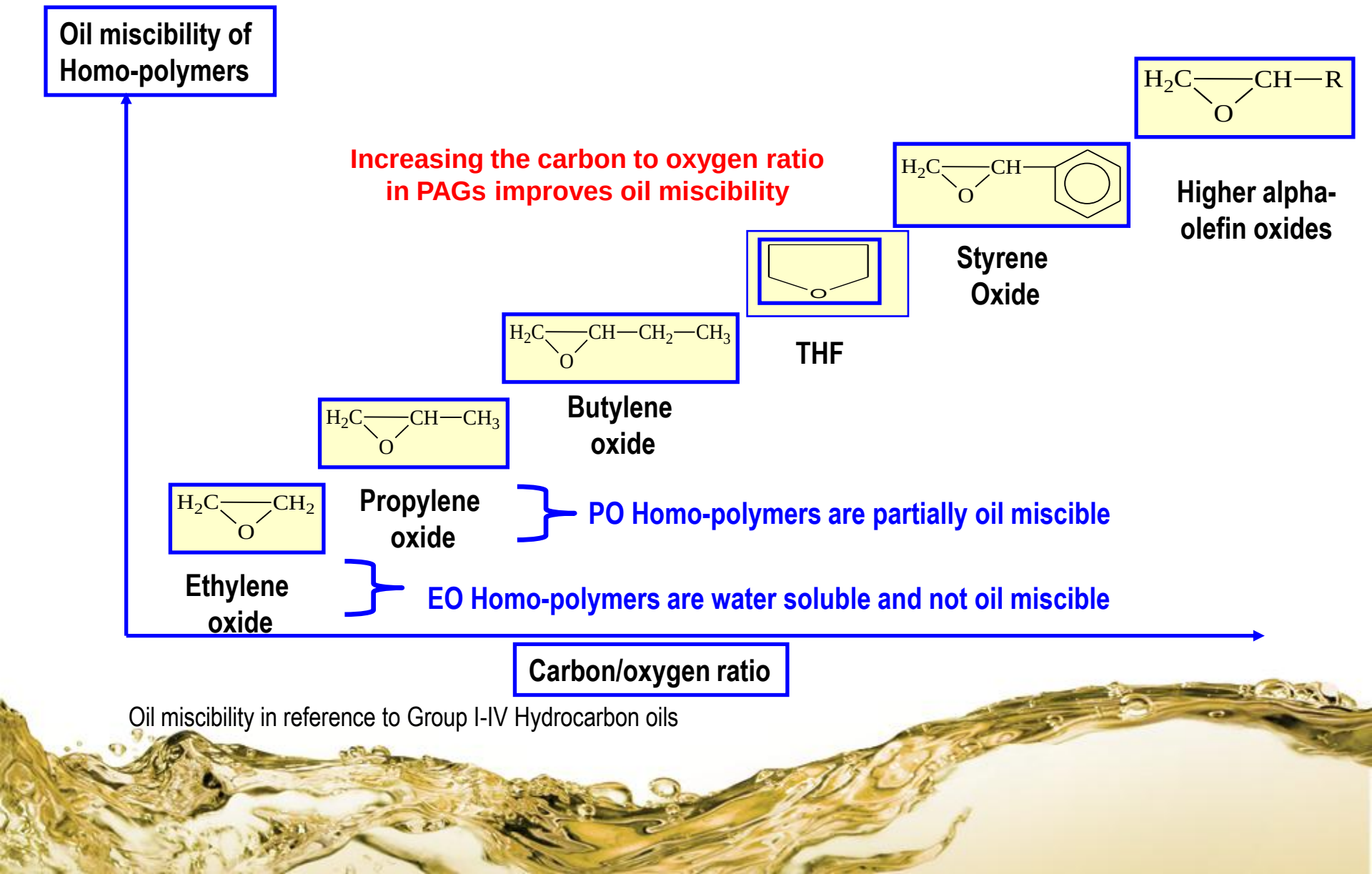
CLASSICAL POLYMER STRUCTURES BASED ON EO & PO



Initiators are typically monols, diols or triols
(for example butanol, propylene glycol, glycerol)

- **Polymers can be designed having a wide range of viscosities (10-20,000 cSt at 40°C)**
- **Extremely versatile and can be tailored designed to have many specific functionalities**

Synthetic Options in Designing Oil Soluble PAGs



Oil miscibility in reference to Group I-IV Hydrocarbon oils

Oil Soluble Polyalkylene Glycols – Benefits

BENEFITS

- ✓ Availability in a very wide range of viscosity grades with design flexibility
- ✓ High viscosity index
- ✓ Good low temperature properties
- ✓ Excellent deposit control and equipment cleanliness
- ✓ Hydrolytic stability
- ✓ Safe to Use

