

Polymethacrylate Technology

STLE - Commercial Marketing Forum

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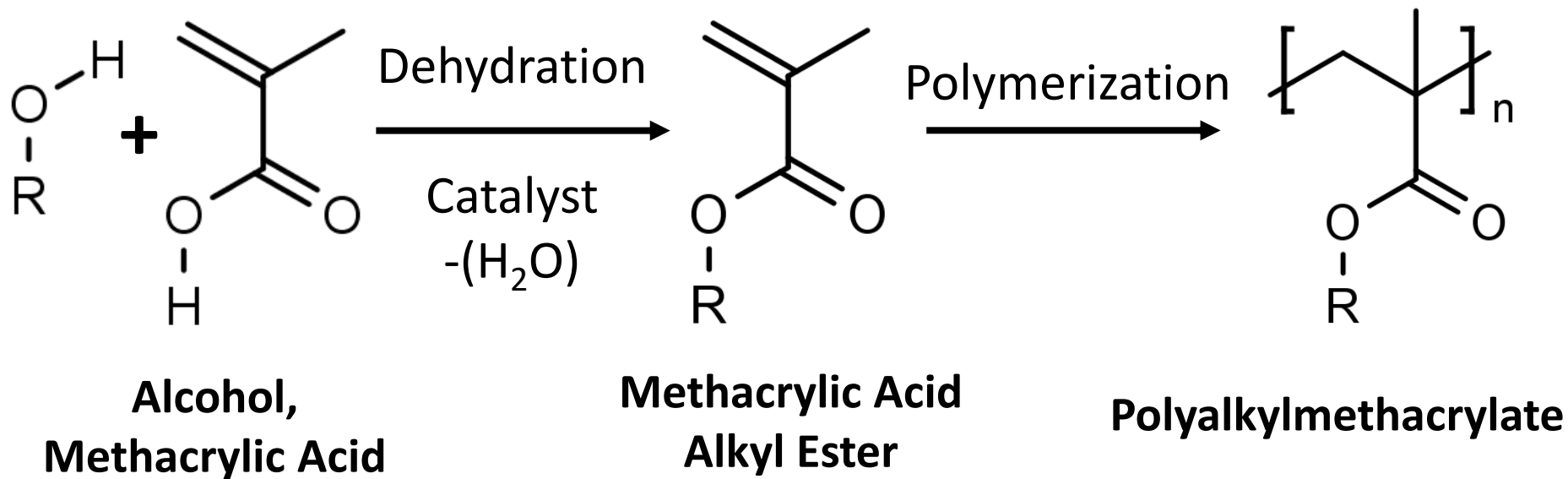
Functional Products Inc.



- Polymethacrylate (PMA) chemistry
 - Easily customizable by varying the ratios of different monomers, amount of initiator and polymerization temperature
 - Excellent shear stability due to branched structure
 - Built-in pour point depressant functionality



Overview



R = Alkyl group



- Performance Benefits
 - Excellent viscosity index improvement
 - Superior shear stability
 - Low wax formation and built-in pour point depression performance
 - Wide range of compatibility in base oils and blends



- Lubricants
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 - Superior shear stability
 - Low wax formation and built-in pour point depression performance
 - Wide range of compatibility in base oils and blends
 - Stable against contamination or oxidation of oil
- Environmental benefits
 - Solvent-free synthesis
 - No byproducts to exhaust
 - Mild reaction conditions / low energy requirements
 - Bio-based feedstocks

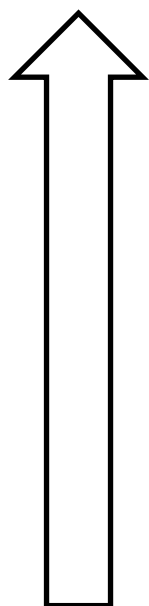


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 - Bio-based feedstocks
- Customizable to particular applications



Functional M Series

High Shear Stability
High Treat
Premium



**“MG-”
Gear**

**“MH-”
HF**

**“MD-”
Dispersant**

Low Shear Stability
Low Treat Rate
Fighting Grade

Thickening Efficiency
cSt, 100 °C, 10wt% in ISO32

Suggested Treat* (wt%)

Applications			Features		Shear Stability		
Hydraulic Fluid	Gear Oil	ATF / Tractor	Multi-grade / Low T.	Dispersant	Bosch (ASTM D6278) 5wt% in 150N		
					Sonic (ASTMD5621) Suggested wt%, 150N		
					KRL 20hr (CEC L45-A) MG:20-25wt% MH:5-10wt%		

