



Exploring the Frontier with Next-Generation Tribology Components for E-Fluids

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Agenda

1. Syensqo at a Glance
2. EV Lubricant Requirements
3. Next-Generation Tribology Additives applied to EV



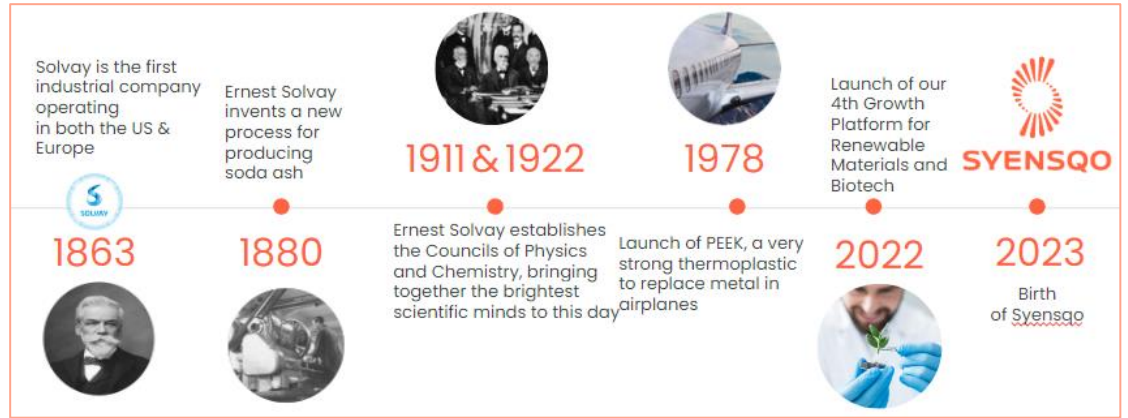
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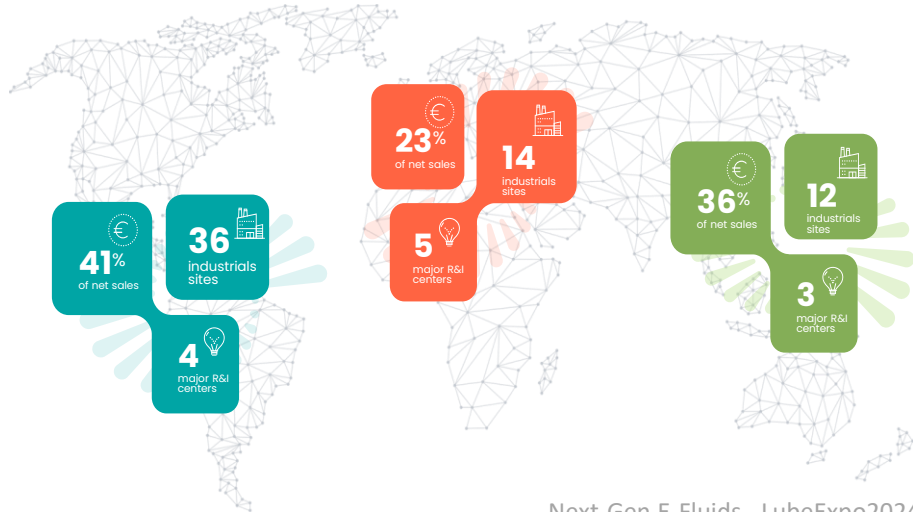


Syensqo at a Glance

A Pioneering Legacy



Global & Close to our Customers



Top-Tier Specialty Player



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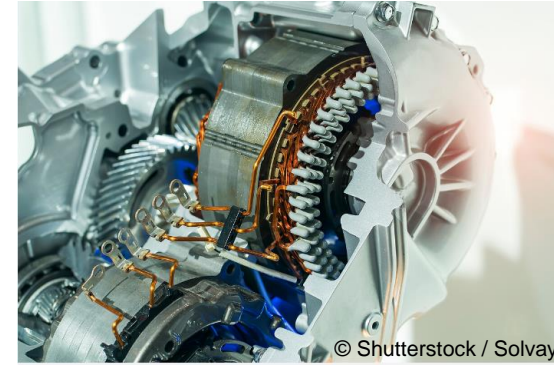