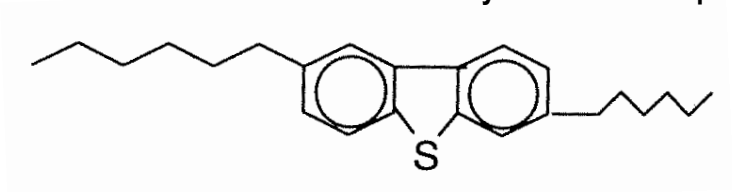
NEW BENEFITS

- Δ Oil Miscibility (Compatibility)
- Δ Low Aniline Point
- Δ Solvency Provider
- Δ Excellent Capability for Additive Solubility

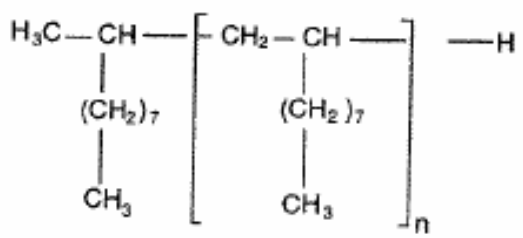
What is Different?

CHEMICAL COMPOSITION: POLYALKYLENE GLYCOL VS. HYDROCARBON OILS

Mineral Oil – Petroleum- based Hydrocarbon Group I Base stock



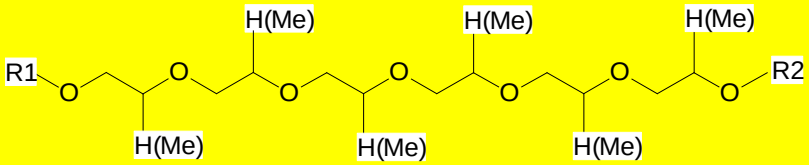
PAO- Poly Alpha Olefin- Synthetic Hydrocarbon Oil Group IV



Non-Polar

Heavily additized for oxidation stability and has poor solvency

PAG – Poly Alkylene Glycol Base Fluid Group V



Polar

Inherently thermo-oxidatively stable with high VI

OSP Typical Properties

OSP Grade	Aniline point temperature, °C	Viscosity at 40°C, cSt	Viscosity at 100°C, cSt	Viscosity Index	Pour point, °C	Flash point (COC), °C	Fire point, °C
OSP-32	< -30.0	32	6.5	146	< -43	216	242
OSP-46	< -30.0	46	8.5	164	< -43	210	240
OSP-68	< -30.0	68	12	171	< -40	218	258
OSP-150	< -30.0	150	23	186	-37	228	258
OSP-220	-26.0	220	32	196	-34	226	258
OSP-680	ND	680	77	196	-30	243	260

Comparison Typical Properties of OSP's / PAO's

UCON Grade	Viscosity at 40°C, cSt	Viscosity at 100°C, cSt	Viscosity Index	Pour Point deg. C
	ASTM D445	ASTM D445	ASTM D2270	ASTM D97
OSP-32	32	6.5	146	<-43
OSP-46	46	8.5	164	<-43
OSP-68	68	12	171	<-40
OSP-220	220	32	196	-34
OSP-680	680	77	196	-30

UCON Grade	Viscosity at 40°C, cSt	Viscosity at 100°C, cSt	Viscosity Index	Pour Point deg. C
	ASTM D445	ASTM D445	ASTM D2270	ASTM D97
PAO-6	31	5.1	138	-57
PAO-8	48	8.0	139	-48
PAO-10	66	10	137	-48
PAO-40	396	29	147	-36
PAO-100	1240	100	170	-30

