



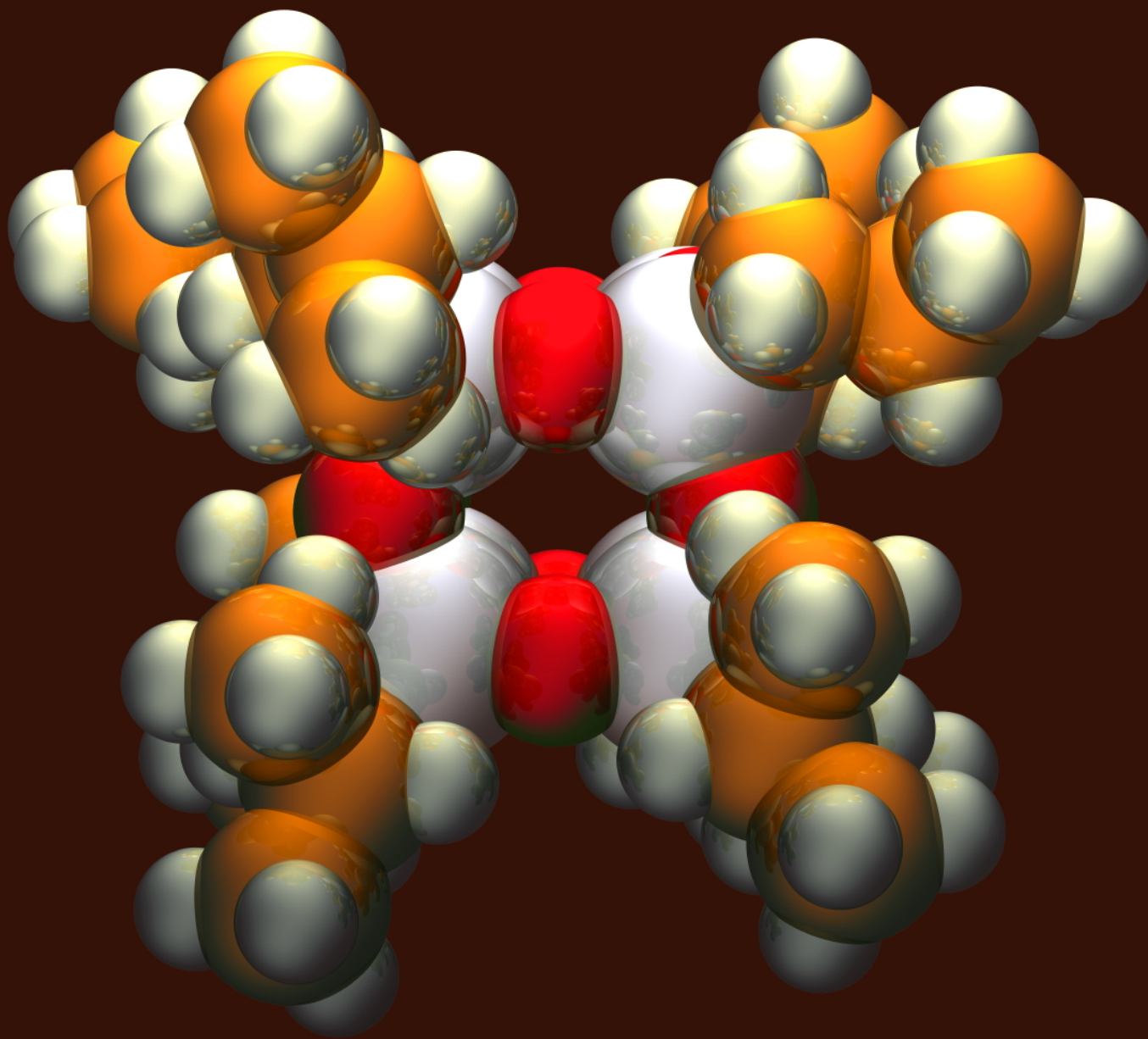
Enhanced Polymers using POSS[®]

Dr. Chris DeArmitt FRSC
Chief Scientist

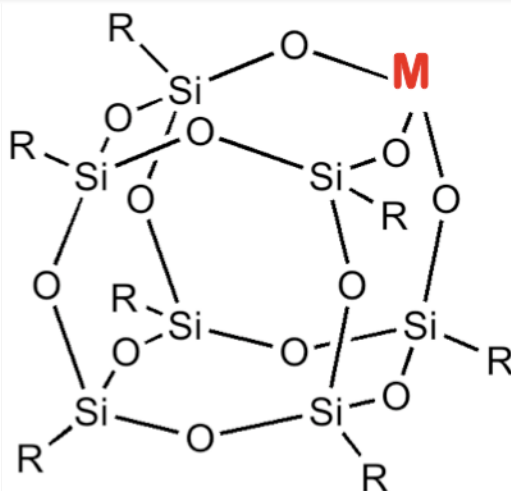
Hybrid
Plastics™

Overview

- What is POSS[®]?
- POSS[®] Flow enhancers
- Friction & hydrophobicity control
- Dispersants for pigments & fillers
- Copper passivation
- POSS[®] thermosets
- Safety and production of POSS[®]
- Conclusions



Elements Incorporated into POSS®



POMS Reported

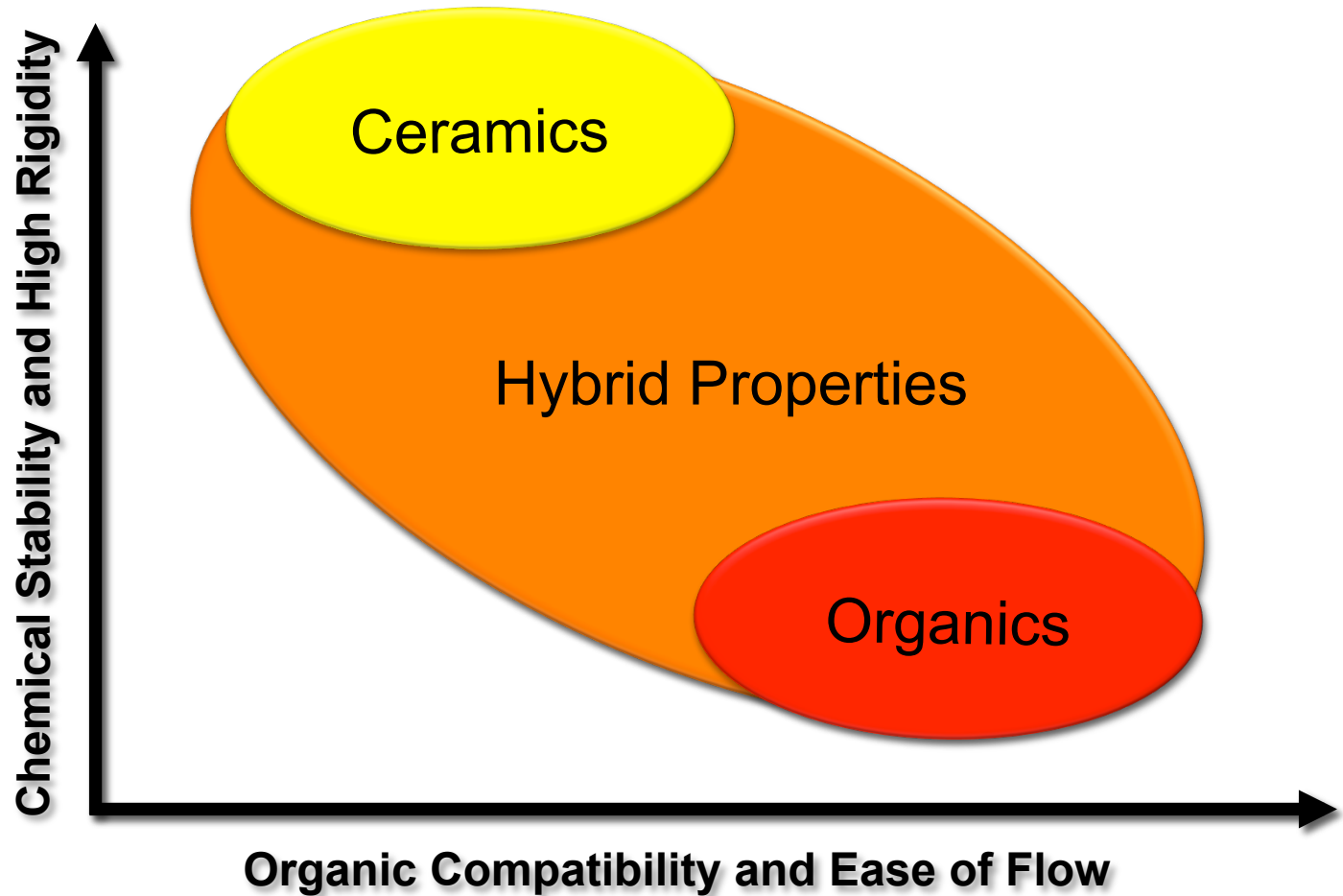
Not yet reported

H																	He
Li	Be											B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Fr	Ra	Ac															

Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr

Why Hybrid Materials?

