STLE Annual Meeting
Commercial Marketing Forum
May 22, 2018

Ken Hope, Ph.D., CLS

Synfluid® mPAOs: Brief Overview and use in Lithium and Polyurea Greases

SYNFLUID® POLYALPHAOLEFINS

Outline

- Synfluid® mPAO Overview
- Physical and Lubricant Properties Compared to Conventional PAO
- Lithium Grease Advantages
- Polyurea Grease Advantages
- Summary
- Questions

Introduction

Synfluid® mPAO

History

- Available since 2011

1st Gallon Produced in Lab

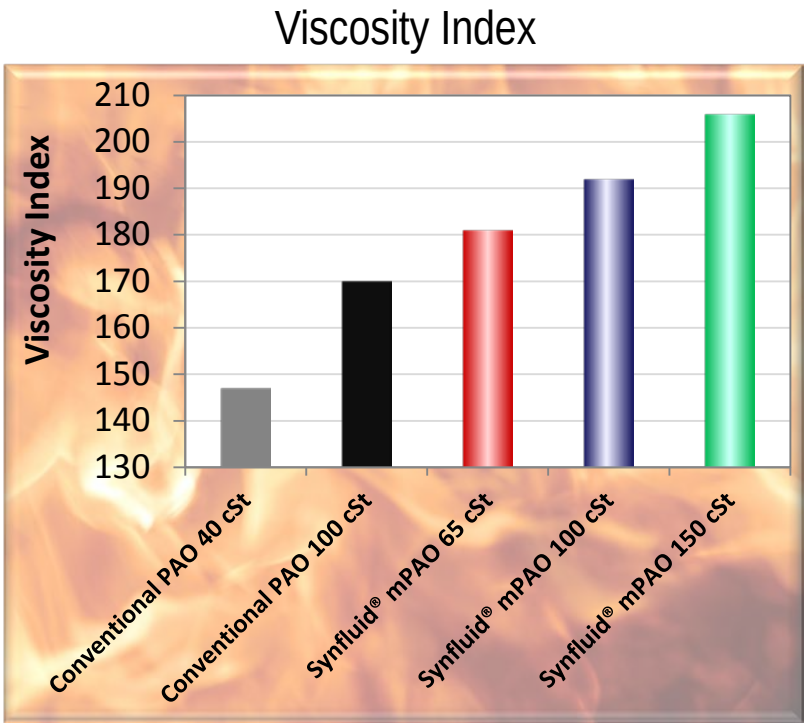
Previous presentations highlighted:

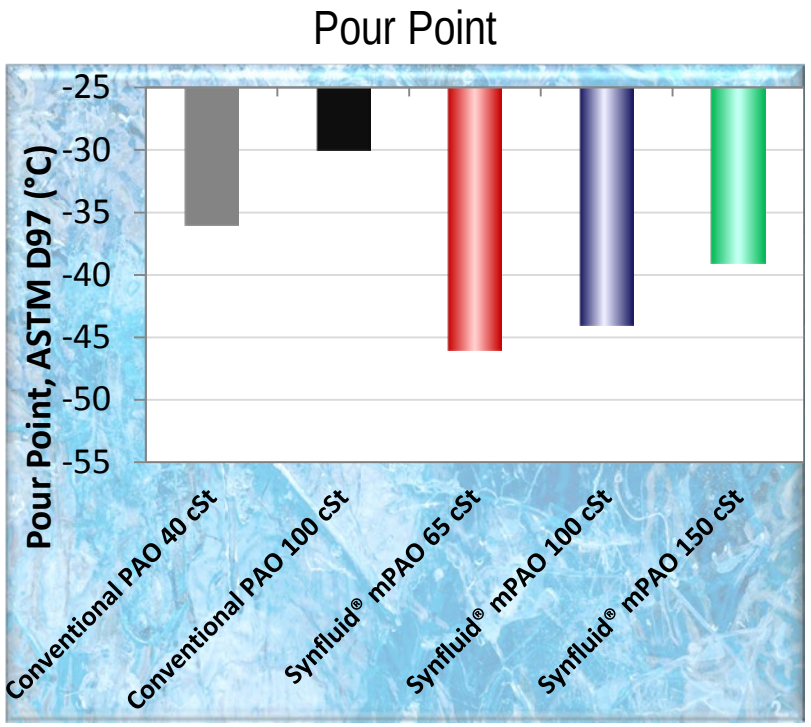
- VI
- Pour Point
- Low Temperature Viscosity
- Foaming Characteristics
- Oxidative Stability
- Thickening Efficiency

