SYNTHETIC GREASE FORMULATED USING PAO 6 AND mPAO 65

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Investigation

Synthetic lubricants are superior to petroleum products in terms of:

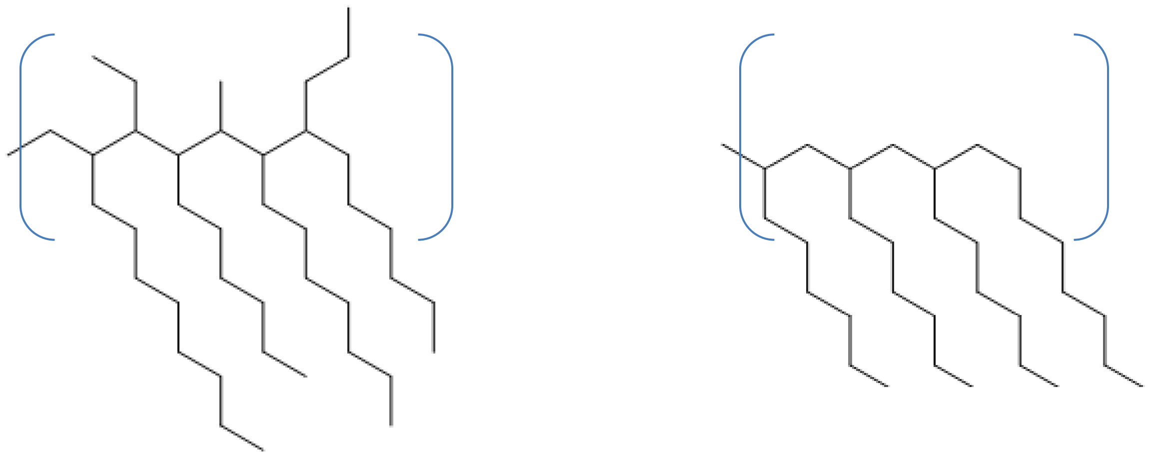
- *Thermooxidative Stability*
- *Low Temperature Performance*

Automotive requirements frequently demand serviceability to -40°C while military specifications may demand performance at -54°C.

In this presentation, we discuss a grease formulated using Chevron Phillips PAO 6 and mPAO 65.

Background of Base Oils Used

The high viscosity component was synthesized using a metallocene catalyst. Metallocene catalyzed PAO's differ from conventional PAO's in that their pendant groups have a comb-like structure with a chiral center at the branch carbon.



Typical traditional PAO (left) and typical mPAO structure (right)

Chirality provides for a random distribution of branch stereoregularity and isomer distribution resulting in improved low temperature performance.

MIL-PRF-32014 Requirements

According to MIL PRF 32014, the KV requirements for the base oil in the grease are:

- KV40°C = 140 cSt maximum
- KV100°C = 16 cSt minimum

The specified viscosity requirements are achievable blending PAO 6 and PAO 40. However, MIL PRF 32014 requires the low temperature torque per ASTM D1478 not to exceed (at -54°C):

- 14,000 g/cm for the starting torque
- 2,800 g/cm for the running torque

Decene based PAO 40 is a viable blending component to attain the viscometrics of the specification. However, mixed-monomer fluids can be problematical. This work suggests that blends using mPAO 65 can produce stellar results in terms of low temperature torque requirements at -54°C.

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Grease Preparation

- Five kilograms of a lithium 12-hydroxystearate grease were 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

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Physical Properties of Grease Preparation