POSS® is a **unique** hybrid organic-inorganic composition



Hybrid Properties

Material Type	Density (gcm ⁻³)
Quartz	2.60
Amorphous silica	2.18
Octa hydrido POSS	1.82
Octa methyl POSS	1.50
Octa ethyl POSS	1.33
Octa i-butyl POSS	1.13
Octa i-octyl POSS	1.01
Iso-octane	0.69

What does POSS[®] look like?

Crystalline Solids

Wide melting range 24°C to 400°C

Liquids/Oils

Wide viscosity range 1000cP to 100000cP

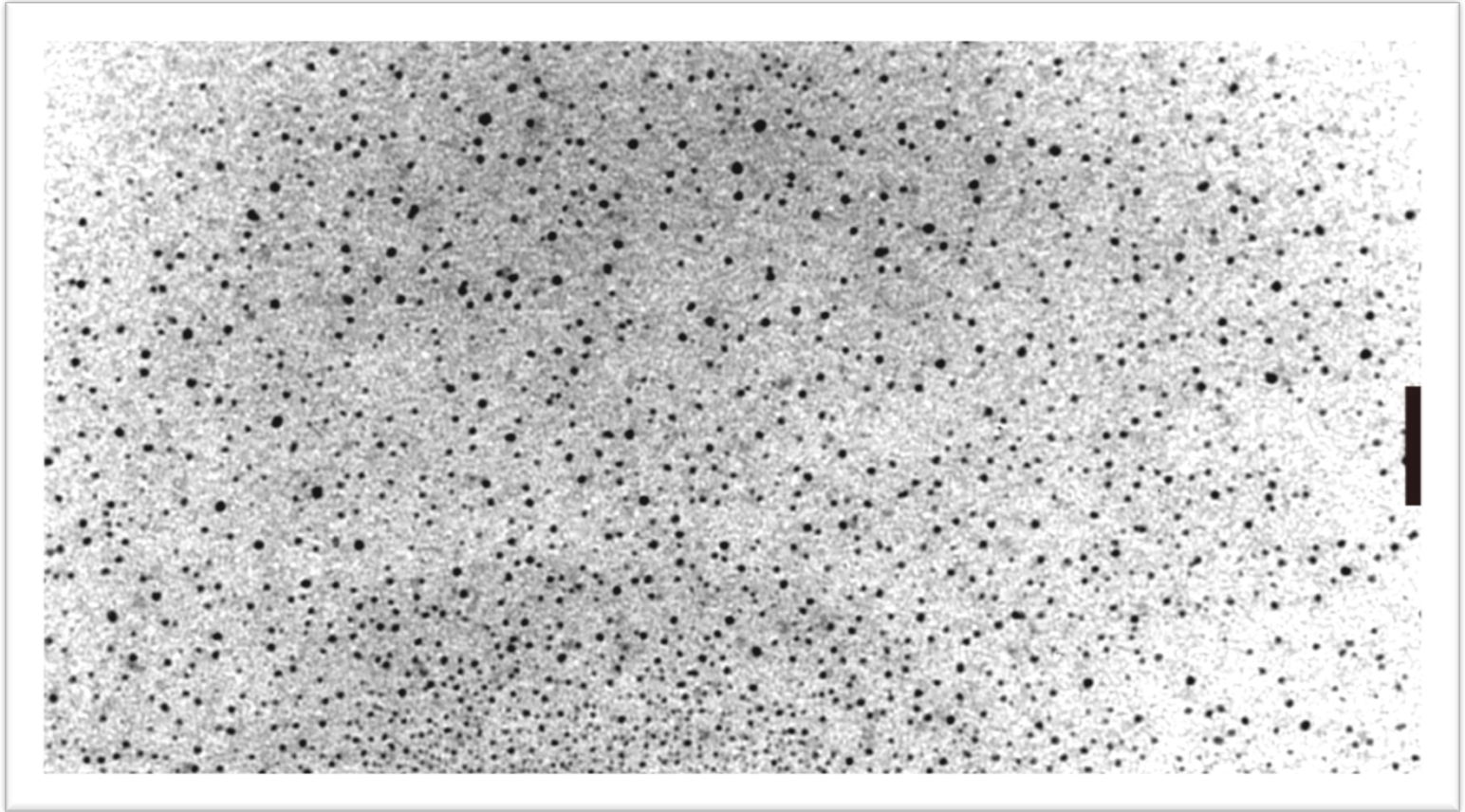


Waxes

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POSS[®] Actually Dissolves in Polymer

Each “black dot” represents a 1.5nm POSS[®]



*scale of bar = 50nm

Viers - US Air Force Research Laboratory

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What can POSS[®] do for you?