Miscibility of OSPs in Common Base Oils

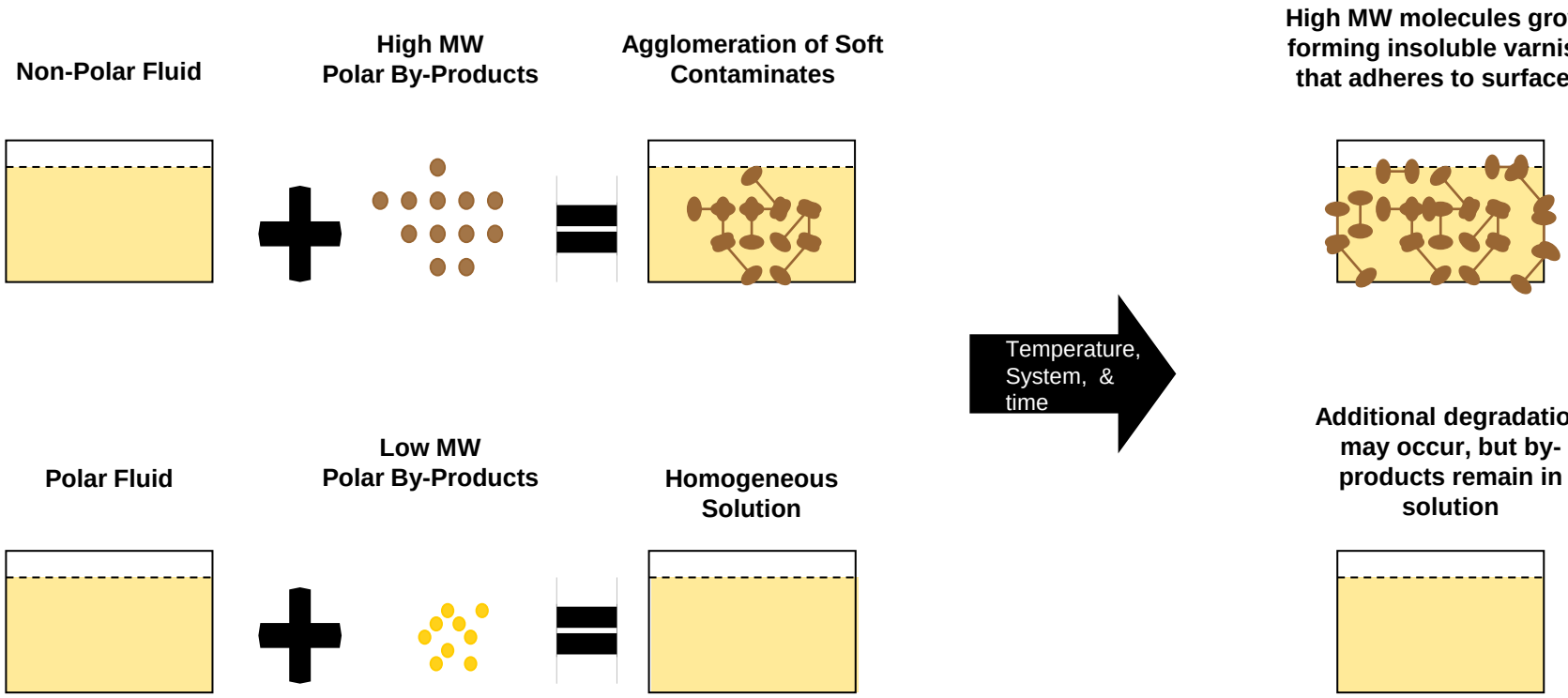
Typical Miscibility Features

Chemistry	OSP/Base Oil 10/90 w/w	OSP/Base Oil 50/50 w/w	OSP/Base Oil 90/10 w/w
Group I Mineral oils	Miscible	Miscible	Miscible
Group II and III Mineral oils	Miscible	Miscible	Miscible
PAO-4, 6, 8	Miscible	Miscible	Miscible
Diesters & Polyol esters	Miscible	Miscible	Miscible
Naphthenics	Miscible	Miscible	Miscible
PAG's - PO homo-polymers	Miscible	Miscible	Miscible

