Novel rheology booster for hydrophilic and hydrophobically treated fumed silica

Coatings Trends & Technologies Summit 2025

Sarah Vezzetti
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Agenda

- Background of silica
- Development of novel synergist
- Experimental design- Thixotropy
- Novel synergist as tool to improve shear recovery
- Conclusions

Silica: An introduction

- The two most abundant elements in the earth's crust: Oxygen and Silicon.
- There are a variety of precipitation methods and flame-based processes to manufacture SiO_2 products.
- All fumed SiO_2 products are synthetically produced and X-ray amorphous.
- Some applications:
  - Rheological additives
  - Filler material
  - Flow enhancer for powders
  - Insulation material
  - Abrasion enhancers

| Reference: AEROSIL® – Fumed Silica: Technical Overview (https://corporate.evonik.com/)

Production of fumed silica: Flame-based process

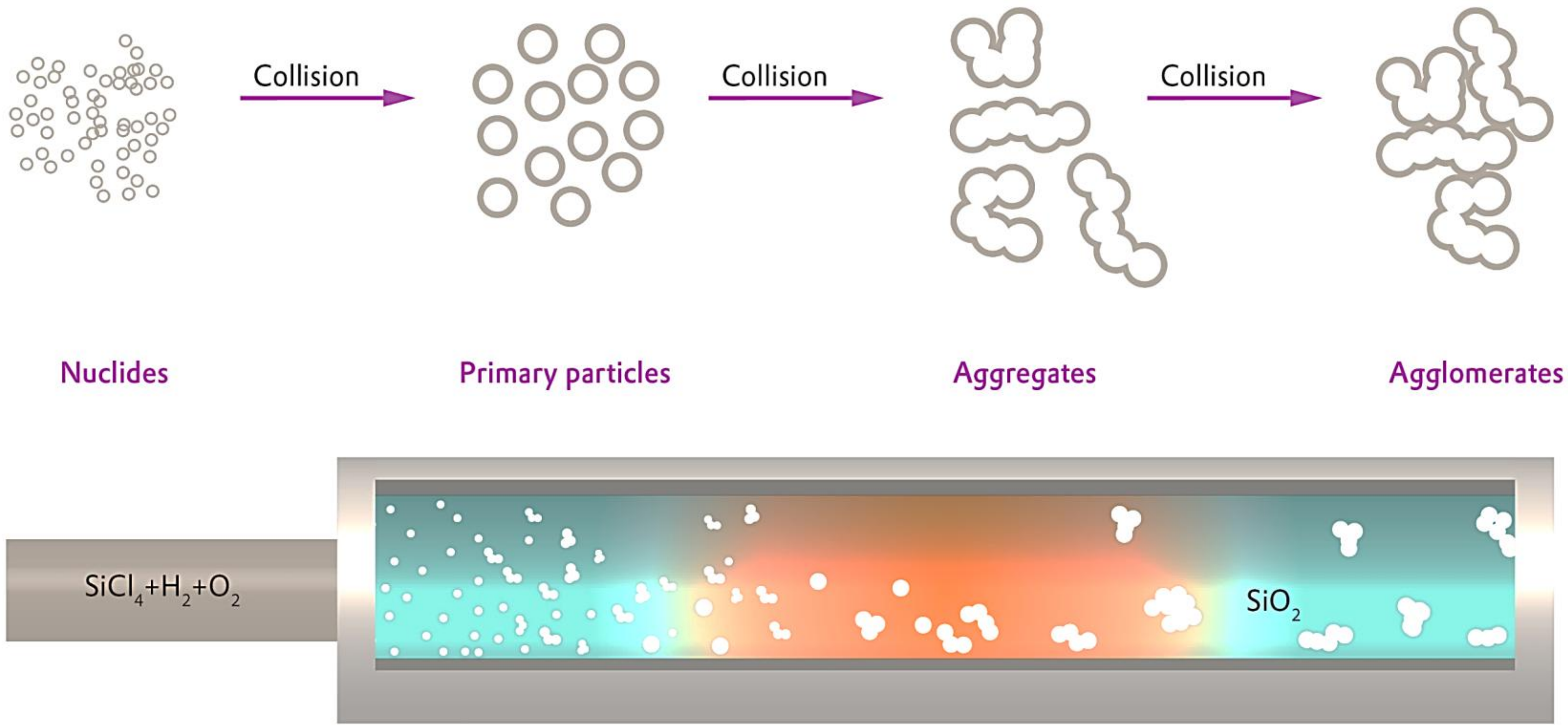
The fumed silica process can be expressed in the following straightforward equations:

$2\,H_2 + O_2 \rightarrow 2\,H_2O$

$SiCl_4 + 2\,H_2O \rightarrow SiO_2 + 4\,HCl$

Overall reaction:

$2\,H_2 + O_2 + SiCl_4 \rightarrow SiO_2 + 4\,HCl$



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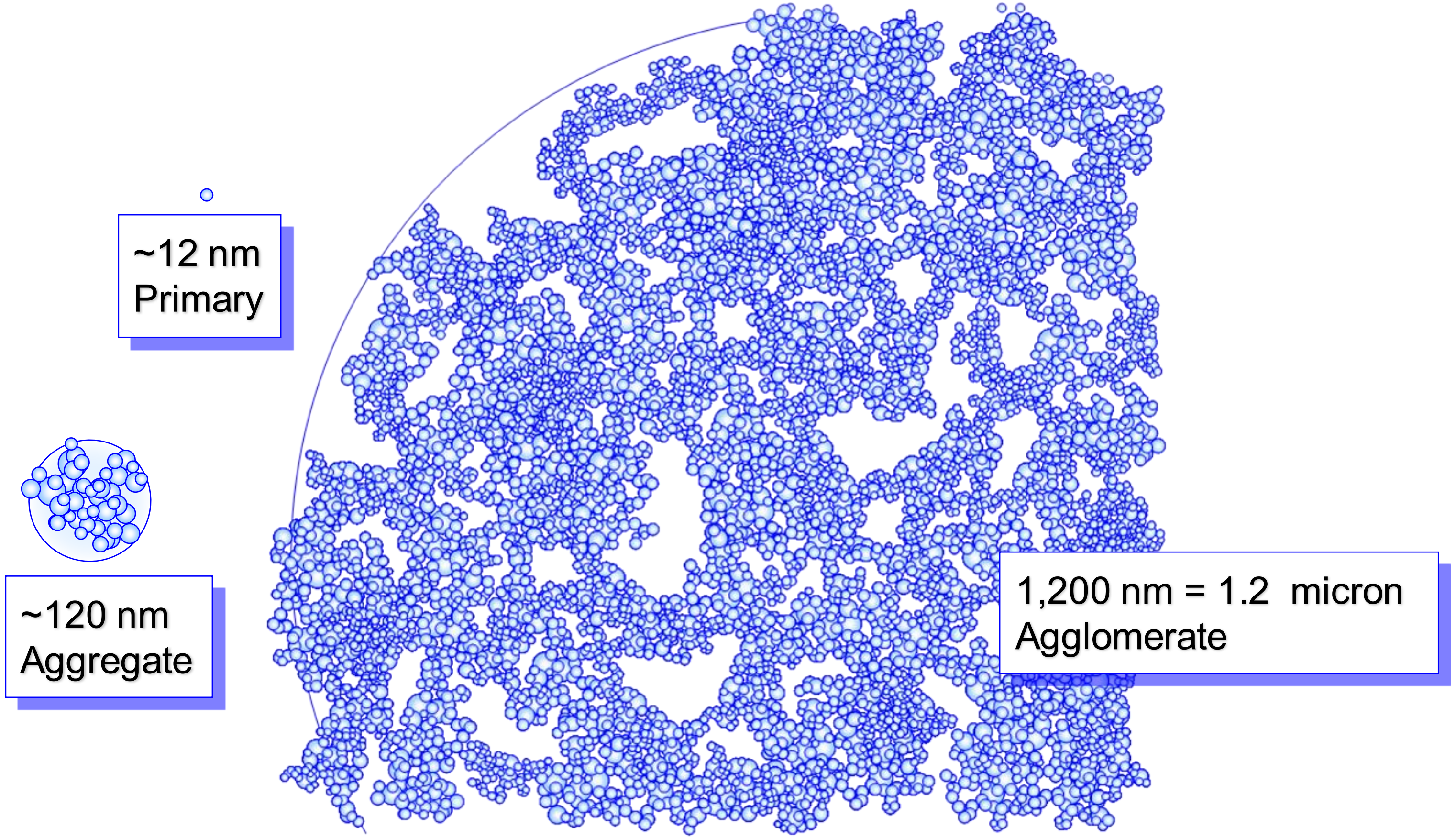
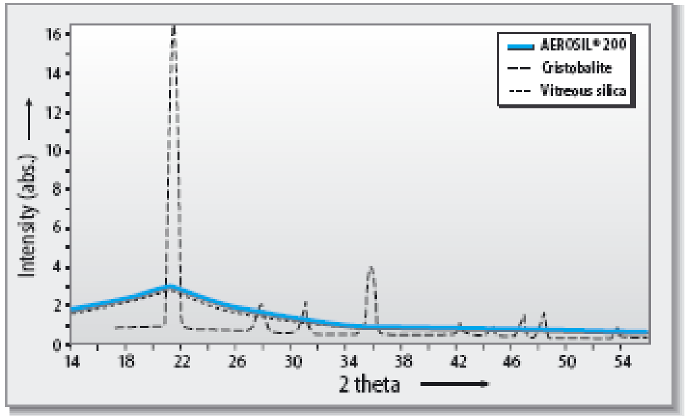
Primary, secondary, and tertiary structures of fumed silica