High Performance Gear Oil VII

MG-1000	8.6	10%	.	.				0%	–	15%
MG-3000	8.0	11%	.	.		.		0%	3%	20%

Hydraulic Fluid and Industrial Gear Oil VII

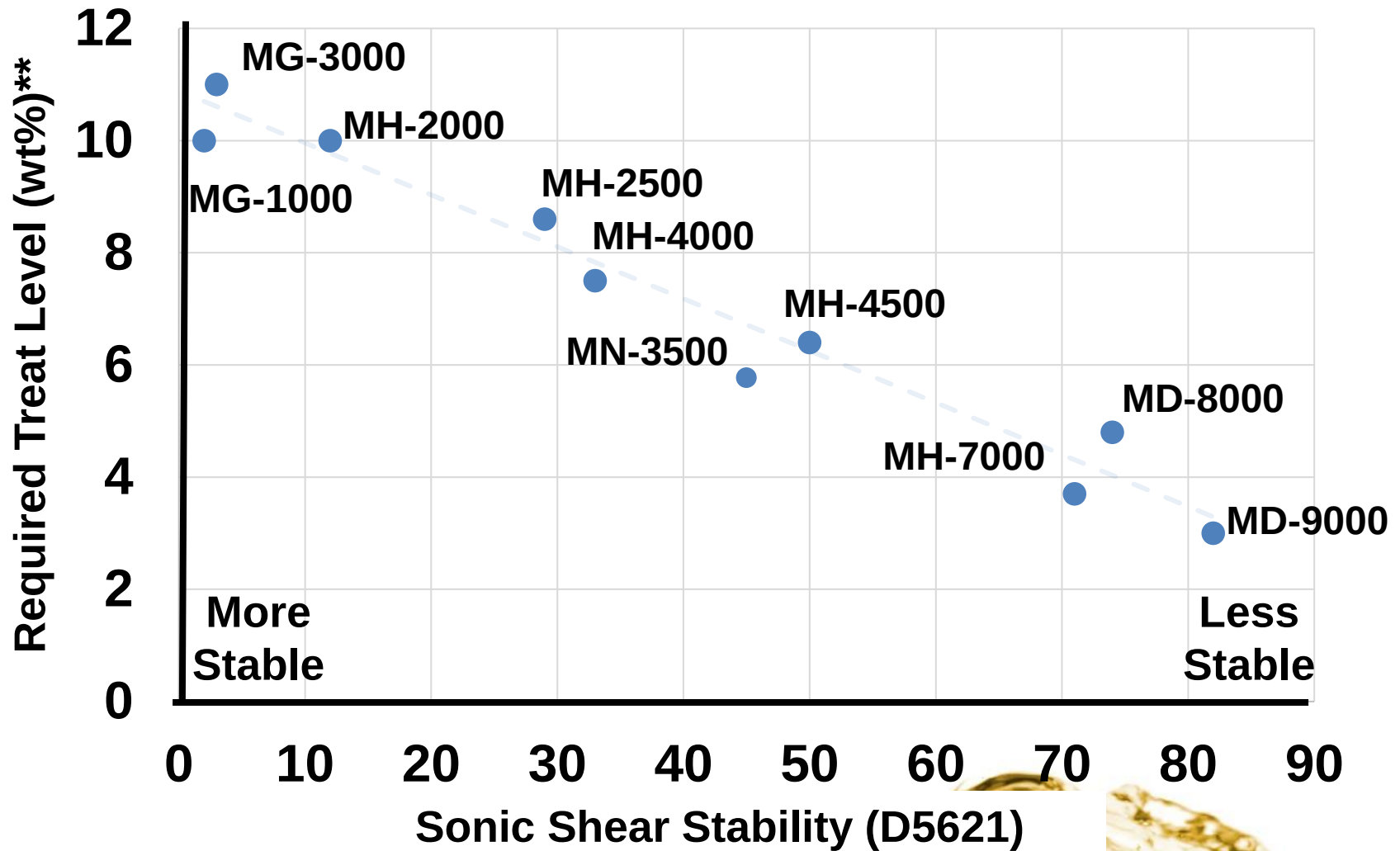
MH-2000	9.2	10%	.	.		.		1%	12%	35%
MH-2500	11.1	8.6%	.	.		.		3%	29%	50%
MH-4000	11.3	7.5%	.	.		.		7%	33%	58%
MH-4500	12.3	6.4%	.	.		.		15%	50%	65%
MH-7000	15.0	3.7%	.	.		.		36%	71%	–

Dispersant Tractor (8000) and ATF (9000) VII

MD-8000	16.0	4.8%	.		.		.	40%	74%	–
MD-9000	20.0	3.0%	.		.		.	51%	82%	–

*Suggested treat to increase ISO viscosity grade (22 to 32, 32 to 46, etc.).