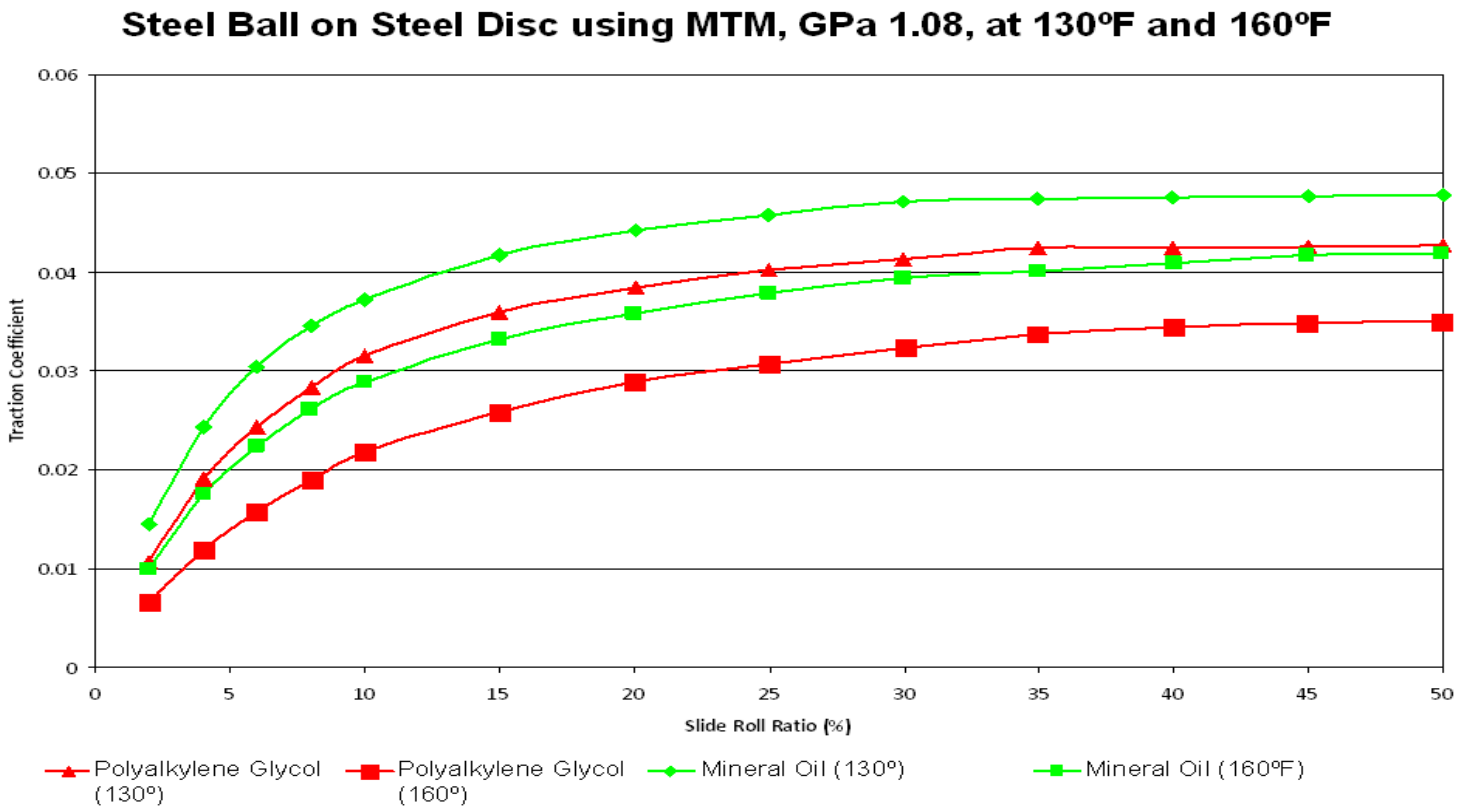
Miscibility defined as clear homogeneous solutions before and after storing at ambient temperature and 80°C for 168 hours