Typical Applications:

- Industrial Gear Oils
- Transportation Gear Oils
- Racing Oils
- Greases
- Compressor Oils
- Hydraulic Fluids
- Greases

High Viscosity PAO: Conventional vs. mPAO



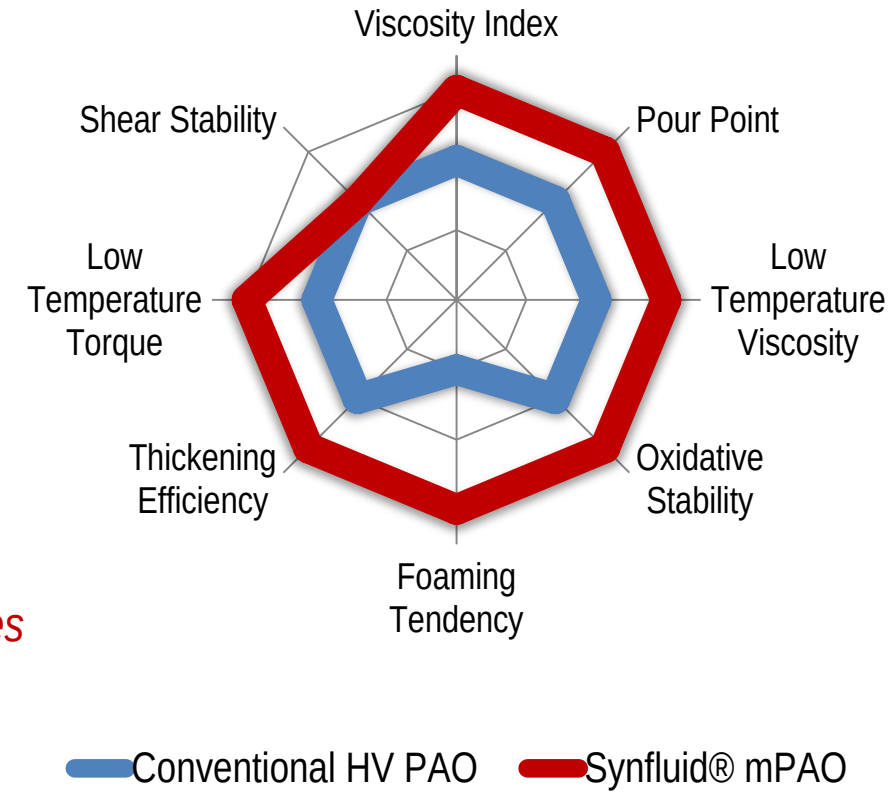


- Synfluid® mPAOs offer very high viscosity indices; providing less viscosity loss at high temperatures and excellent low temperature properties
- Pour points are extremely low for high viscosity grade materials!

Comparison of benefits of Synfluid® mPAO to conventional HV PAO

- HV PAOs have performed well over many years. Synfluid® mPAOs offer many advantages.
- PAOs are used to meet specific technical advantages, improvements to the base oil components should increase the overall formulations space.
- Other applications have been highlighted in previous STLE presentations

Let's take a look at a couple grease examples



Lithium grease

Lithium Grease Preparation

Studies performed in conjunction with Paul Bessette, Triboscience & Engineering Inc.