AW/EP is a Key Component of the new E-Driveline Lubricants

New OEM EV-Driveline design increases demand for a single lubricant in contact with gear set, bearings and e-motor

Specific New Requirements on Additives especially on AW/EP:

AW/EP Requirements	Application
Metal-free	<ul style="list-style-type: none">- Electrical conductivity requirements- Avoid deposits and pitting- Better labelling
Anti-wear and Extreme pressure capacity	Higher loads, torque, T → protect gears and bearings
Sulfur-Free	Very strong copper corrosion resistance → due to presence of electrical wires
Low foam and good air release	Compact design of the transmission
'Fill-for-life'	Ultimate requirement for durability



Lubricated Electric Drive Unit (EDU)

Source: FEV: <https://magazine.fev.com/en/electronic-drive-unit>



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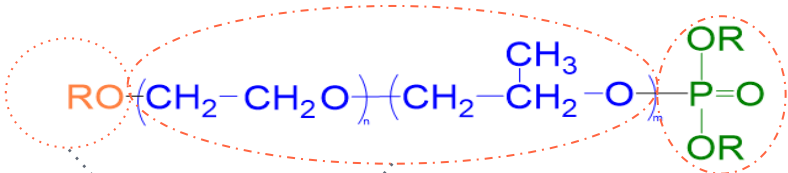
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Next-Generation Anti-Wear Development

2 Solutions:

Phosphate Esters



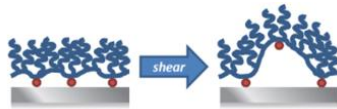
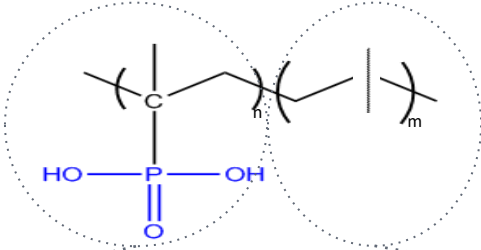
EO=Ethylene Oxide
PO=Propylene Oxide

Lipophobicity

Surface Active

Ashless & Sulfur-free Technology

Polymeric AW



Phosphorus Monomer(s)		Lipophilic Monomer(s)	
Anchoring group outside of the backbone	Tribofilm strength	Type of lipophilic groups	Solubility

Ashless, Sulfur-free and Low Phosphorus Polymer with pendant Phosphorus anchoring groups protecting the surface



New Phosphate Ester Development

4 lead candidates identified:



	Benchmarks		PE201	PE210	PE205	PE216
	ZDDP	ref.PE				
P (wt%)	8	5.6	6.4	4.5	2.5	6.8
S (wt%)	16	0	0	0	0	0
Zn (wt%)	9	0	0	0	0	0
TAN (mgKOH/g)	148	180	344	132	80.2	385