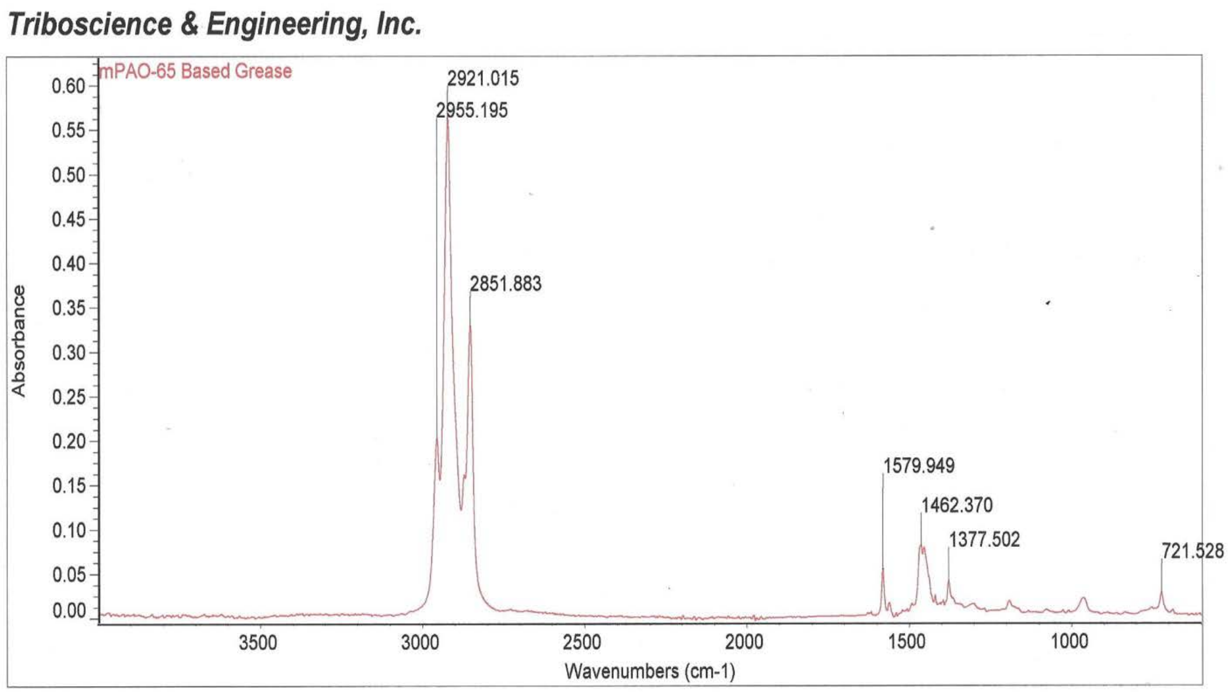
Note: The above formulation does not contain the necessary ingredients to meet all of the requirements of MIL PRF 32014. The main objective was to determine the viability of mPAO-65 as a blend component.

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

Physical Properties (continued)

Property	Method	Result
Oil Separation 24h at 100°C	ASTM D6184	1.7%
Dropping Point	ASTM D2265	200°C
Copper Corrosion 24h at 100°C	ASTM D4048	1b
Water Washout 40°C	ASTM D1264	5.8%
Four Ball Wear	ASTM D2266	0.54 mm
Chemistry	FT-IR	Next slide
Apparent Viscosity -54°C T-C Spindle at 1 RPM	CTM Brookfield Viscometer	13.6 x 10^6 cP
OIT at 210°C	MIL PRF 32014	59.20 minutes
Volatility 5% Weight Loss	TGA	250°C

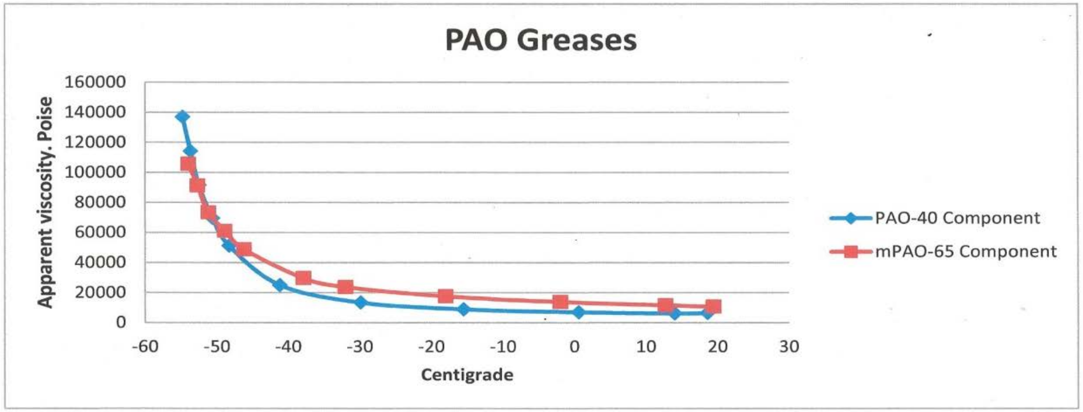
FT-IR Spectrum of the Grease



The spectrum clearly indicates a hydrocarbon. The absorption band at 1579 cm^{-1} is the carbonyl vibration due to the thickener. Moreover, band intensity is a function of the amount of thickener in the grease.

Low Temperature Viscosity

The low temperature apparent viscosity of the mPAO 65 grease was compared to a similar grease formulated with PAO 40 shown below.



A Tantalizing Question

Based on the low temperature viscosity, mPAO 65 appears to be a suitable blending component for formulating grease to the requirements of MIL PRF 32014.

However, a tantalizing question arose regarding the low temperature performance of grease formulated with mPAO 40 versus mPAO 65.