- Lithium 12-hydroxystearate grease prepared from PAO 6 and mPAO 65 using dry thickener technology
- Grease was formulated to an NLGI Grade 2 consistency
- All of the thickener and half of the base oil were heated until the thickener was completely melted above 200°C
- The balance of the base oil was added to rapidly quench the vessel contents
- The gel and various additives were subsequently homogenized at 6000 psi
- The composition of the grease is shown below:

Ingredient	Weight %
Lithium 12-Hydrosystearate	9.7
mPAO 65	42.4
PAO 6	42.4
Amine AO	1.0
Phosphorus AW Agent	3.0
Zinc Sulfonate RI	1.5

Physical Properties of Lithium Grease Preparation

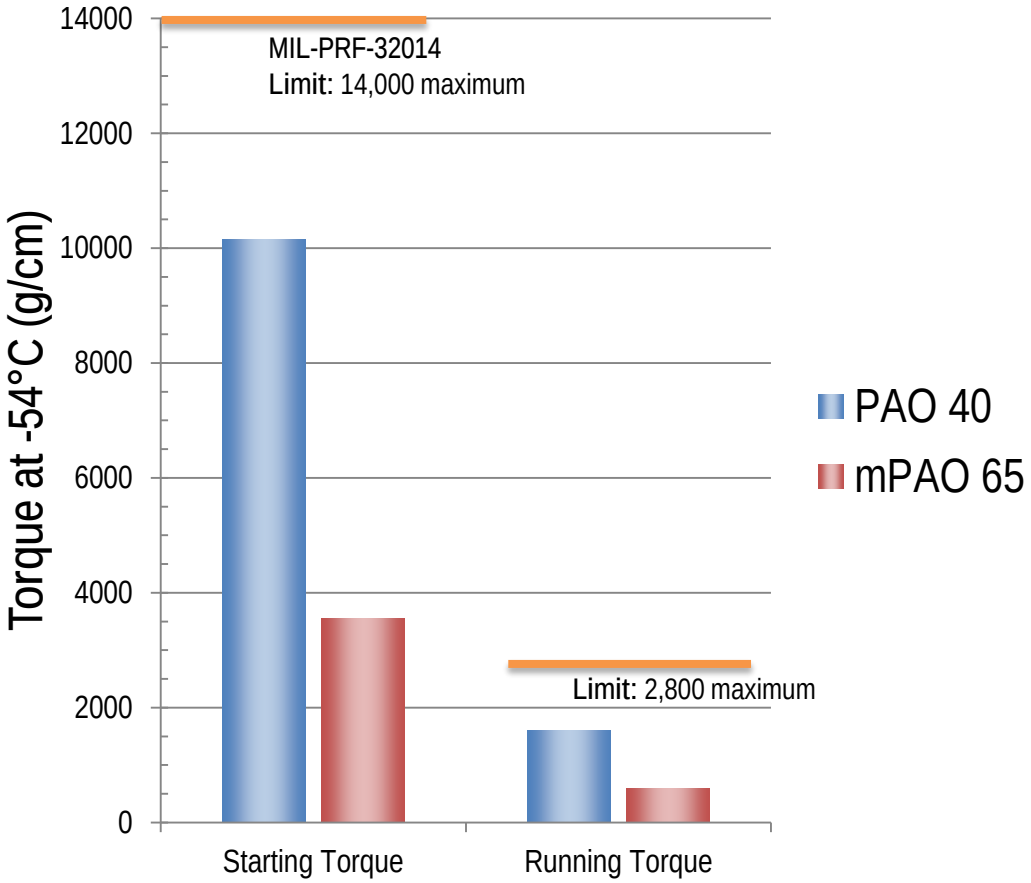
Property	Method	Result
Color	Visual	Light Beige
Appearance	Visual	Smooth
KV40°C	ASTM D445	122.8 cSt
KV100°C	ASTM D445	18.06 cSt
VI	ASTM D2270	164
P_0	ASTM D217	270
P_{60}	ASTM D217	279
NLGI Grade	ASTM D217	2
P10k	ASTM D217	321

Note: The above formulation does not contain the necessary ingredients to meet all of the requirements of MIL PRF 32014. The main objective was to determine the viability of mPAO 65 as a blend component.