Treat Rate vs. Shear



** For an ISO 46 fluid prepared from ISO 32 Group II

Dispersant PMAs – Tractor and ATF

- Dispersant PMA (dPMA)
 - Includes nitrogen functional group to improve varnish control in tractor / transmission fluids
 - Improved resistance to oxidation
 - High SSI products for now



Tractor Hydraulic Fluid – Starting Point Formulations

Group II and III formulations using MH-2500 and MD-8000

Formulation	ISO 46 Gr II	ISO 46 Gr III
Component		
150N Gr II	90.8%	
4 cSt Gr III		65.0%
6 cSt Gr III		18.0%
<i>Functional MH-2500</i>		5.0%
<i>Functional MD-8000</i>	3.2%	4.5%
Tractor Ad-Pac	6.0%	6.0%
KV100, cSt	8.07	10.56
KV40, cSt	43.6	49.98
VI	162	209



ATF Fluid – Starting Point Formulations

Formulations using MG-3000 and MD-9000

Formulation Component	Gr. I	Gr. II	Gr. III	Gr. IV
100SN Gr I	90.1%			
100N Gr II		84.8%		
4 cSt Gr III			83.8%	
PAO 4 Gr IV				80.5%
<i>Functional MG-3000</i>		5.5%	5.0%	8.3%
<i>Functional MD-9000</i>	1.8%	1.8%	1.8%	1.8%
Petroleum base Ad-Pac	7.9%	7.9%		
Synthetic base Ad-Pac			9.4%	9.4%
<i>Functional PD-610</i>	0.2%			
KV100, cSt	6.06	7.00	7.05	7.08
KV40, cSt	31.4	36.65	33.90	32.65
VI	145	155	174	188

- Mid to High SSI PMA
 - Excellent for economic applications
 - Top-treat for added thickening and VI improvement



Economy Industrial HF– Starting Point Formulations

VI 135 industrial hydraulic fluid in 600N / ISO 460 BS

- MH-7000 formulas shear in grade by D6278 30 cycle (Kurt-Orbahn)
 - Light duty, single pass applications

ISO VG	220	320	460	680
600N	81.02	55.47	32.18	9.50
ISO 460 Bright Stock	10.13	35.18	57.72	79.15
Functional MH-7000	7.50	8.00	8.75	10.00
Ad-Pac	0.85	0.85	0.85	0.85
PD-610	0.50	0.50	0.50	0.50
KV40	229.7	334.3	482.1	721.9
KV100	24.8	32.3	41.7	55.1
VI	136	136	135	135

Need to meet a specific low temperature specification?

Ask about a pour point study (w/ your base oil and ad-paks)

Economy Industrial HF– Starting Point Formulations

VI 135 industrial hydraulic fluid in 600N / ISO 460 BS

- MH-4000 formulas shear in grade by D5621 / D2603 40min (sonic)