Oxidation Processes Comparison – Deposit Control

Mineral & Synthetic Hydrocarbon Oil vs. Polyalkylene Glycols



Tribological Properties- MTM Curves of OSP vs. Hydrocarbon Oil

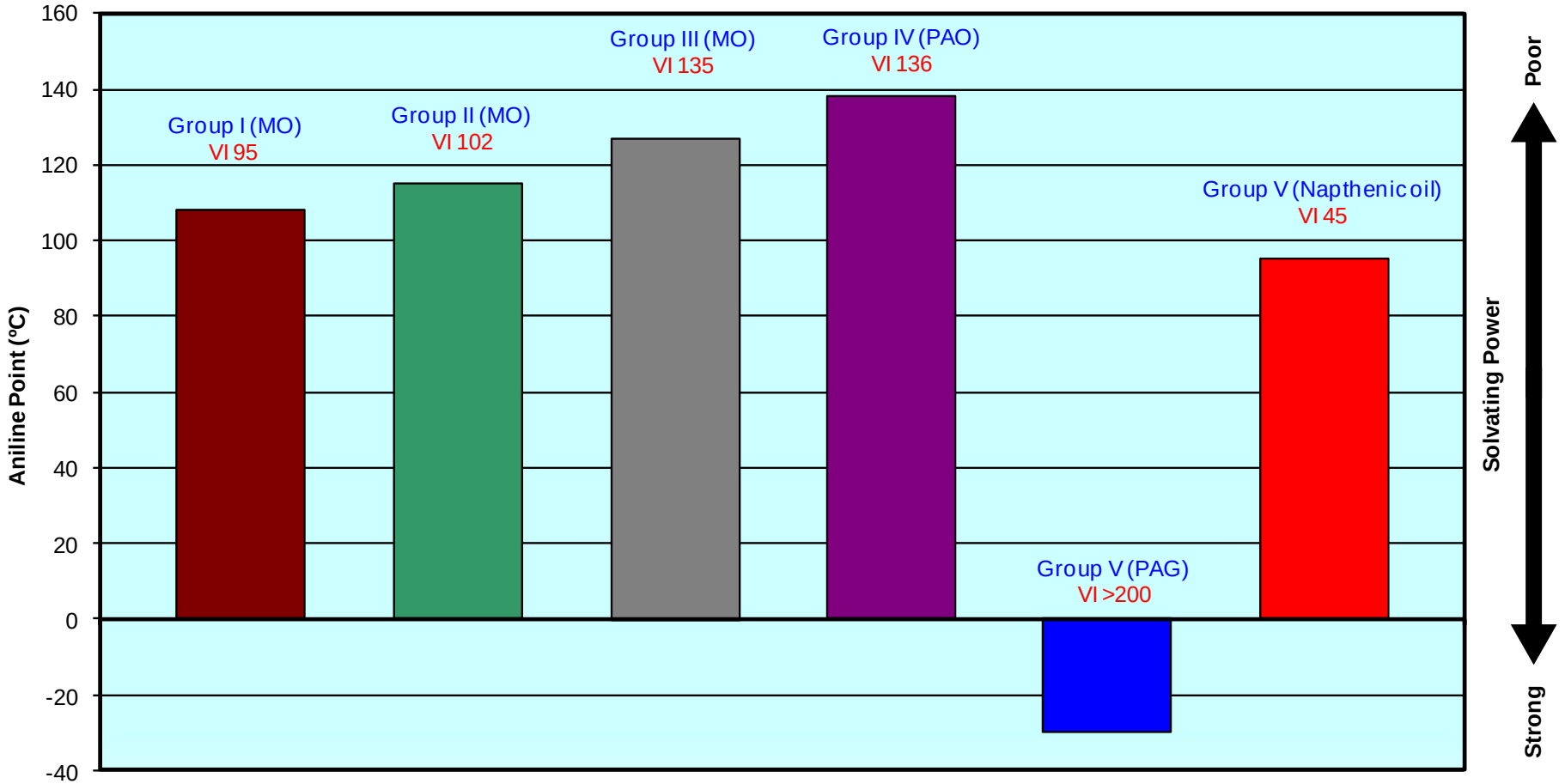


OSP-Based Greases

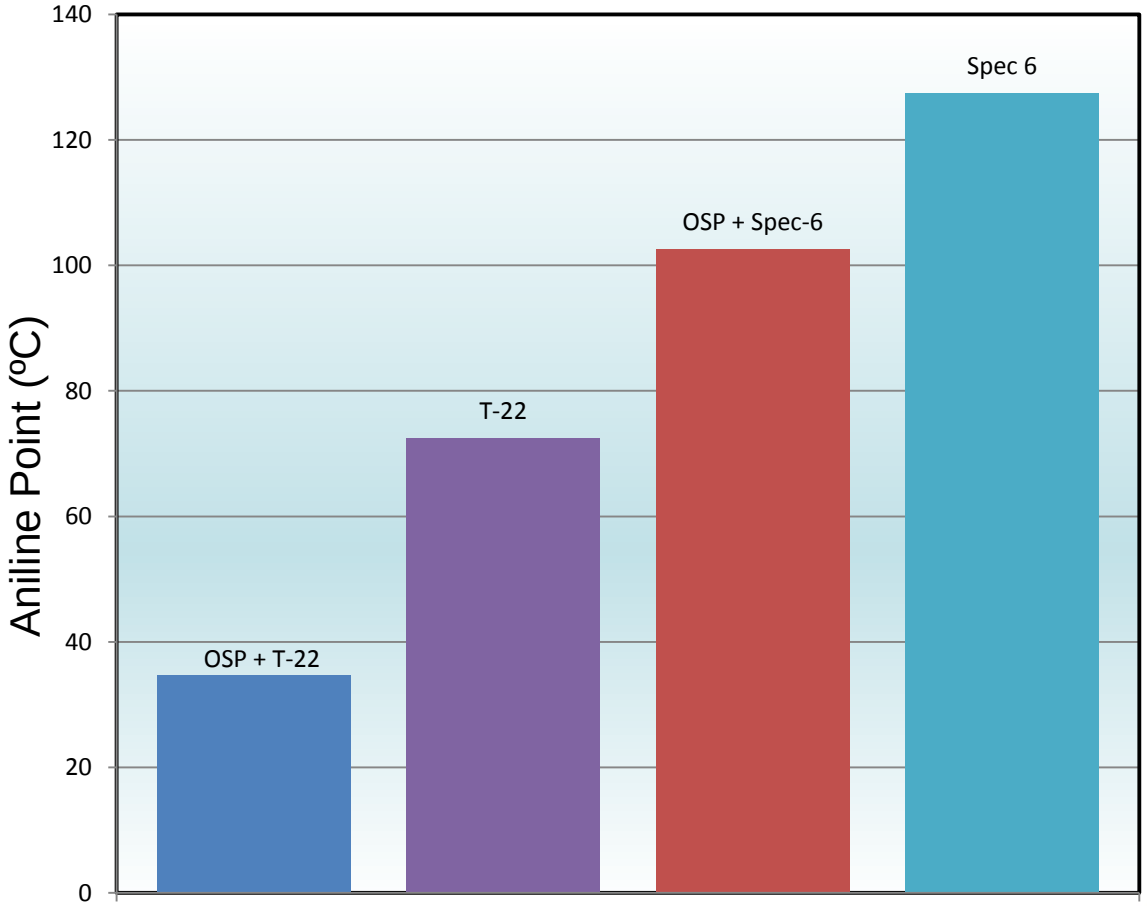
Benefits OSP-based Premium Lithium complex Grease