Increased T_g

Increased T_{decomp}

Extended temperature range

Reduced flammability

Radiation Resistance

Oxidation resistance

Reduce friction

Change permeability

Solvent resistance

Low volatility

Catalytic activity

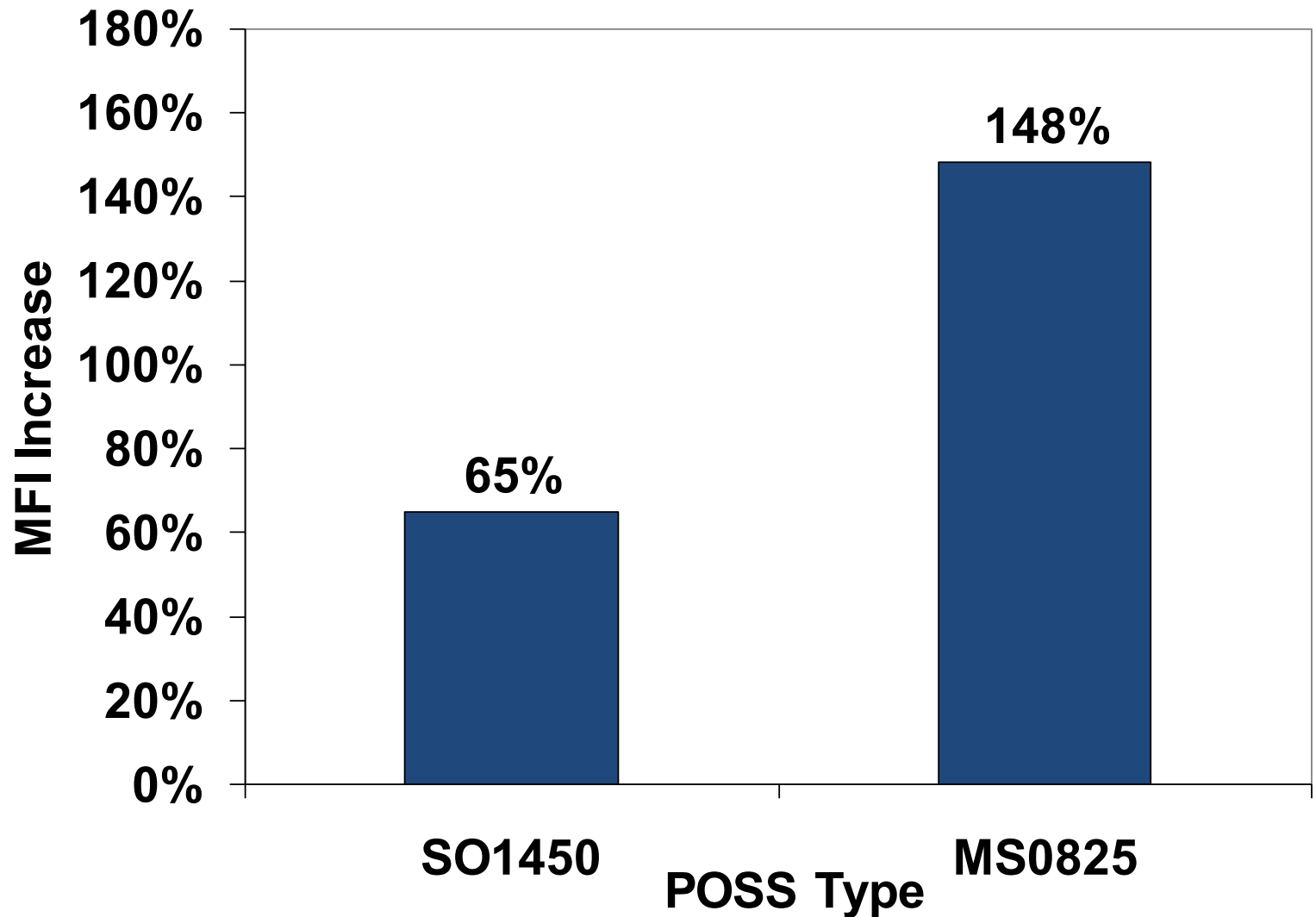
Improved Flow

Surface passivation

As a dispersant

Beat Competitor Patents

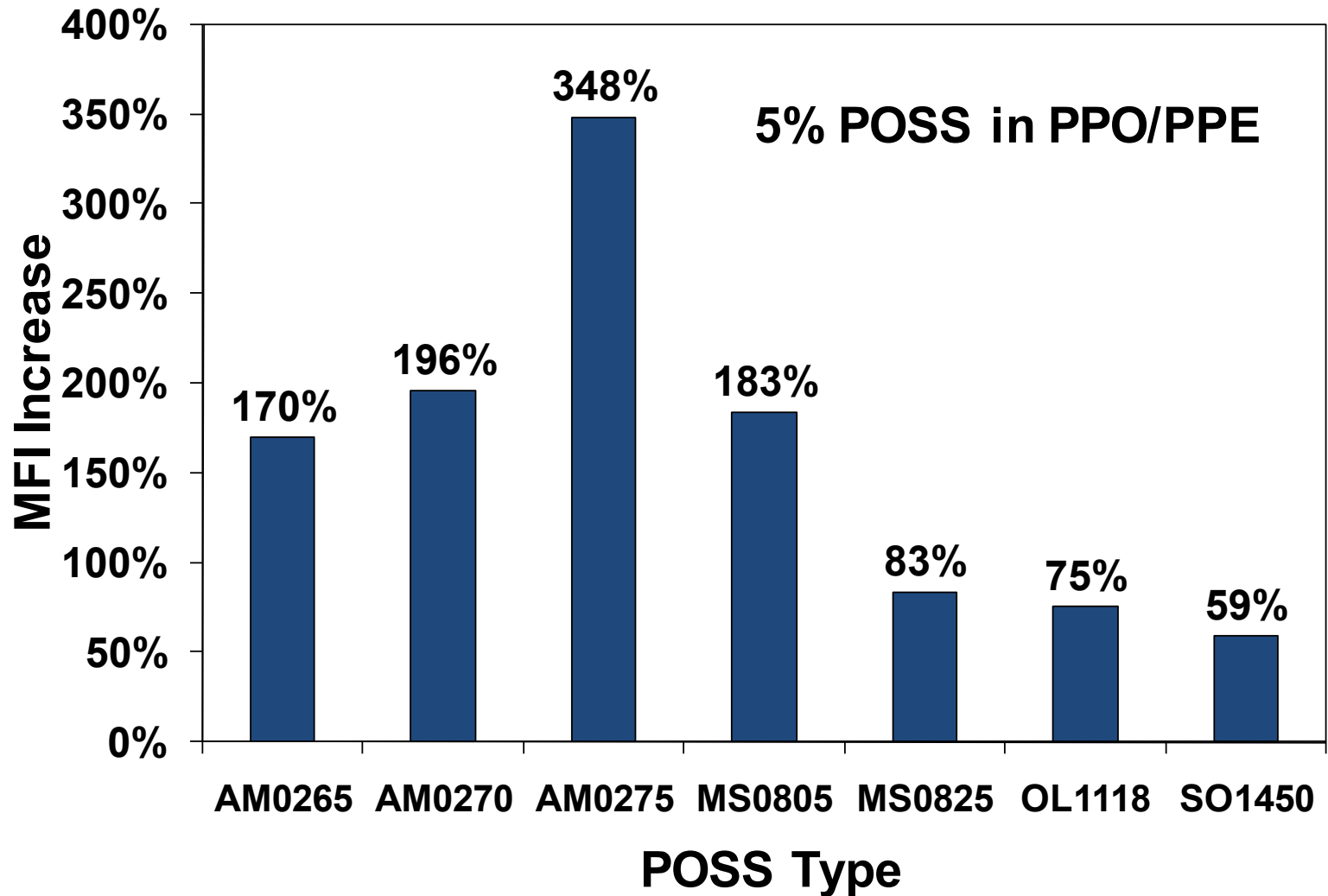
Flow Enhancement in COC (5% POSS®)