Low Temperature Torque of mPAO based Lithium Grease (ASTM D1478 @ -54ºC)

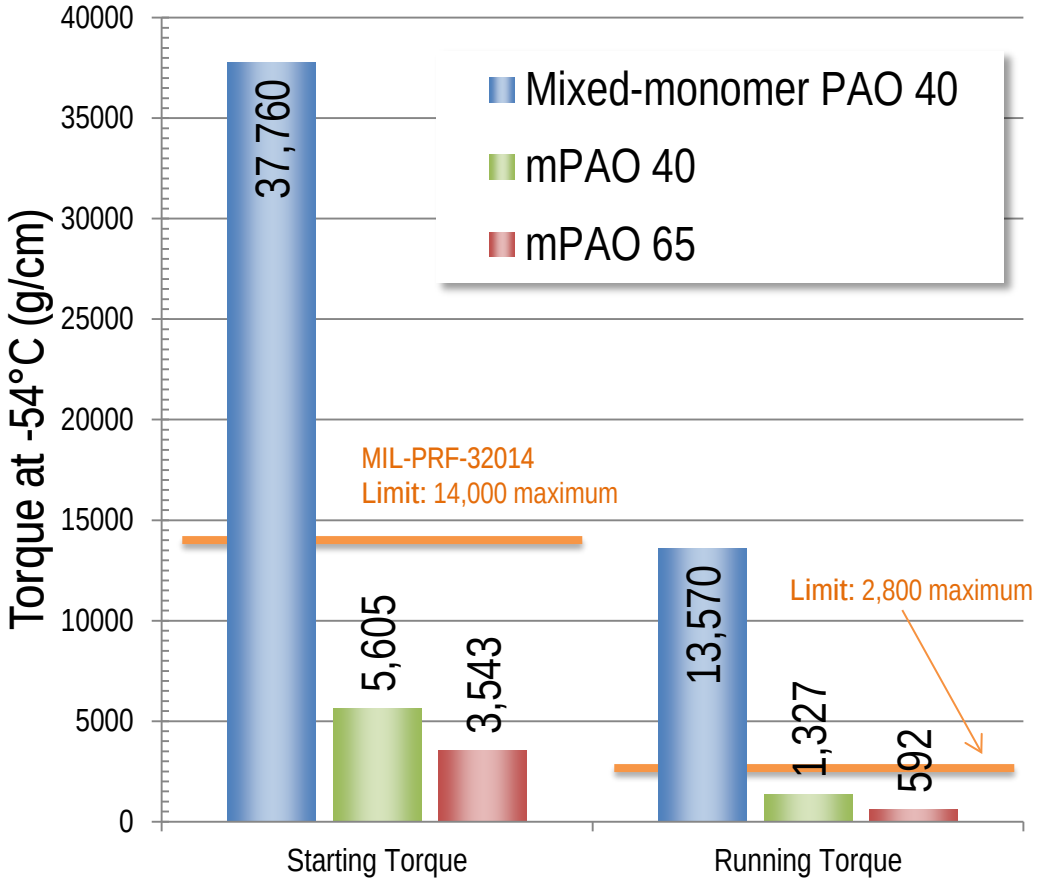
NLGI Grade 2 Lithium Greases prepared with PAO 6 and high viscosity PAOs (PAO 40 or mPAO 65) show significant differences in low temperature torque numbers.

This test indicates the force needed to rotate a bearing initially and while running. Lower torque values equates to lower energy required for starting and running conditions.



Low Temperature Torque of mPAO based Lithium Grease (ASTM D1478 @ -54ºC)

NLGI Grade 2 Lithium Greases prepared with PAO 6 and high viscosity PAOs (PAO 40 or mPAO 65) show significant differences in low temperature torque numbers especially when the PAO 40 is from a mixed-monomer feeds.