- Significantly higher temperature performance
  Oxidation Induction Time
- Significantly increased dropping point
  313°C versus 200°C of benchmark greases
- Significantly reduced energy and time to produce
  Excellent Solvating Power (Aniline Point)

Aniline Point for Various Base Stocks



OSP as Solvency Provider



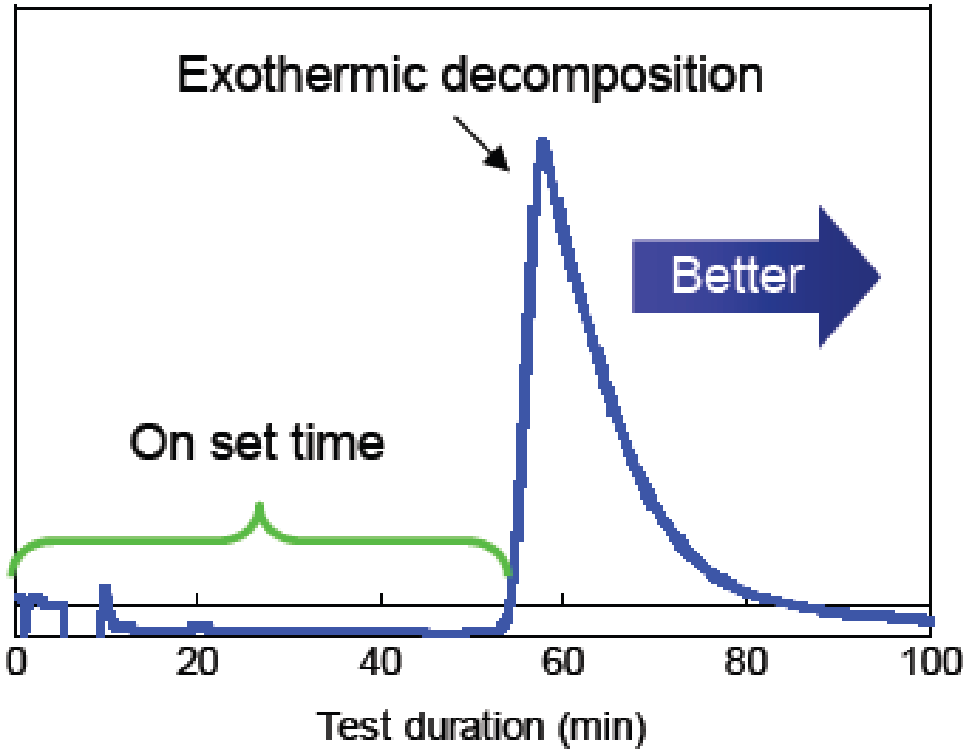
Dow OSP 220 Grease Typical Properties

Property	Method	Result
Color	Visual	Light Beige
Appearance	Visual	Smooth
Po, mm/10	ASTM D217	265
P60, mm/10	ASTM D217	275
NLGI Grade	ASTM D217	2
DP ºC	**ASTM D2265**	**313**
Oil Separation, 24h, 100ºC, %	ASTM D6184	0.00
Evaporation, 24h, 100ºC, %	CTM	0.75
Water Washout, 79 ºC, %	**D 1264**	**13.6**
PDSC, 175ºC, minutes	**D 5483**	**>120 (see graph)**
Cu Corrosion, 24h at 100ºC	ASTM D4048	1A
Four Ball Wear, mm	ASTM D2266	0.54
Oxidation Test @ 100 hr, psi	**ASTM D942**	**1.8**
Low Temperature Apparent Viscosity at -29.5ºC, m Pa.s	CTM	0.4 x 10^6 mPa.s
Low Temp Torque, -40 ºC	**ASTM D 4693**	**3.88 (see graph)**
Four Ball EP, Weld Load, Kg **Load wear Index**	**ASTM D 2596**	**200** **62**
Roll Stability, P60 Change	**ASTM D 1831**	**+30**