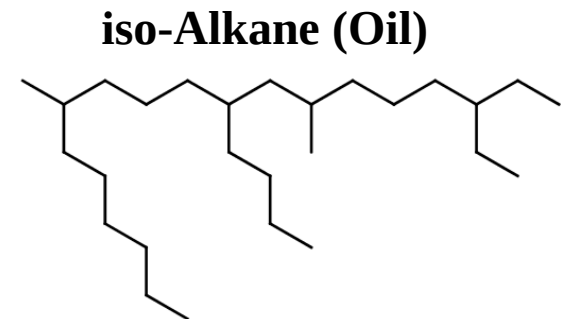
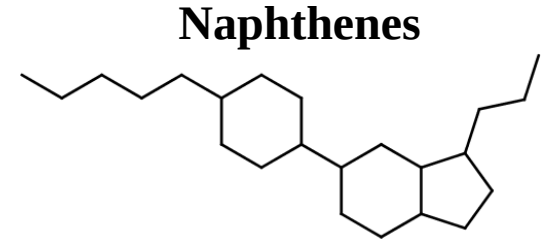
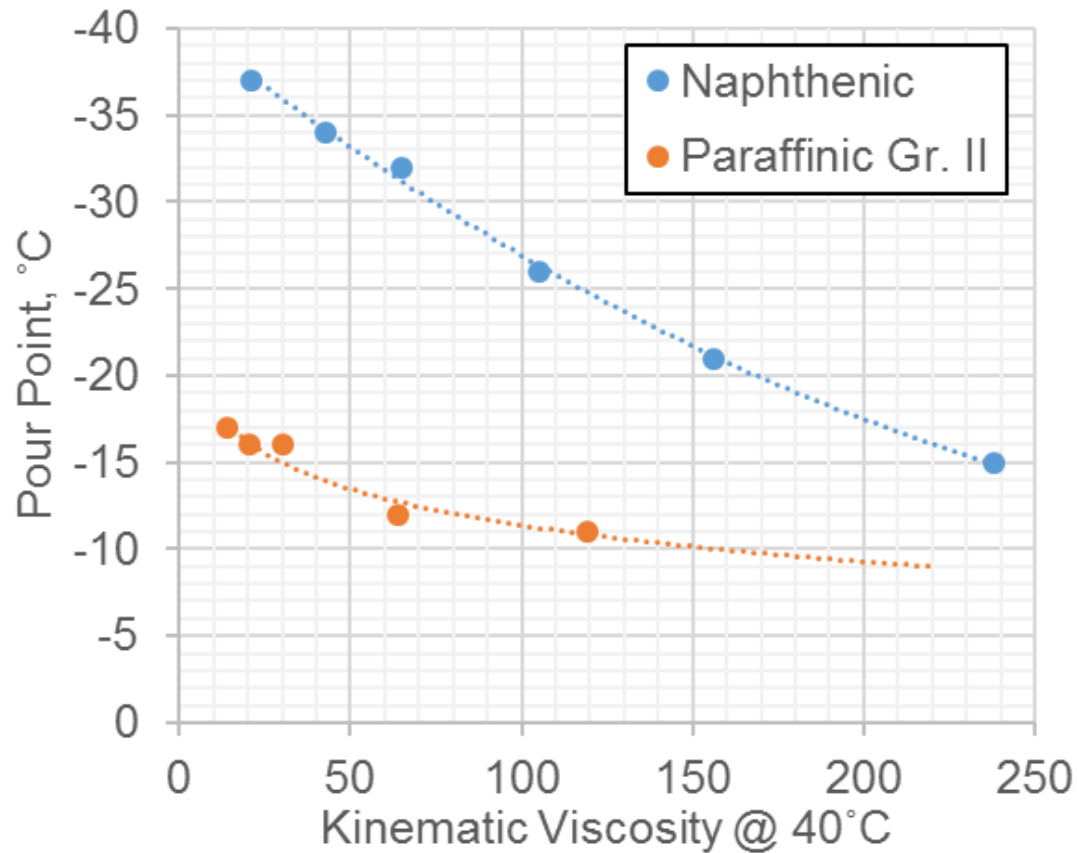
ISO VG	220	320	460	680
600N	77.89	53.45	31.42	7.74
ISO 460 Bright Stock	10.51	34.20	54.98	77.41
<u>Functional MH-4000</u>	10.25	11.00	12.25	13.50
Ad-Pac	0.85	0.85	0.85	0.85
PD-610	0.50	0.50	0.50	0.50
KV40	229.0	334.3	483.2	721.4
KV100	24.6	32.1	41.8	54.9
VI	135	135	135	135

Need to meet a specific low temperature specification?

Ask about a pour point study (w/ your base oil and ad-paks)

- Functional MN-3500 (NEW)
 - 9 SSI polymethacrylate in low viscosity naphthenic oil
 - Naphthenic oils provide excellent low temperature performance

ISO VG	15	46
30 SUS naphthenic	29.3	
60 SUS naphthenic	58.4	
100N paraffinic		87.5
Ad-Pac	2.3	2.3
Functional MN-3500	10	10
Functional PD-620		0.2
Pour Point (D97)	< -65C / -85F	-48C / -54
VI	252	187



n-Alkane (Wax)



- MH-2000 and MH-2500
 - Premium HF products with excellent shear stability for HF