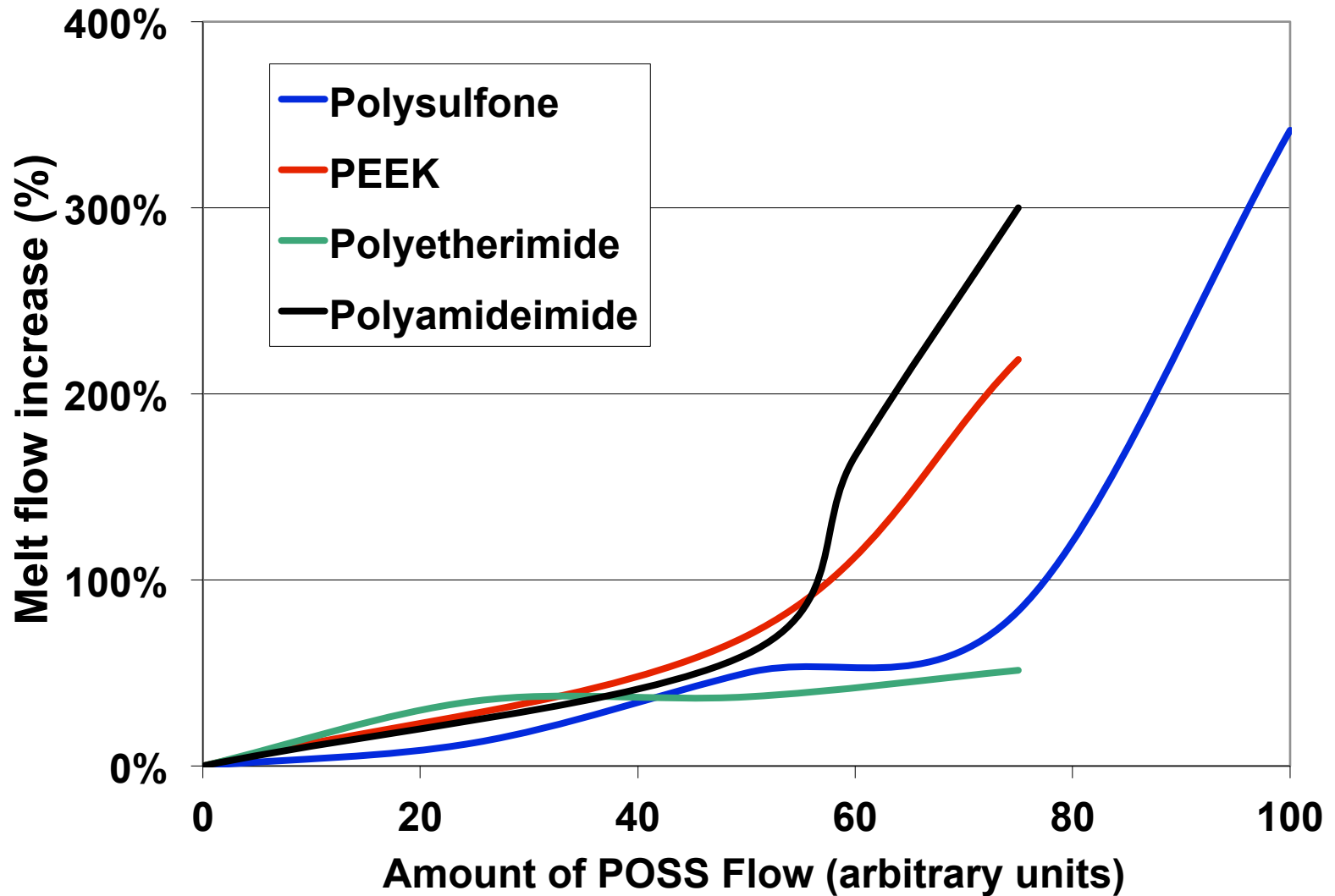
260°C 2.16kg

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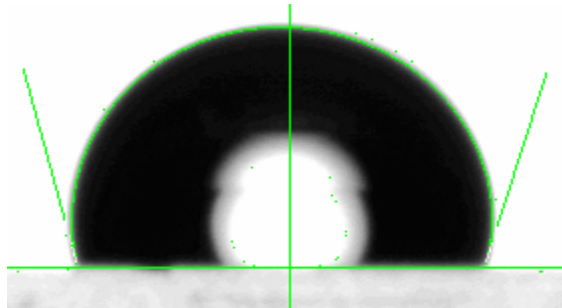
Flow Enhancement in PPO/PPE



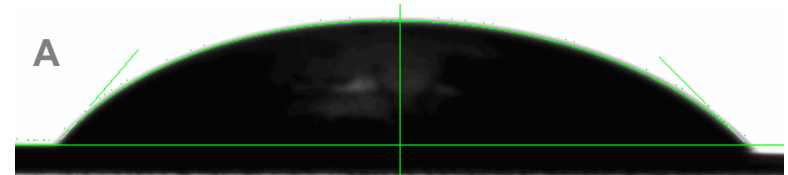
POSS® Flow Masterbatches



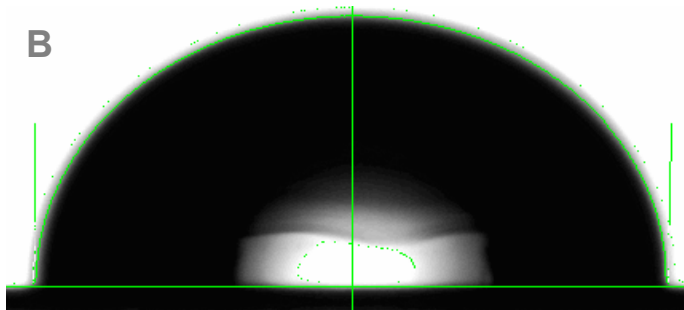
Hydrophobization



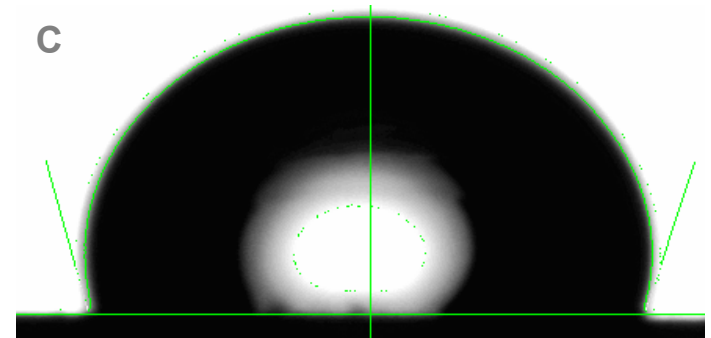
Teflon
Contact angle: $110 \pm 2^\circ$



A
Nylon 6
Contact angle: $49^\circ \pm 2^\circ$



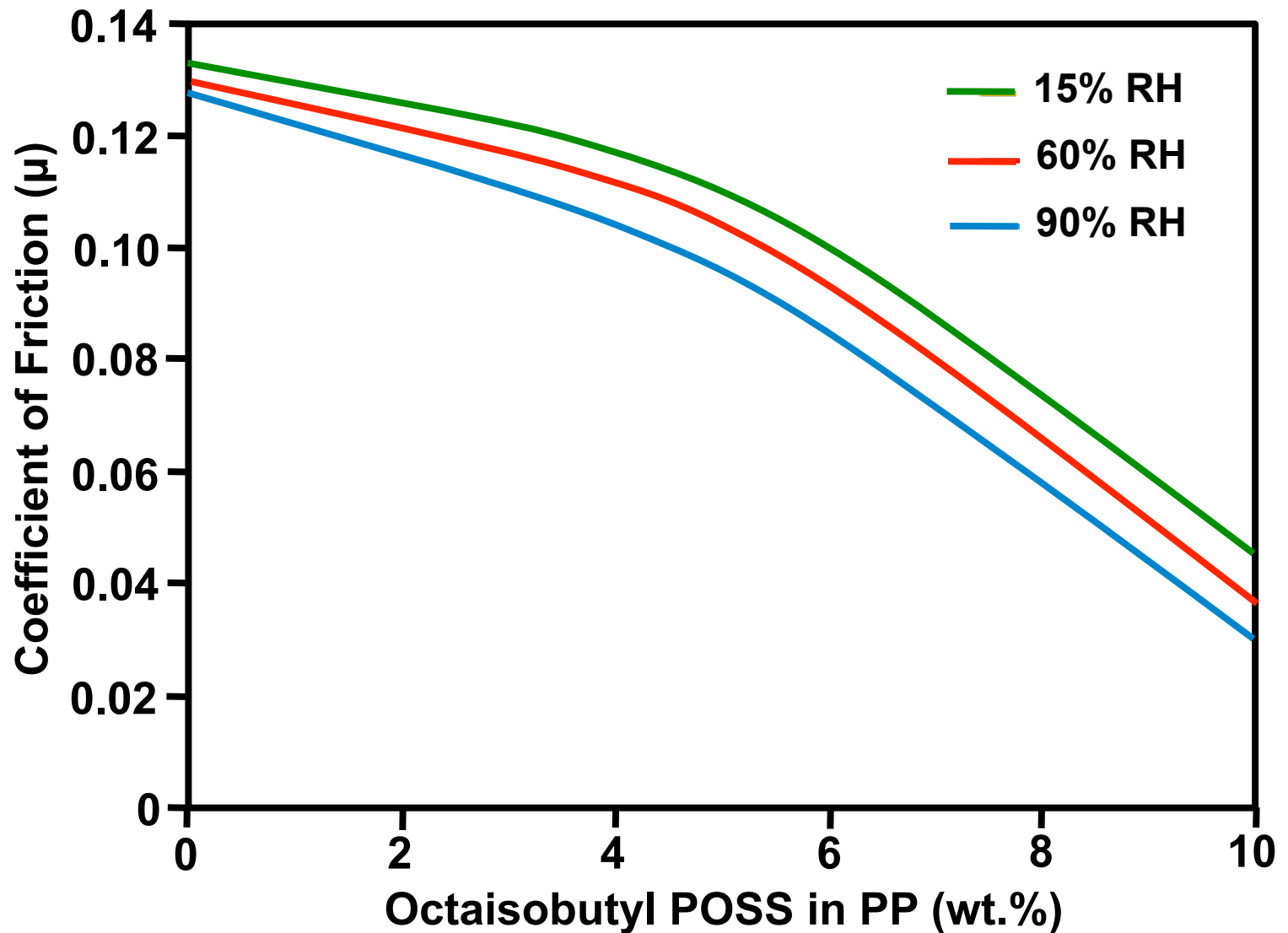
B
Nylon 6 + 5% Octaisobutyl POSS
Contact angle: $88^\circ \pm 3^\circ$