Soap Content:9.5%

OSP-220: VI 196

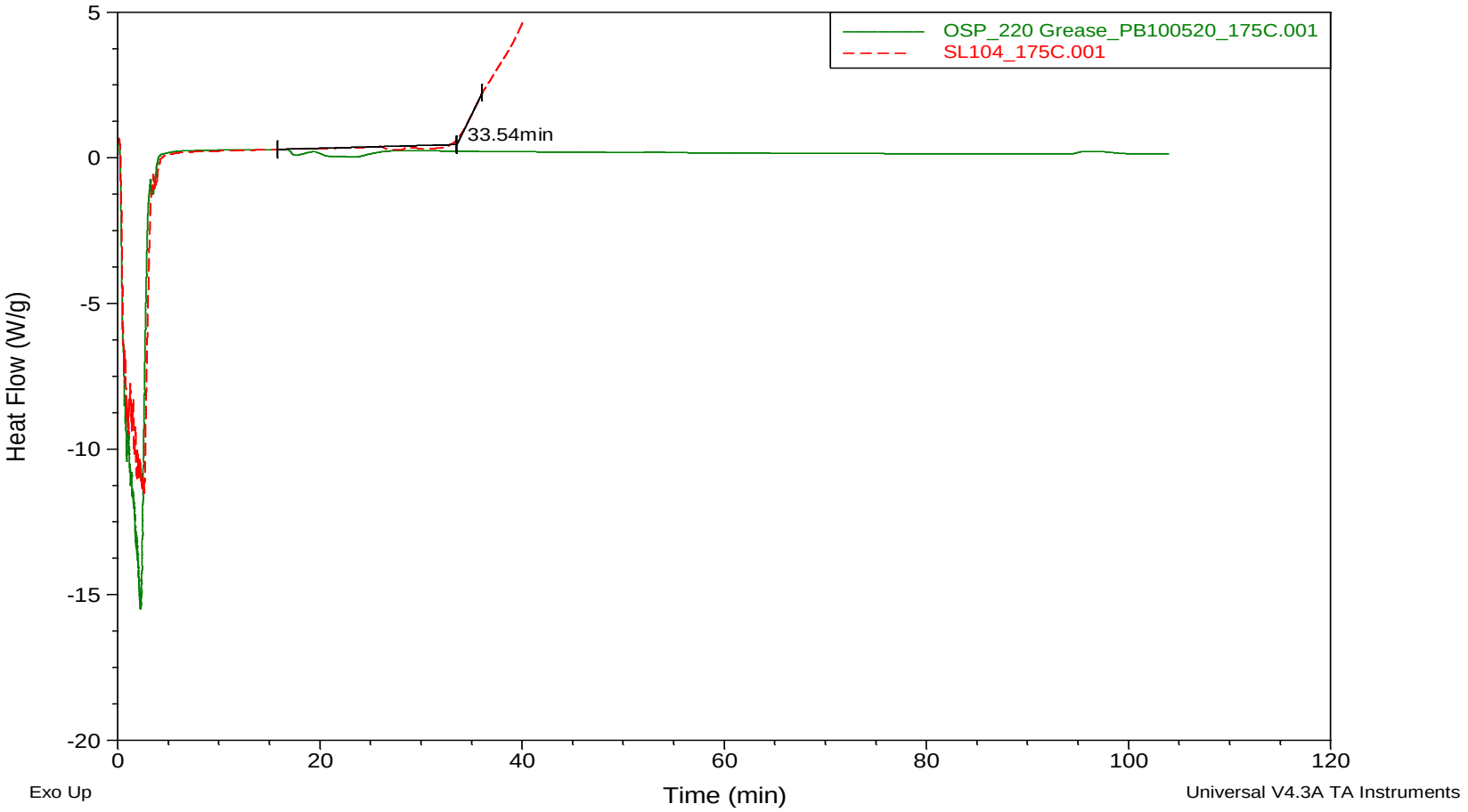
Pressurized Differential Scanning Calorimetry (PDSC) Method