P. A. Bessette and K. D. Hope , "*Synthetic Grease Formulated Using PAO 6 and mPAO 65*", NLGI 2016 Annual Meeting, Hot Springs, Va., June 13, 2016.

Polyurea Grease

Preformed Polyurea Grease Composition

Studies performed in conjunction with Paul Bessette, Triboscience & Engineering Inc.

Why the interest in Polyurea Grease?

- Traditional preparation of polyurea grease involves working with hazardous materials
- Preformed polyurea thickener simplifies the preparation improving safety of operations
- Polyurea does not contain metal cations, therefore these usually have superior thermooxidative stability at elevated temperatures

Preparation

- Grease components were heated to 180°C with constant mechanical stirring. After cooling, the gel was homogenized at 6000 psi.

Ingredient	Weight %
Thickener	20
mPAO 65	80

P. A. Bessette and K. D. Hope , "*The Preparation of a Polyurea Grease Using mPAO 65*", NLGI 2017 Annual Meeting, Lake Tahoe, NV., June 11, 2017.

Polyurea Grease Properties

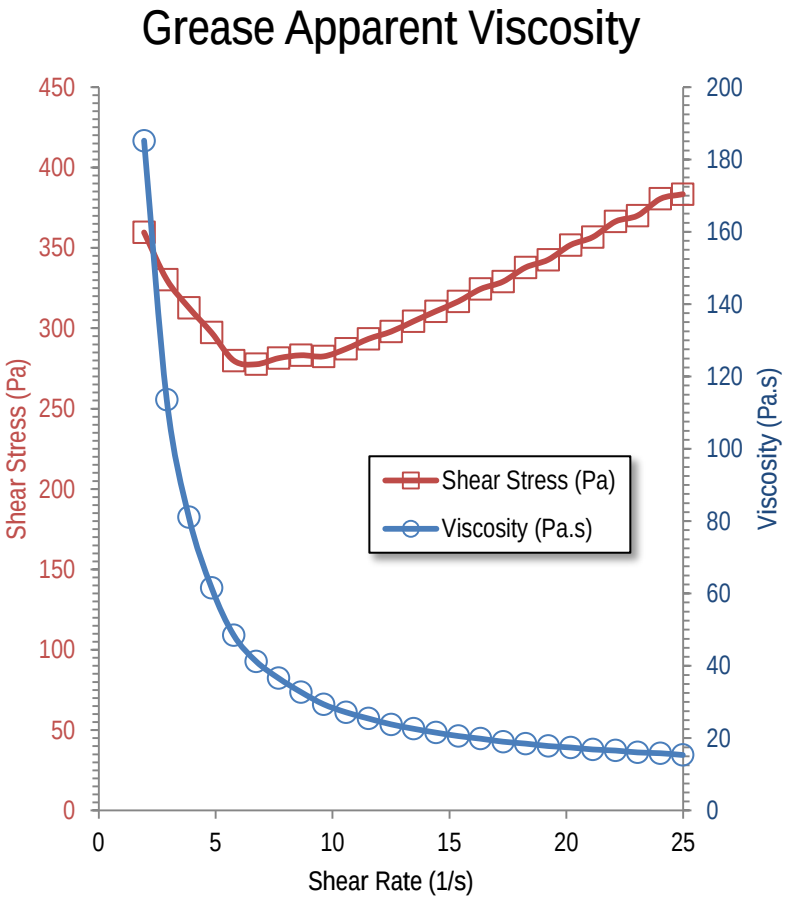
Property	Method	Result
Color	Visual	Light Beige
Appearance	Visual	Smooth
KV40C	ASTM D445	616 cSt
KV100C	ASTM D445	65 cSt
VI	ASTM D2270	179
Cone penetration (unworked) Po	ASTM D217	285 (1/10 mm)
Cone penetration (worked) P60	ASTM D217	294 (1/10 mm)
NLGI Grade	ASTM D217	2
Oil Separation 24h at 100C	ASTM D6184	1.03%