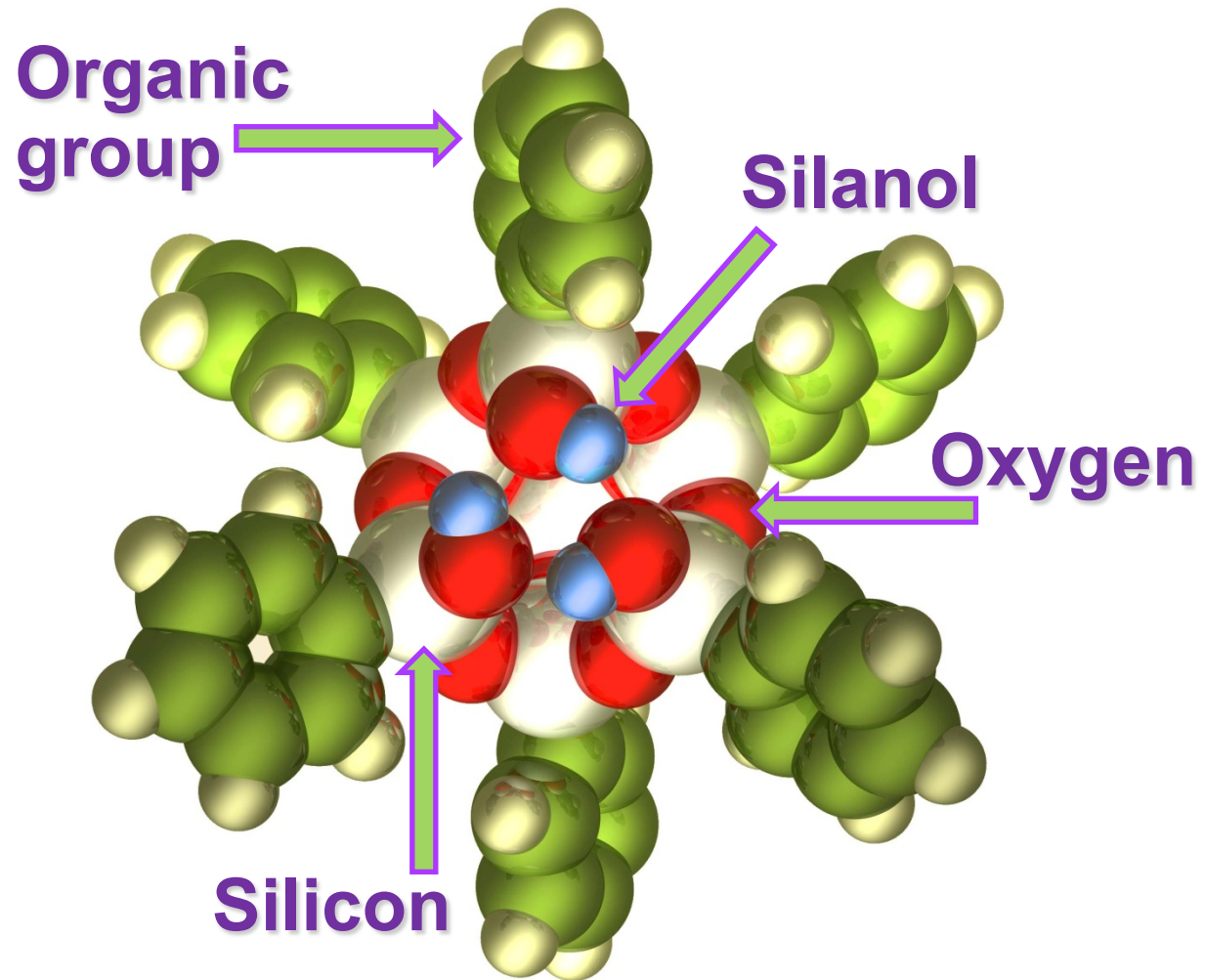
C
Nylon 6 + 10% Octaisobutyl POSS
Contact angle: $108^\circ \pm 2^\circ$