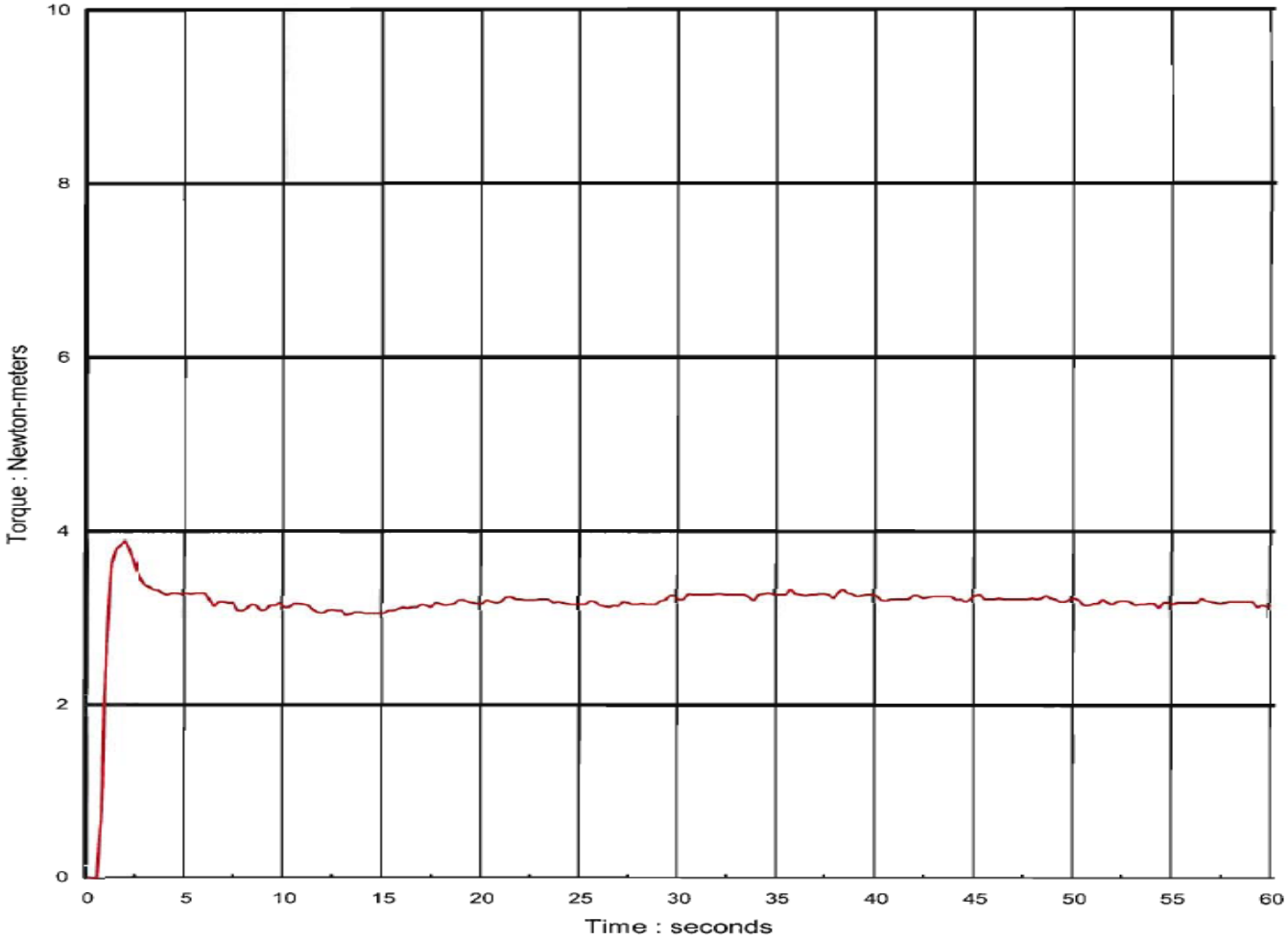
Parameter Assessed	Heat Flow vs. Time
Reported Data	Oxidation Induction Time (OIT)
Gas	Gas Composition : Oxygen Gas Flow : 6 l/h Gas Pressure : 3.5MPa
Sample Size	2.0 mg
Pans	Solid Fat Index (SFI), AL
Temp Programme	Isothermal, between 155 & 210 °C

Determination of the OIT on a thermal curve

PDSC Thermal Curve: OIT of OSP 220 Grease and Lithium Grease



Low Temperature Torque – ASTM D 4693

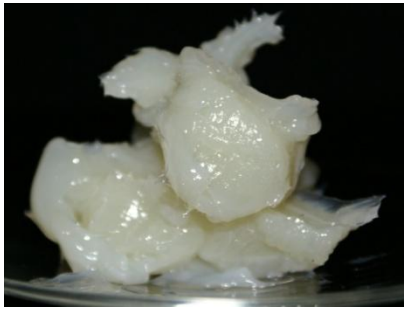


Sample : Grease 220
Lab# 10102102 Maximum Torque = 3.88 N-m

Test Temperature: -40 °C Date: 11/3/10
60 Second Reading : 3.14 N-m

Conclusions

- The formulators and researchers have another option for using PAGs as a “tool” for solving some of our industry problems.
- Equipment conversions from hydrocarbon oils to Oil Soluble PAGs is simpler and less problematical
- OSPs offer options to upgrade hydrocarbon oils & synthetics to boost additive solubility for robust grease formulations
- OSPs can provide improved aniline point when used as co-base oil in grease formulations.
- The flexibility of PAG chemistry provides a huge amount of space for innovation and providing solutions to specifications and standards of the future



THANK YOU

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