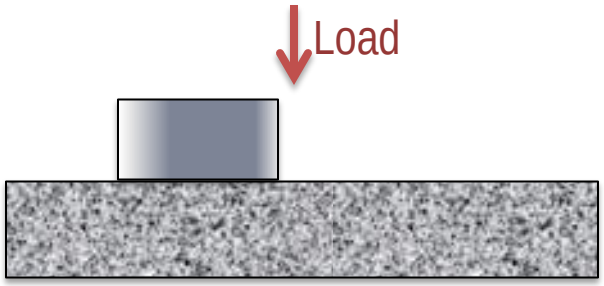
Polyurea Grease Properties Continued

Property	Method	Result
Dropping Point	ASTM D2265	> 260°C
Copper Corrosion (24h at 100°C)	ASTM D4048	1 a
Four Ball Wear (s. dev.)	ASTM D2266	0.63 mm (0.044)
Apparent Viscosity (25°C 1.94 s^{-1})	ASTM D1092	185,200 mPa.s
Apparent Viscosity (25°C 24.98 s^{-1})	ASTM D1092	15,350 mPa.s
Apparent Viscosity (-40°C, T-C Spindle, 1 RPM)	Brookfield	6.9 x 10^6 cP
Oxidation Induction Time 180°C	ASTM D5483 (modified)	14.49 minutes
Temperature for 5% Weight Loss	TGA	294°C
Finness of Grind	ASTM D1210	65 microns
Density, 25°C	Pycnometer	0.837 g/cc

Apparent Viscosity

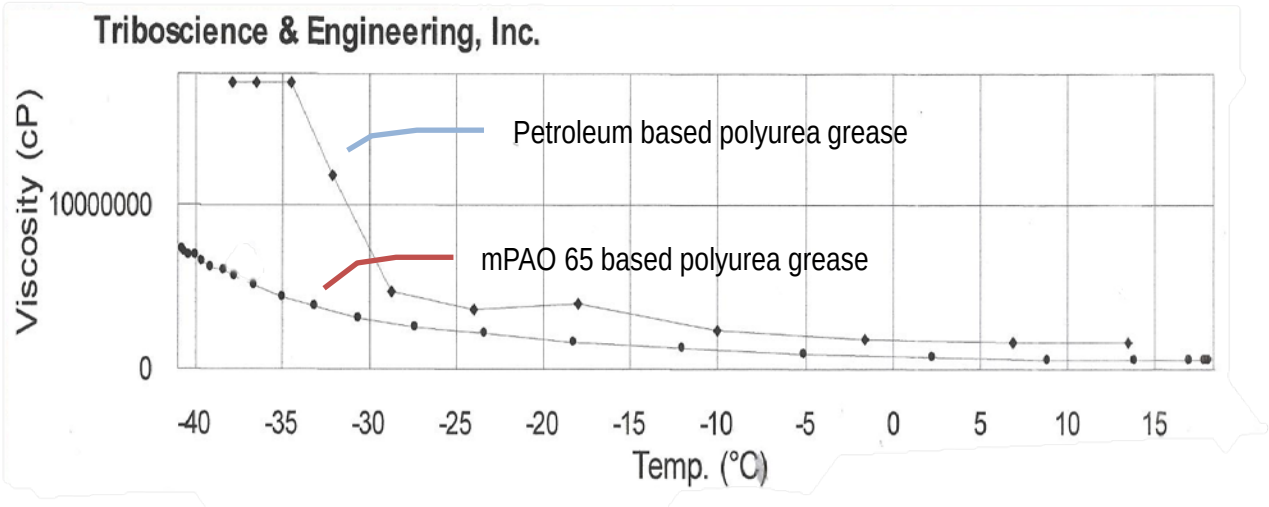
- Fretting corrosion (FC) is a form of wear that occurs when two surfaces experience vibrations of limited amplitude. Under FC conditions, lubricant is usually precluded from entering the inlet and the contact starves.
- Greases that are prone to soften with shear are more likely to enter the contact zone and mitigate fretting damage.
- In our opinion, this particular type of grease formulation would be a viable candidate for automotive stationary / separable electrical contacts.