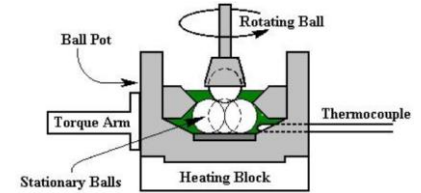
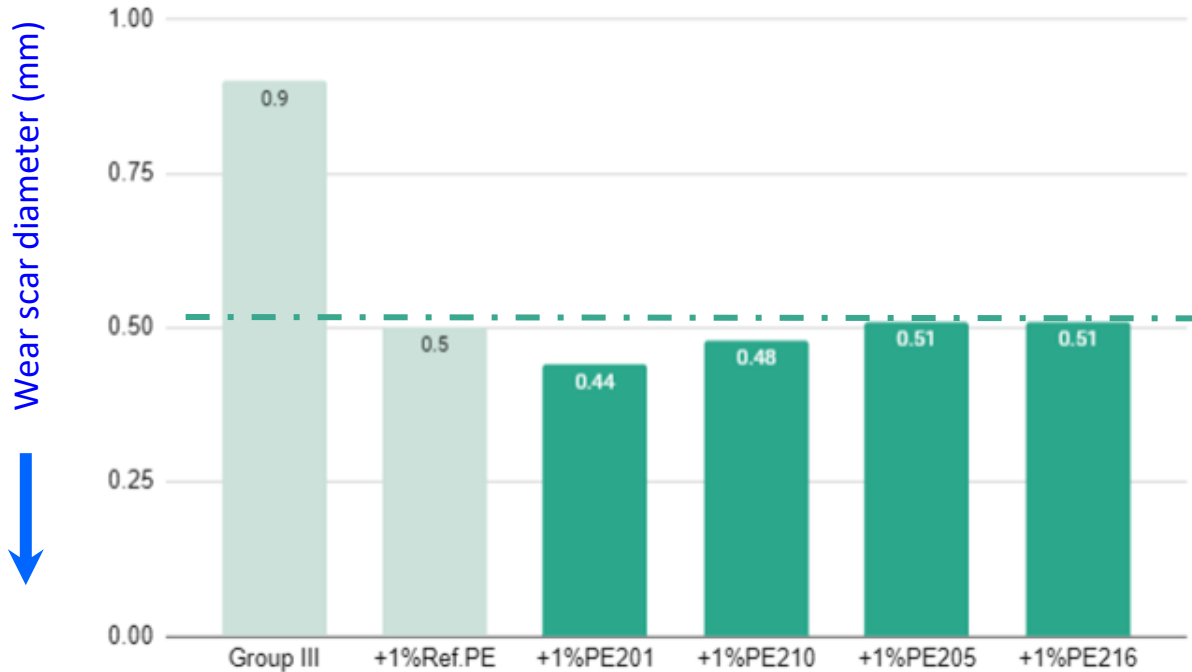
Evaluation on 4 Performances @1wt% in a 4.3 cSt GIII Base Oil:

- 4 ball wear
- 4 ball EP
- Cu Corrosion Protection
- Electrical conductivity

New Phosphate Esters - Anti-Wear Evaluation

in GIII
Base Oils

⇒ Equivalent AW performance



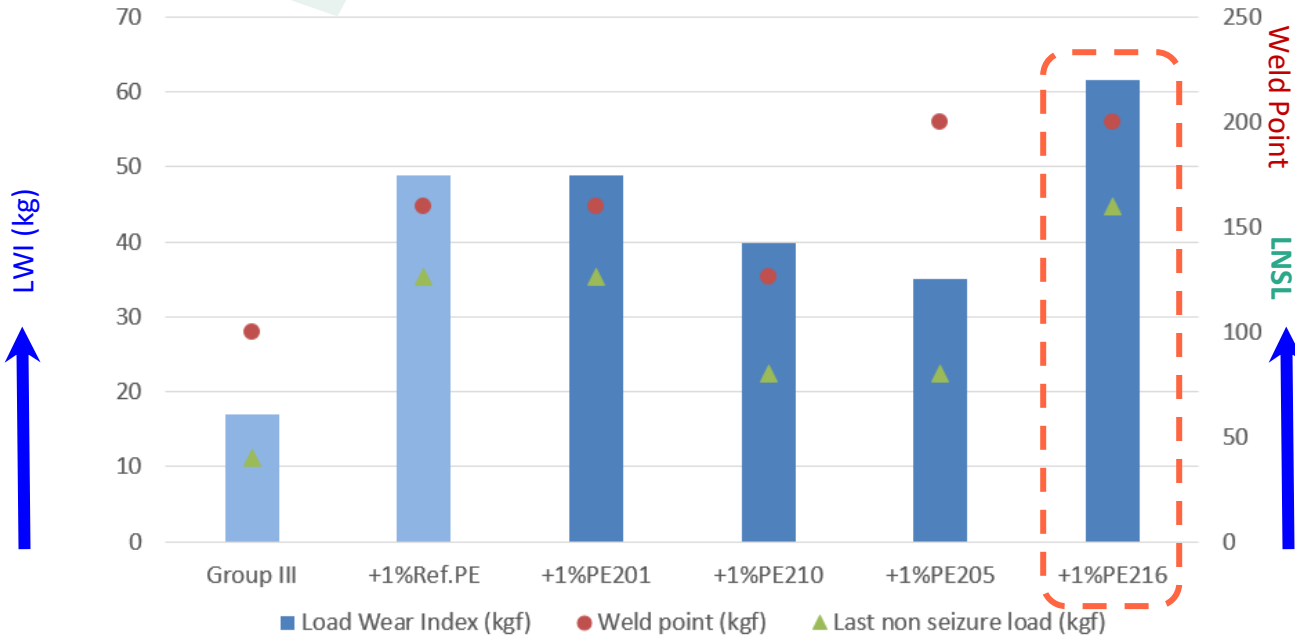
Testing conditions:

- 4 ball wear test - ASTM D4172:1200 rpm - 60 min - 75°C - 40kg
- 1wt% AW in Group III: KV100°C=4.3 cSt

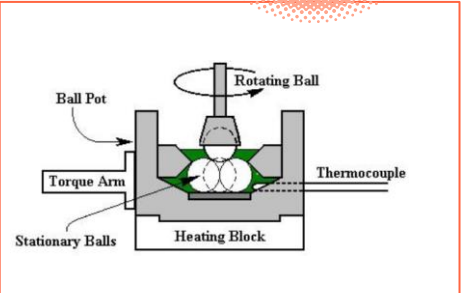


New Phosphate Esters - Extreme Pressure Evaluation

⇒ 1 candidate (PE216) better than the benchmark



in GIII
Base Oils



Testing conditions:

- 4 ball EP test - ASTM D2783: 1760rpm-35C-10s/load
- 1wt% AW in Group III: KV100°C=4.3 cSt



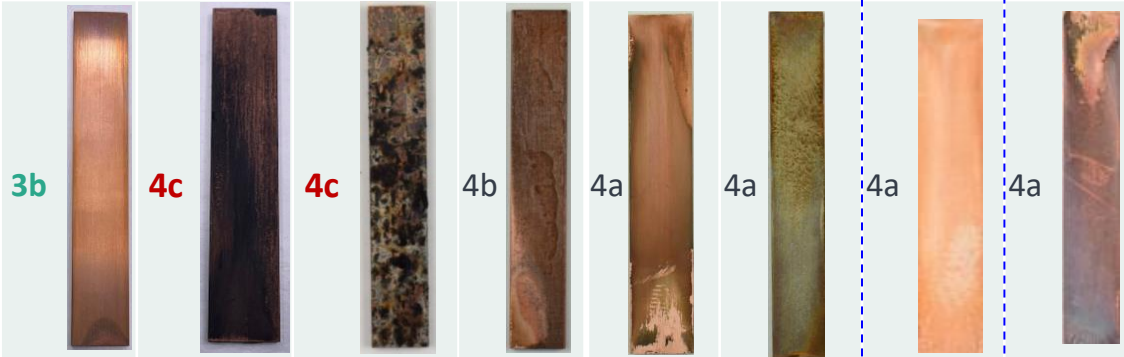
New Phosphate Esters - Cu Corrosion Protection

in GIII
Base Oils



- ⇒ 1 candidate (PE205) > ZDDP, Polysulfide and ref. PE
- ⇒ 1 candidate (PE205) ≈ Group III Base Oil

ASTM D130: 150°C for 168hrs	4.3 cSt GIII	Benchmarks			+1% PE201	+1% PE210	+1% PE205	+1% PE216
		+ 1% ZDDP	+0.28wt% Polysulfide*	+1% ref. PE				
Zn in oil (ppm)	0	950	0	0	0	0	0	0
P in oil (ppm)	0	800	0	560	640	450	250	680
S in oil (ppm)	0	1600	1120	0	0	0	0	0
Cu strip rating	3b	4c	4c	4b	4a	4a	4a	4a
Cu in oil (ppm)	11	46	44	39	63	228	15	200