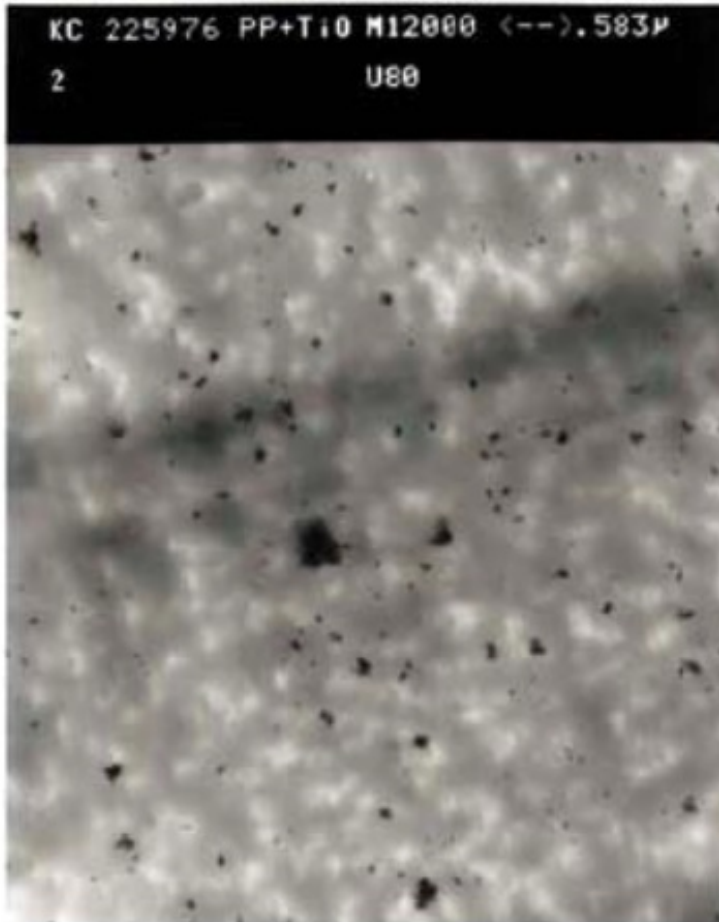
Reduction of Friction in PP



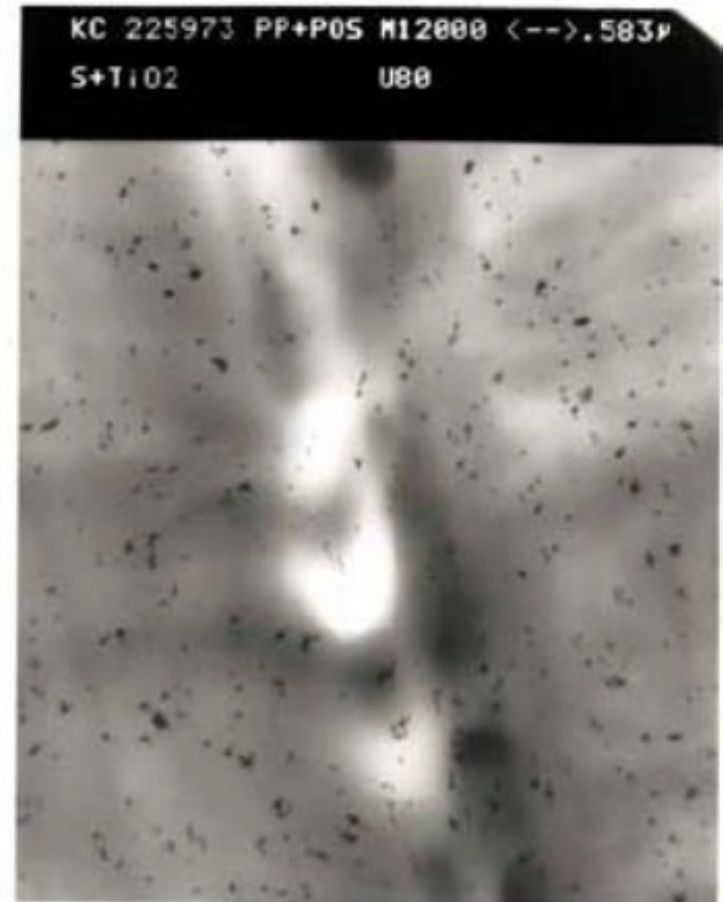
POSS[®] Trisilanol



TiO₂ Masterbatch with POSS[®] Dispersant

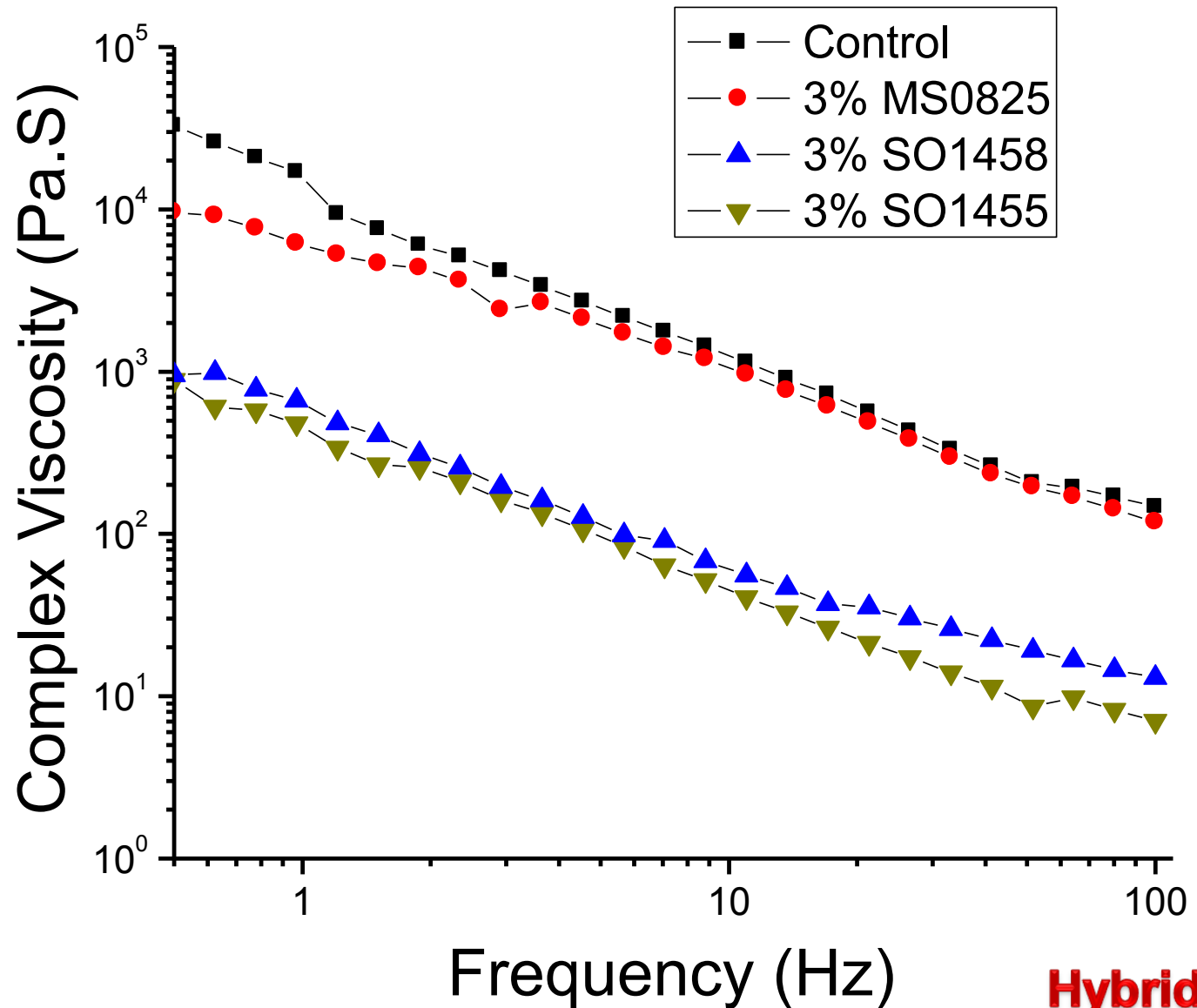


PP with 1wt%
TiO₂

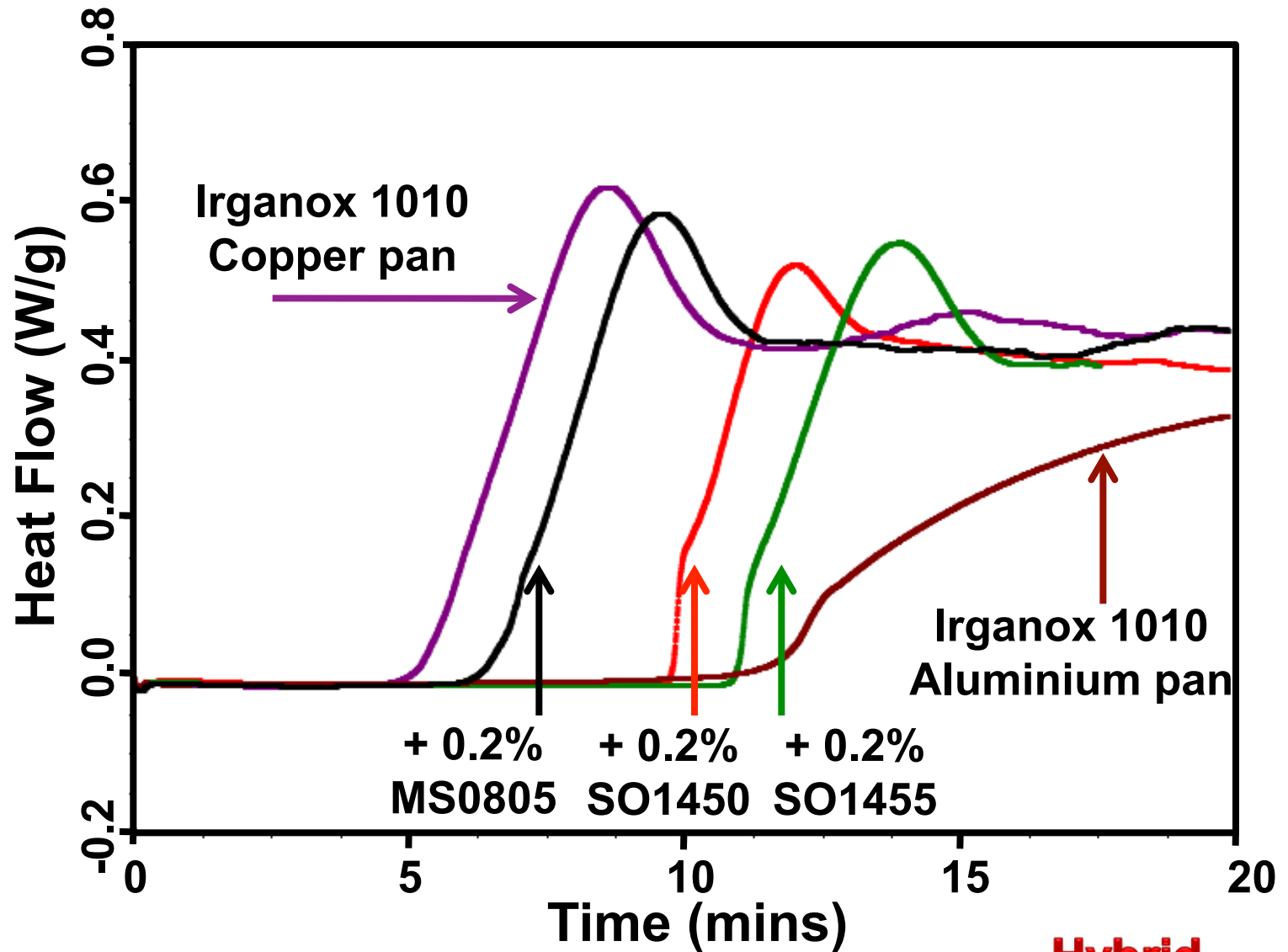


PP with 1wt% TiO₂
+ 5 wt% POSS

POSS® Dispersants for Boron Nitride