Premium Hydraulic Fluids – Starting Point Formulations

VI 135 industrial hydraulic fluid in 110N / 600N Group II

- Formulated with MH-2000 to shear in grade by KRL 20hr

ISO VG	46	68	100	150
110N	58.15	45.49	28.50	10.45
600N	37.80	46.86	59.85	75.20
Functional MH-2000	3.00	6.60	10.50	13.00
Ad-Pac	0.85	0.85	0.85	0.85
Functional PD-610	0.2	0.2	0.3	0.5
KV40	45.2	67.8	104.7	158.3
KV100	7.6	10.1	14.1	18.9
VI	136	134	136	135

- MG-3000 and MG-1000
 - Gear oils commonly operate under boundary lubrication



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 - MG-3000 built to provide shear stability and low temp thickening for 75W formulations



PAO Multi-grade Gear Oil – Starting Point Formulations
GL-5 75W full synthetic gear oils using PAO

SAE Gear Grade	75W90	75W140
Component		
Synfluid PAO 4	63.0%	50.0%
<i>Functional MG-3000</i>	33.0%	46.0%
GL-5 Gear Ad-Pak	4.0%	4.0%
KV100, cSt	16.79	32.39
KV40, cSt	103.98	271.91
VI	176	163



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- Very poor VI improvement and low temperature properties



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- PMA and PB can be blended for cost reduction without sacrificing low temperature properties



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- Very poor VI improvement and low temperature properties
- PMA and PB can be blended for cost reduction without sacrificing low temperature properties
 - Depends on mw of PMA and PB



Gr III Multi-grade Gear Oil – Starting Point Formulations

Lower cost 75W gear oils using Group III and PIB

SAE Gear Grade	75W140
Component	
4 cSt Gr III	36.0%
Diocetyl adipate	10.0%
<i>Functional MG-3000</i>	20.0%
PB 32	30.0%
GL-5 Gear Ad-Pak	4.0%
KV100, cSt	32.5
KRL (20hr)	< 8%



- 5-10% liquid OCP can be used as a top-treat to reduce PMA usage before pour point is negatively affected
- V-160F and V-460 (SSI 22) + MH-2000 (SSI 1)

Base Oil	PD-610	MH-2000 (SSI1)	V-160F (SSI22)	V-460 (SSI22)	KV40	KV100	VI	pp., C	ISO VG	AGMA	SAE Eng.	SAE Gear
150N Gr. II	0.2	5	5		62.8	10.6	159		68	2	30	85
150N Gr. II	0.2	5	10		92.6	15	171	-42	100	3	40	90
150N Gr. II	0.2	5	20		104	16.2	168	-42	100	3	40	90
150N Gr. II	0.2	10	5		66.5	11.7	173	-45	68	2	30	85
150N Gr. II	0.2	10	10		127.7	19.7	176	-42			50	110
150N Gr. II	0.2	10	20		317.3	39.9	179	-33	320	6		190
150N Gr. II	0.2	20	5		133.7	20.2	174	-30			50	110
150N Gr. II	0.2	20	10		223.5	29.8	174	-27	220	5		140
100N Gr. III	0.2	5		5	40.6	8.3	186	-42			20	80
100N Gr. III	0.2	5		10	66.9	12.8	195	-42	68	2	40	85
100N Gr. III	0.2	5		20	182.7	28.4	195	-42				140
100N Gr. III	0.2	10		5	50	10.7	211	-39	46	1	30	85
100N Gr. III	0.2	10		10	80	15.4	205	-39			40	90
100N Gr. III	0.2	10		20	194.3	29.8	195	-39				140
100N Gr. III	0.2	20		5	82	15.8	206	-33			40	90
PAO 6		5		5	61.2	10.8	169	-52			30	85
PAO 6		5		10	91.5	15.1	174	-52	100	3	40	90
PAO 6		5		20	246.2	33.5	182	-44				190
PAO 6		10		5	77.1	13.3	176	-51			40	90
PAO 6		10		10	105.1	17.5	184	-50	100	3	50	110

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PAO 6		10		10	105.1	17.5	184	-50	100	3	50	110

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- ✓ Un-bundled approach
 - ✓ Control costs
 - ✓ Provide formulators customization options
 - ✓ Market differentiation



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- ✓ FP can assist in providing better market economics on PMA options
- ✓ Short supply chain and packaging options



Thank you for your time and attention!