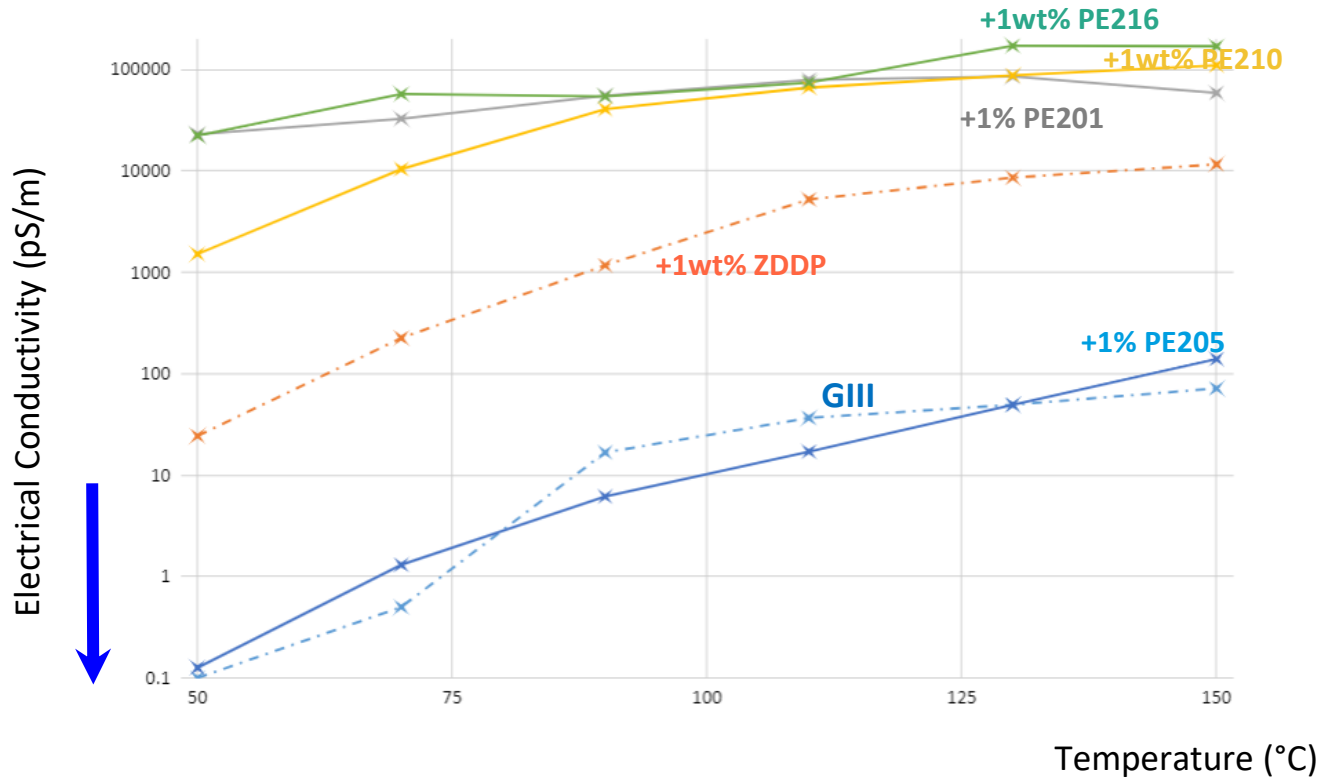
*in 3cSt GIII



New Phosphate Esters - Electrical Conductivity

in GIII
Base Oils

⇒ 1 candidate = GIII: PE205



Testing conditions:

- EPSILON + dielectricity sensor
- T rampe=50-150°C
- 1wt% AW in Group III:
KV100°C=4.3 cSt