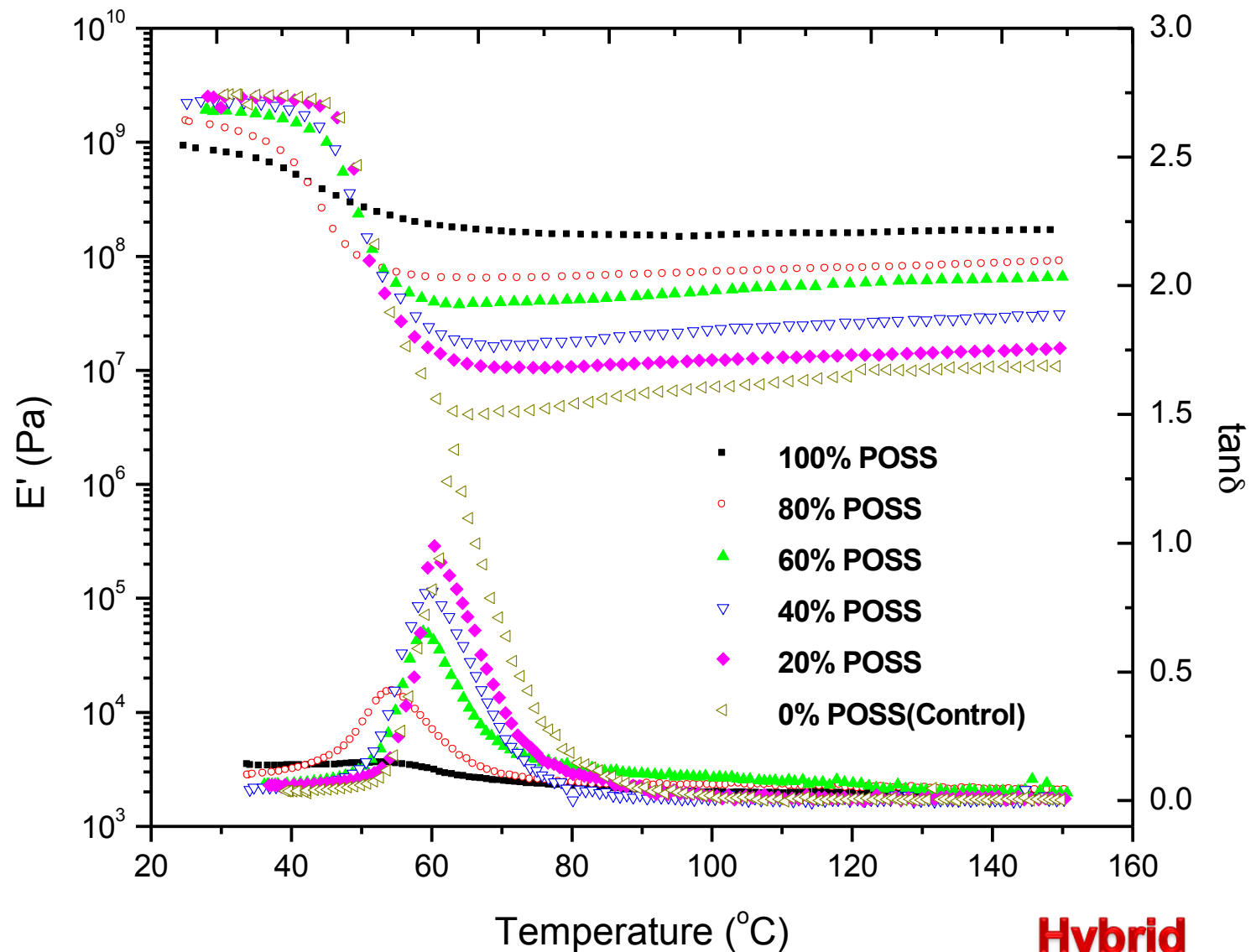


POSS® Passivating Agent for Copper



In hydrocarbon oil (squalane) 190°C, oxygen atmosphere

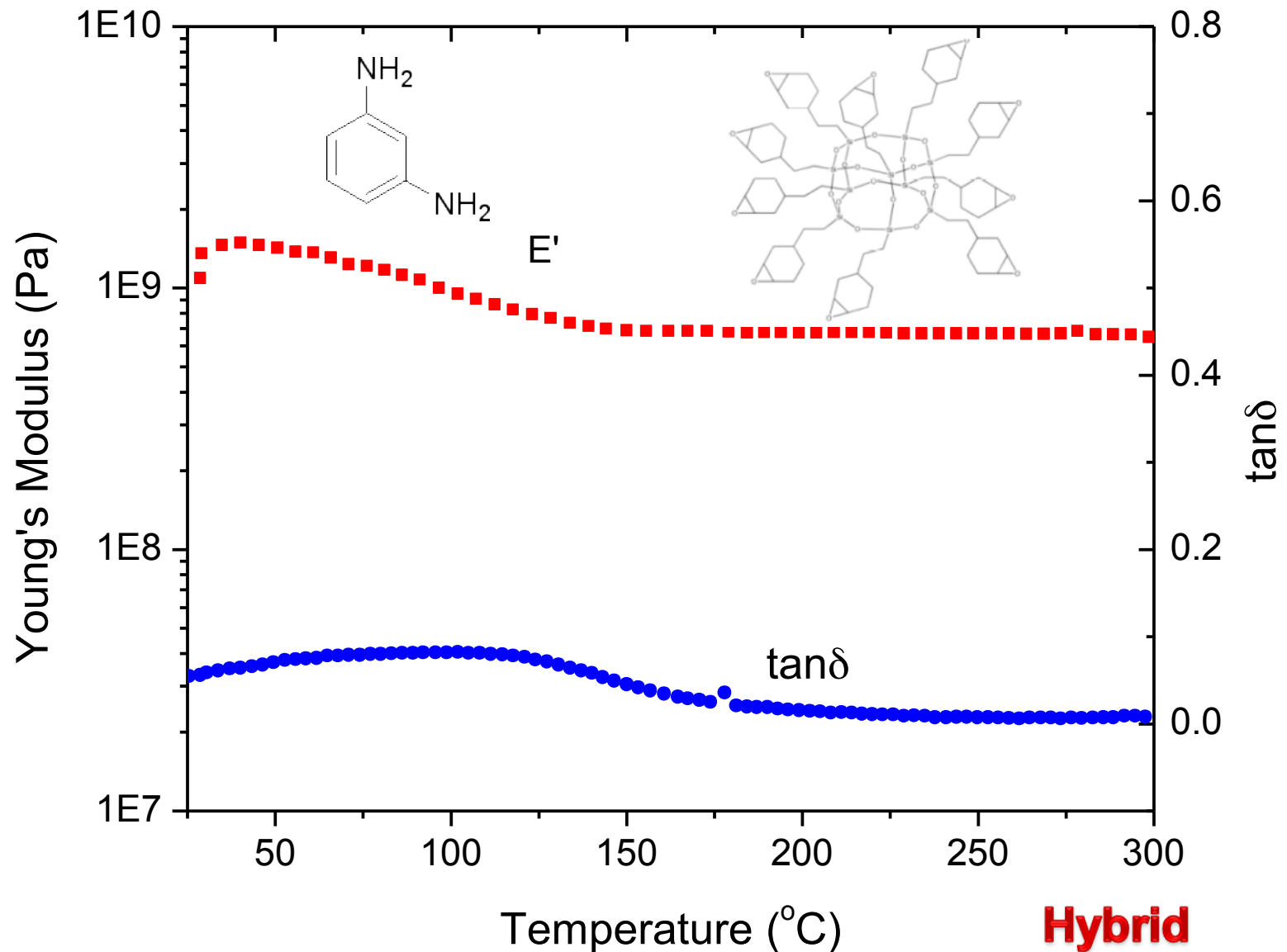
POSS® Epoxy Retains Modulus above Tg



Ambient cure for 3 days; DMA 2 $^{\circ}\text{C}/\text{min}$, 1Hz

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POSS® Ultra-High Temperature Epoxy