For a given family of oils, a higher viscosity at 40°C implies a higher viscosity at a low temperature. However, a blend offers unique opportunities. Since mPAO 40 is less viscous than mPAO 65, less PAO 6 is required to achieve the viscosity target of MIL PRF 32014 while the higher viscosity of mPAO 65 implies that additional PAO 6 is needed to reach the specified military specification viscosities.

Blend Compositions

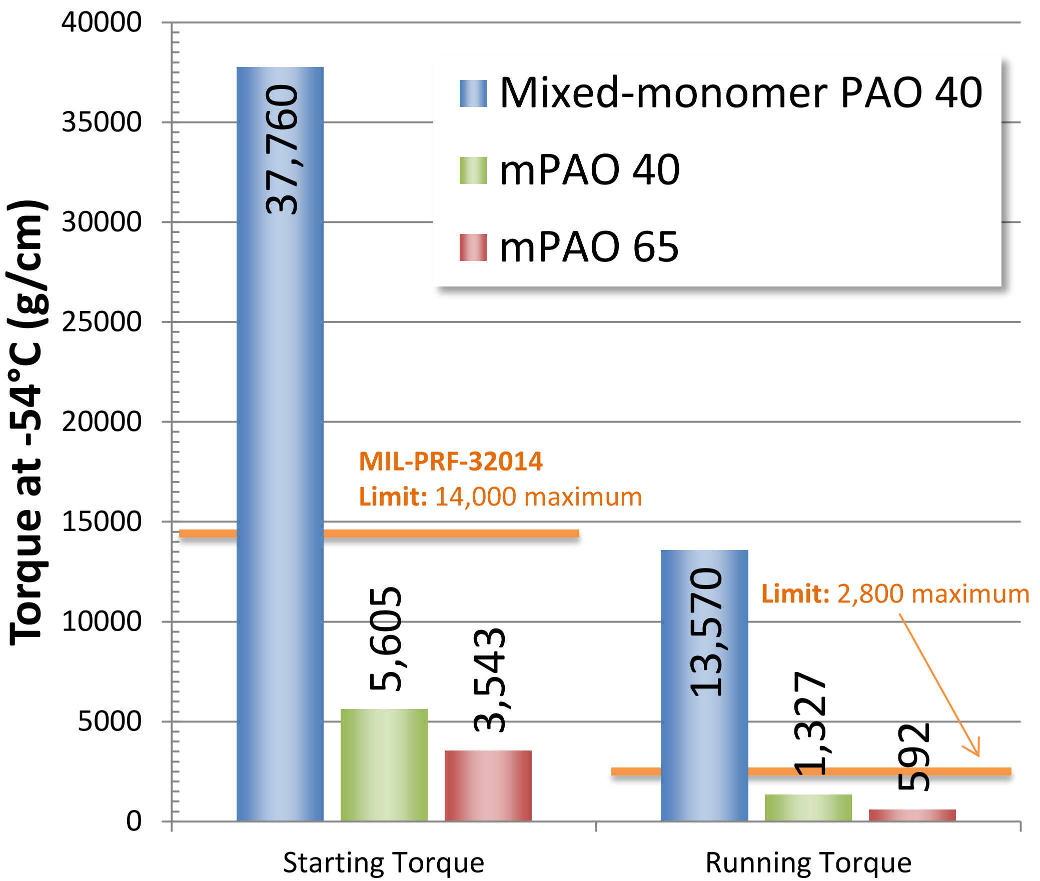
Ingredient	Weight %	Viscosity at 100°C (cSt)	Viscosity at 40°C (cSt)	Viscosity at -40°C (cSt)	Viscosity Index
PAO 6	53.0	16.7	111.0	42,200	163
mPAO 65	47.0				
PAO 6	42.6	16.5	113.2	55,153	158
mPAO 40	57.4				

The results clearly demonstrate the influence of the PAO 6 on the low temperature viscosity of the blends. This data was further corroborated with low temperature torque data determined at -54°C

Low Temperature Torque

There is a clear difference between the low temperature torque of the mixed monomer PAO 40 grease and the mPAO greases.

The best performance was obtained with the mPAO 65 based grease.



Summary & Conclusions

- This paper has examined a comparison of mPAO 65 and PAO 40 for use in grease. A lithium 12-hydroxystearate thickened grease was selected as the prototype; however, our finding of low temperature advantages should translate to other thickeners as well.

- The results indicate that superior low temperatures are achieved due to a reduction in the amount of high viscosity base fluid required and the intrinsic low temperature fluidity of the mPAO 65.