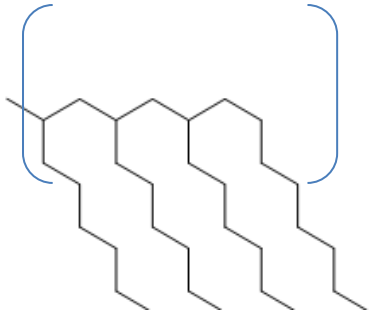




Polyurea Grease: Low Temperature Benefits

- One of the benefits of Synfluid® mPAO is a chemical structure conducive to improving low temperature behavior. This is consistent with the earlier findings of the superior low temperature apparent viscosity of mPAO 65 lithium grease.
- The chart shows the low temperature apparent viscosity of this urea thickened grease compared to a petroleum based product
- Testing was conducted using a Brookfield Viscometer attached to a Tenny environmental chamber at 1 RPM using a T-C spindle.





Typical mPAO structure

Summary & Conclusions

Two separate greases were prepared to demonstrate the viability of mPAO 65 in grease applications

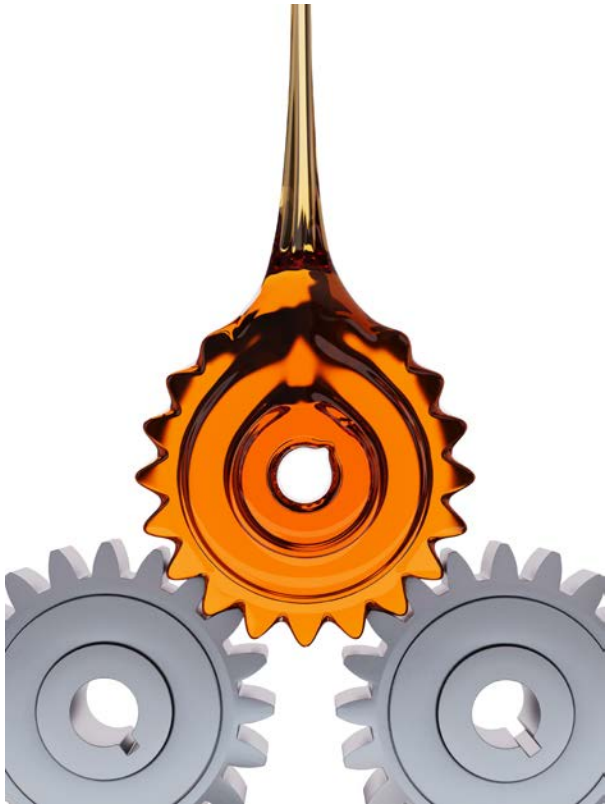
Lithium Grease

- A lithium 12-hydroxystearate thickened grease was selected as the prototype
- Results indicate that superior low temperature torque was achieved due to a reduction in the amount of high viscosity base fluid required and the intrinsic low temperature fluidity of the mPAO 65

Polyurea Grease

- A preformed grease was prepared using mPAO 65
- No additives were used in formulating the grease
- The Dropping Point of the grease was >260°C
- Oil separation was 1% after 24h at 100°C
- The grease exhibits excellent protection towards Cu
- Using an alkylated naphthalene fluid in conjunction with the mPAO 65 is expected to result is a smoother microscopic appearance of the grease
- This grease exhibits appreciable shear thinning which is a desirable attribute for applications where fretting occurs

mPAO 65 based greases have exhibited excellent low temperature behavior



Connect with us Online

facebook

Find out how we're contributing in the community, where we're expanding and how our products are helping make everyday life a little easier.