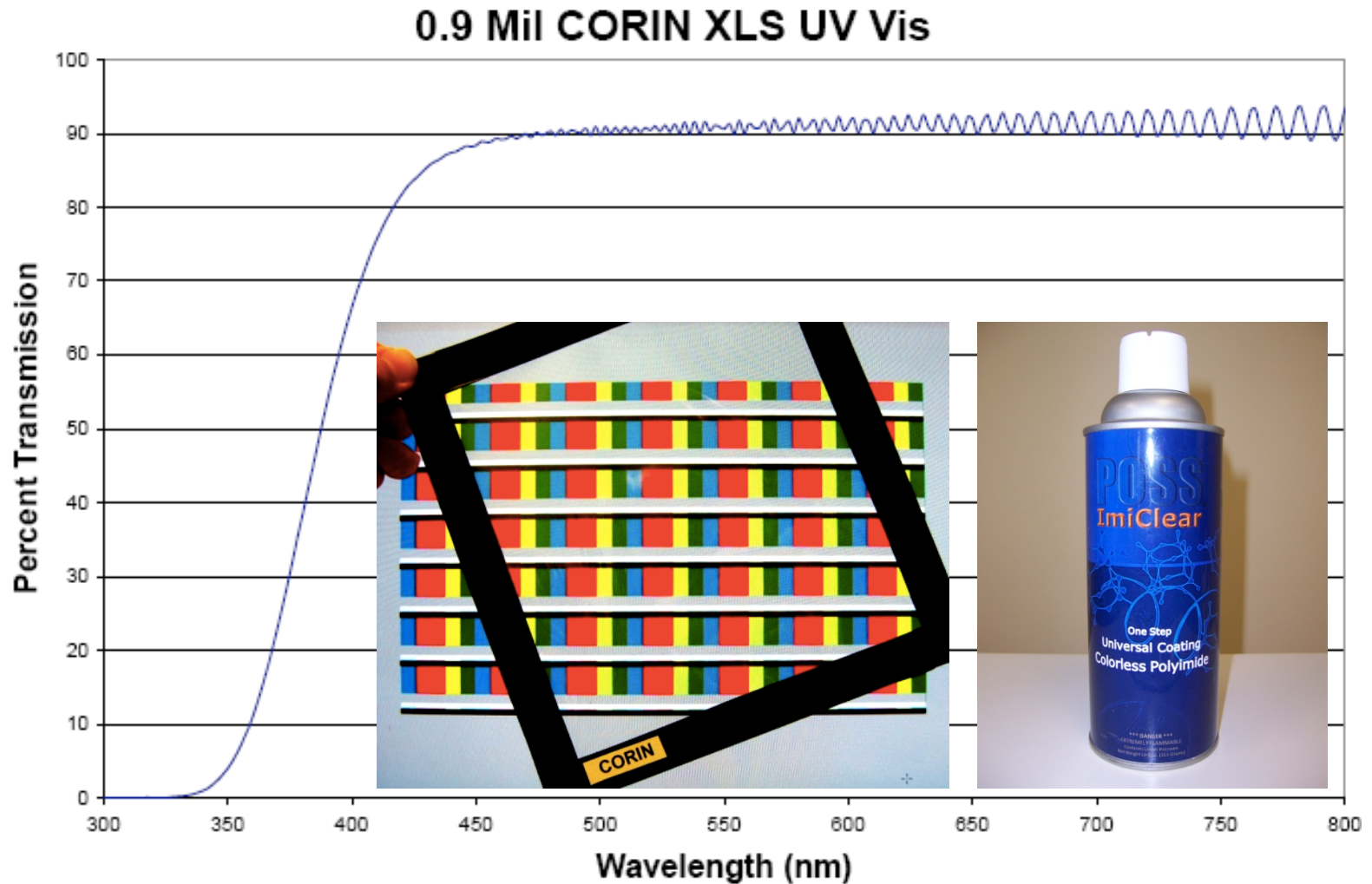
Reduced Solvent Swelling

Material Type	Weight increase (%)
Silicone + 0% POSS	25
Silicone + 20% POSS	19
Silicone + 40% POSS	14
Silicone + 60% POSS	10

- High cross-link density
- The cage cannot swell

1 week in acetone

POSS® Colorless Polyimide Spray



Tg 250°C; tensile strength 74MPa; elongation 8%; CTE 68 um/m/°C
With ManTech Corp.

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Safety of POSS[®]

Several of the larger production volume POSS[®] types are TSCA listed

Octaisobutyl POSS[®] MS0825

US Category IV Oral LD50 > 5000 mg/kg

Octamethyl POSS[®] MS0830

EU Oral LD50 > 2000 mg/kg

Dodecaphenyl POSS[®] MS0802

EU Oral LD50 > 2000 mg/kg

Does **not** require the risk phrase R22
"Harmful if Swallowed."

Tested on rats by independent accredited laboratory

Tooth Restoration Products



Nano-Bond® Nano-Particulate
Reinforced Adhesive System



Artiste™ Nano-Hybrid Flowable Composite



TempSpan GLAZE Eliminates Polishing Step

NIH sponsored products



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POSS® in Food Packaging



- POSS® incorporation provides longer shelf life
- Film blowers like it because it is cheaper to use
- Improves color printing

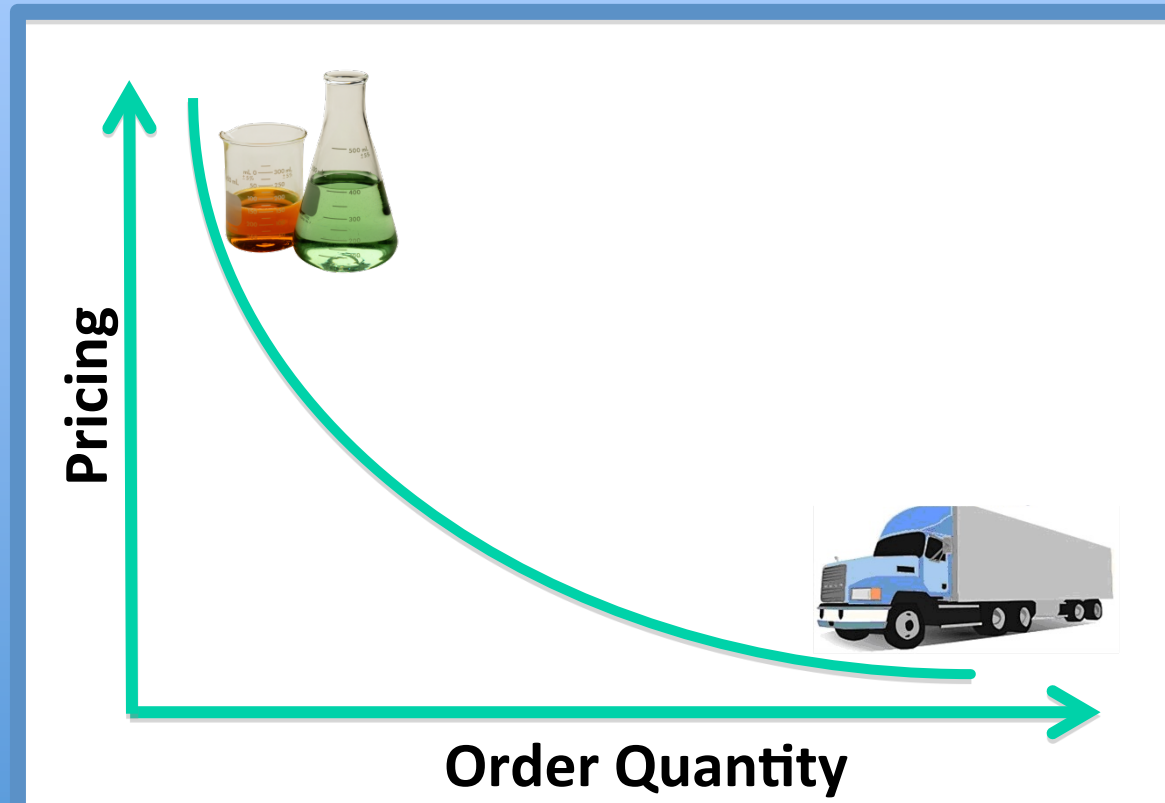


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Hybrid Plastics™ Inc.



POSS® Pricing



Summary

- POSS[®] additives available neat or in masterbatch concentrate
- The hybrid structure provides unique property combinations
- Hybrid Plastics works closely with customers to develop new products
- Custom synthesis of new actives available



Thank you!