Synthetic Silica is Not Crystalline

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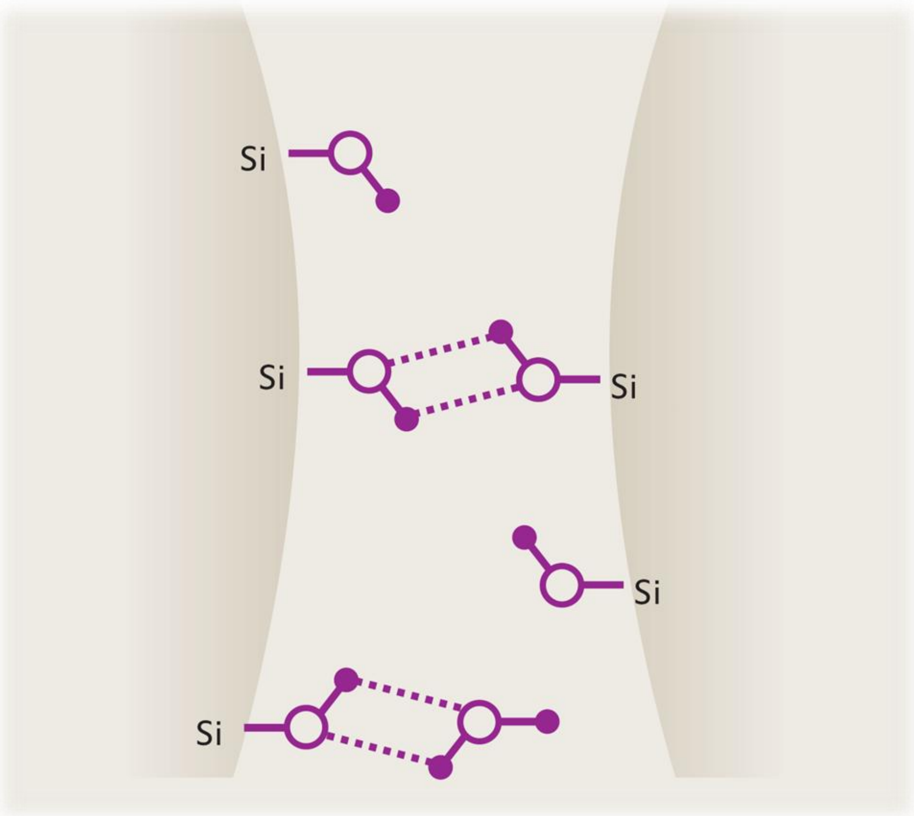
Interparticle interactions