LinkedIn

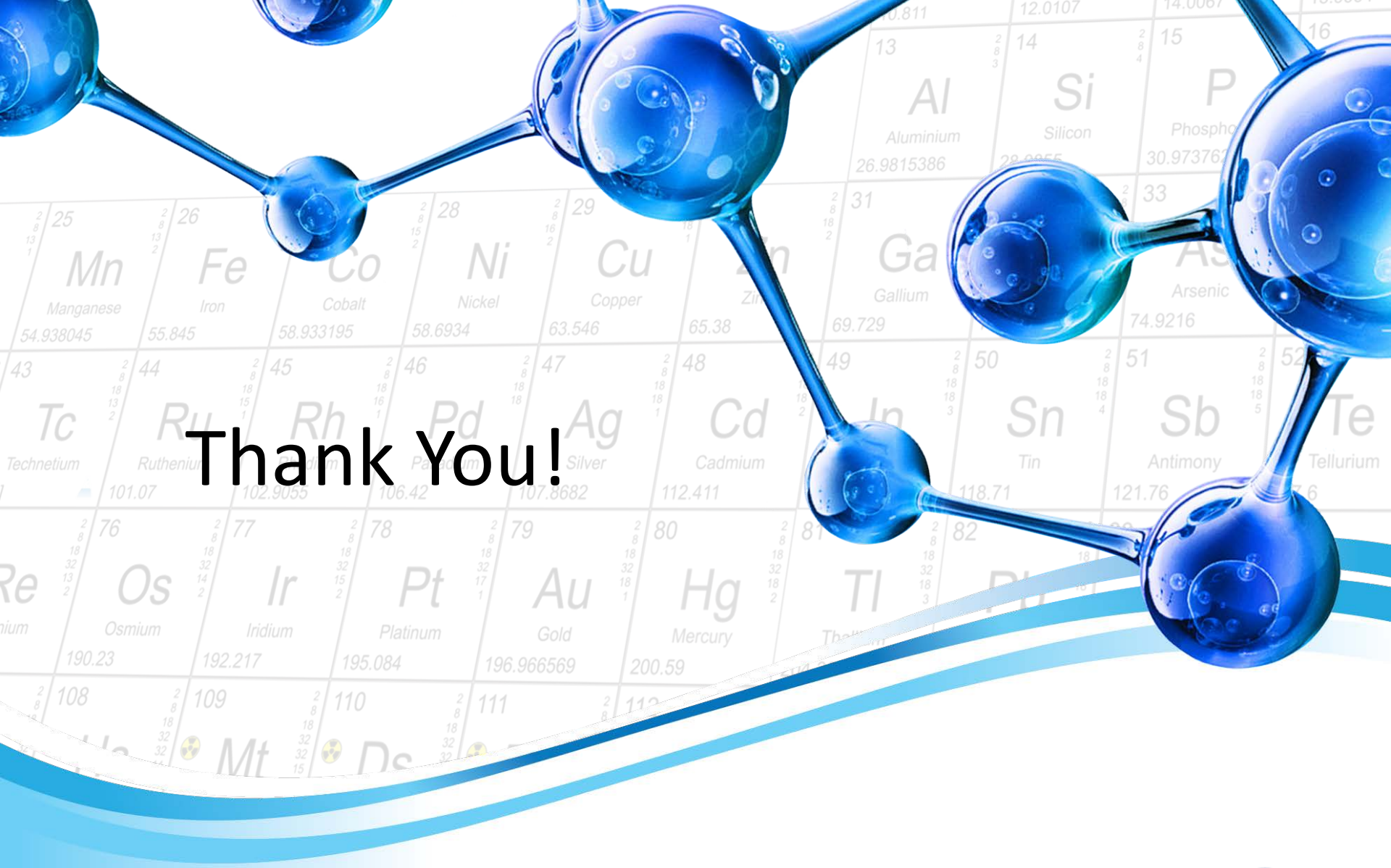
Learn more about working with us, make connections and view current job openings.

YouTube

Check out our latest products and learn more about the chemical industry.

twitter

Read the latest news, find out what conferences we're attending and learn more about what makes Chevron Phillips Chemical great.



Thank You!

CONTACT US | SYNFLUID@CPCHEM.COM | WWW.SYNFLUID.COM

SYNFLUID®
POLYALPHAOLEFINS