Conclusion on New Phosphate Esters

- Very flexible technology with different performance levels
- New candidates under development



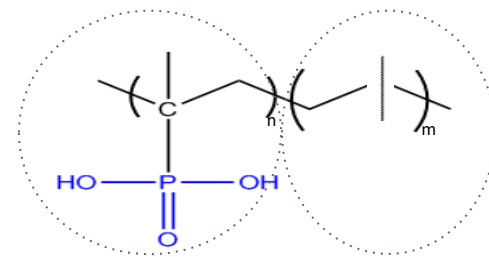
Performances	4.3 cSt GIII	Benchmark	+1% PE201	+1% PE210	+1% PE205	+1% PE216
		+1% ref. PE				
AW	/	++	+++	++	++	++
EP	/	++	++	+	+	+++
Cu Corrosion 150°C-1W	+++	++	++	+	+++	+
Electrical conductivity	+++	/	--	--	+++	--

Polymeric AW Technology

Properties	Polymeric AW Lead Candidate: D.097
Elements	Ashless & Sulfur-Free
P content	0.32 wt%
Physical form	Viscous liquid
Color	Transparent
Thermal stability	> 300°C
TAN (ASTM D664)	7 mg KOH/g

Evaluation on 3 Performances:

- 4 ball wear
- Electrical conductivity
- Cu Corrosion Protection

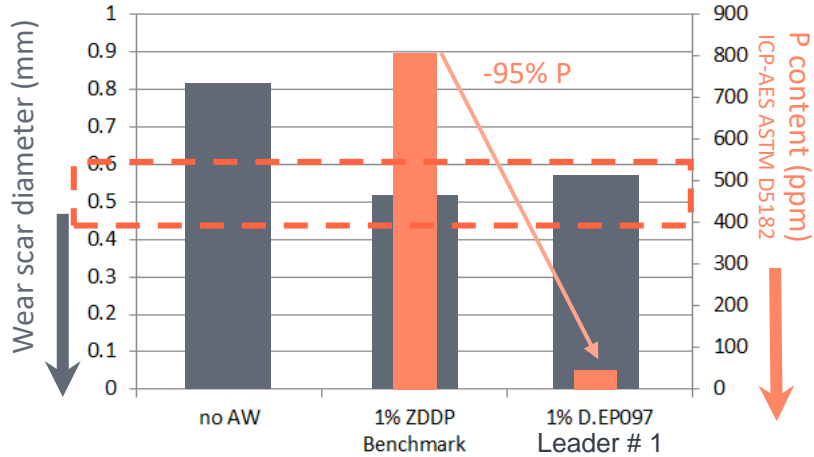


Polymeric AW - Anti-wear Benefits

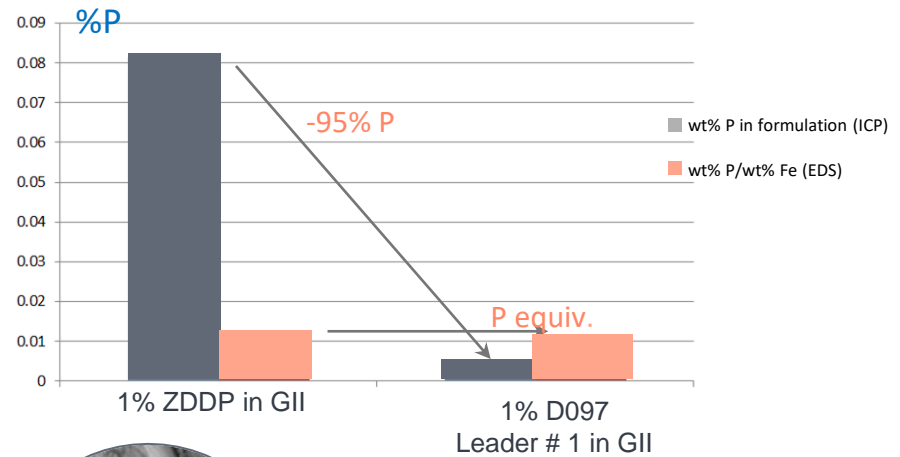


⇒ ANTI-WEAR PERFORMANCE EQUIVALENT TO ZDDP WITH 95% LESS PHOSPHORUS

Anti-Wear Performance

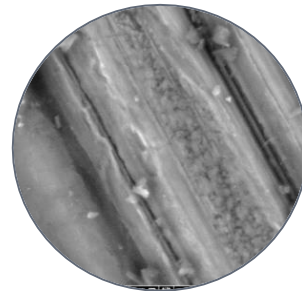


EDS*: Surface Analysis



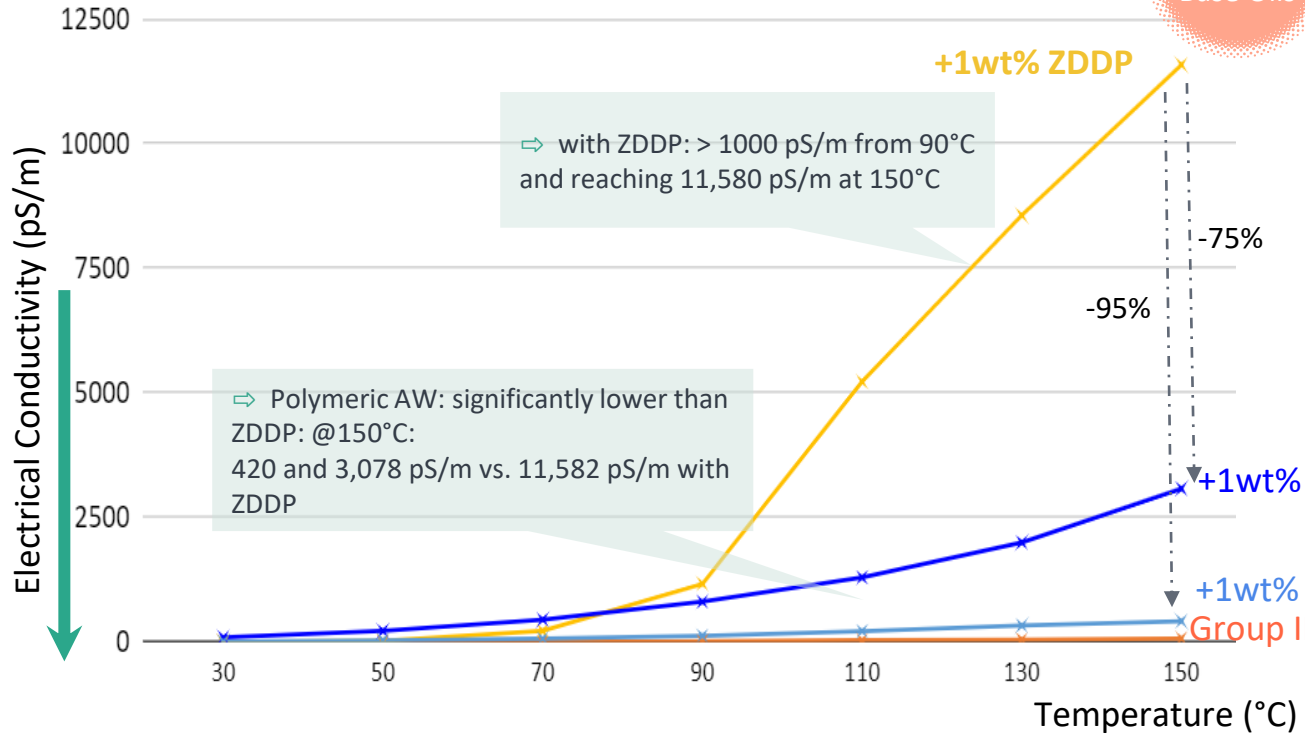
Testing conditions:

- 4 ball wear test - ASTM D4172 (1200 rpm - 60min - 75°C - 40kg)
- 1wt% AW in Group II base oil: KV100°C=9 cSt



- New Polymeric AW vs. ZDDP: 95% less P in the oil vs. equal P on the Surface
⇒ Higher P adhesion power on the surface

Polymeric AW - Electrical Conductivity



Testing conditions:

- EPSILON + dielectricity sensor
- T rampe=30-150°C
- 1wt% AW in Group III: KV100°C=4.3 cSt






Polymeric AW - Cu Corrosion Protection

- ⇒ Polymeric AW technology better protects from Cu Corrosion
- ⇒ ZDDP and Polysulfide detrimental to Cu Corrosion

Improved Corrosion Protection →



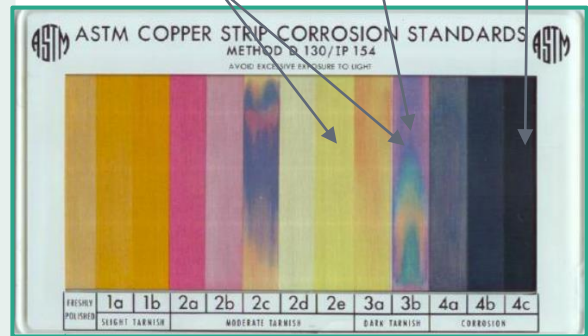
ASTM D130: 150°C for 168hrs	4.3 cSt GIII	+ 1% ZDDP	+0.28wt% Polysulfide*	+1% PolymAW D097 Leader#1	+1% PolymAW D059
Zn in oil (ppm)	0	950	0	0	0
P in oil (ppm)	0	800	0	32	39
S in oil (ppm)	0	1600	1120	0	0

Cu strip rating	3b 	4c 	4c 	3b 	2e 
Cu in oil (ppm) ASTM D5185	11	46	44	51	10

+1wt% PolymAW

GIII

+1% ZDDP +0.28%Polys



← Improved Corrosion Protection



*in 3cSt GIII

Conclusion on Polymeric AW

A potential high-performance next-generation AW solution

	Polymeric AW Lead Candidate: D.097
Electrical conductivity	>>> ZDDP: -95% and -75% lower conductivity than ZDDP
Cu Corrosion	> ZDDP and Polysulfide
AW and Friction	↔ ZDDP
Stability in GIII after 4 weeks	Bright and Clear @ RT, 50°C and 4°C
Thermal conductivity	Harmless

@1wt% in Group III: KV100°C=3cSt and 4.3cSt

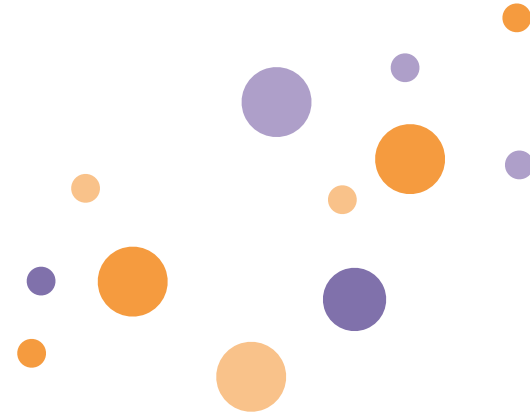


BENEFITS FOR ELECTRIC VEHICLE FLUIDS

- Metal-free and S-free
- Very high protection of copper electrical wires against corrosion
- Very low electrical conductivity
- Shows excellent Anti-Wear

Conclusion

- **Need to Innovate** to meet new requirements in **Electric Vehicles**
- **2 Ashless & Sulfur-Free Next-Generation AW/EP** under **development** showing promising performances and a good sustainability profile
- Evaluation is continuing and new candidates are under development



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- Jean-Raoul Gomez
- Marie-Pierre Labeau
- Anne Vanden Abbeele
- Patrick Moreau



To be continued...

Thank you very much for your attention

ANY QUESTIONS?

PLEASE FEEL FREE TO CONTACT ME:

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