- To describe the rheological properties of dispersions that contain fumed silica it is essential to consider the ways in which the SiO_2 particles interact with one another and with the dispersion phase. These interactions could include the following:

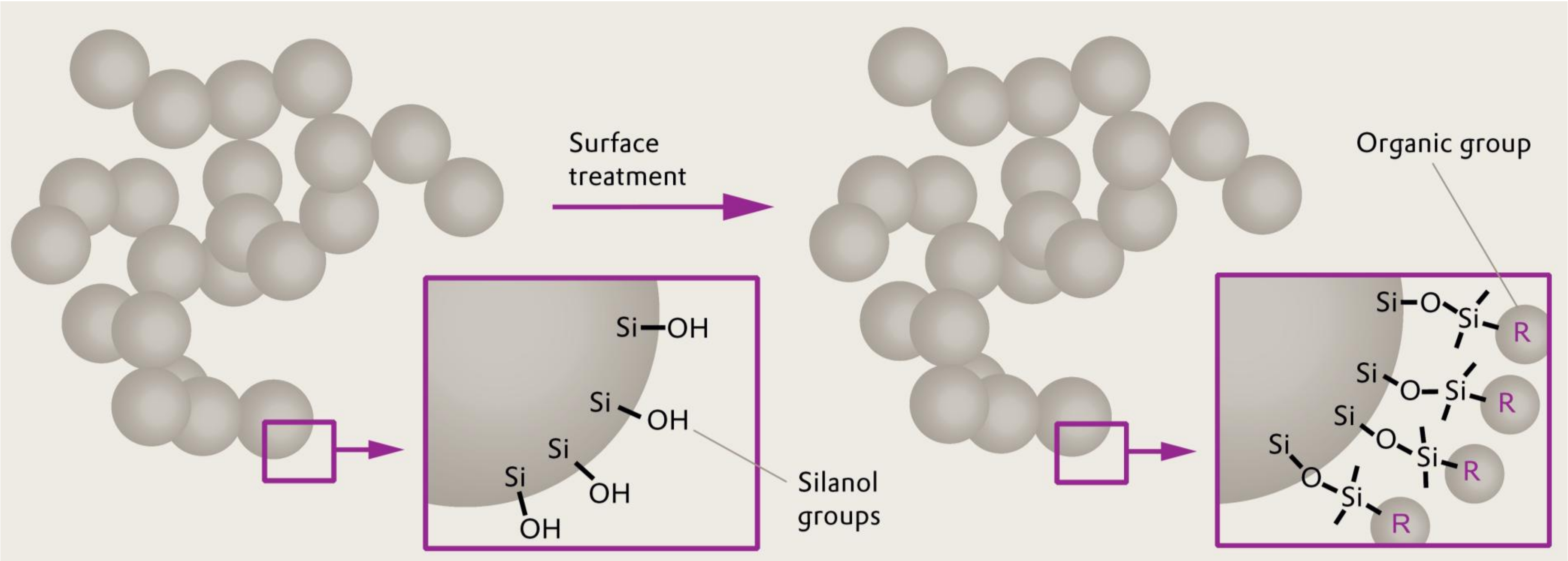
- Van der Waals attraction forces
- Electrostatic interactions (Coulomb interactions)
- Acid/base interactions
- Orbital interactions



A hydrogen bond interaction between two fumed silica primary particles.

| Reference: AEROSIL® – Fumed Silica: Technical Overview (https://corporate.evonik.com/)

Silica can be hydrophobically treated to provide better particle interactions



- Hydrophobic grades are created by subjecting hydrophilic grades to chemical post-treatment with alkoxysilanes, silazanes, or siloxanes
- Provides improvements to water resistance, storage stability, and pigment dispersibility

| Reference: AEROSIL® – Fumed Silica: Technical Overview (https://corporate.evonik.com/)

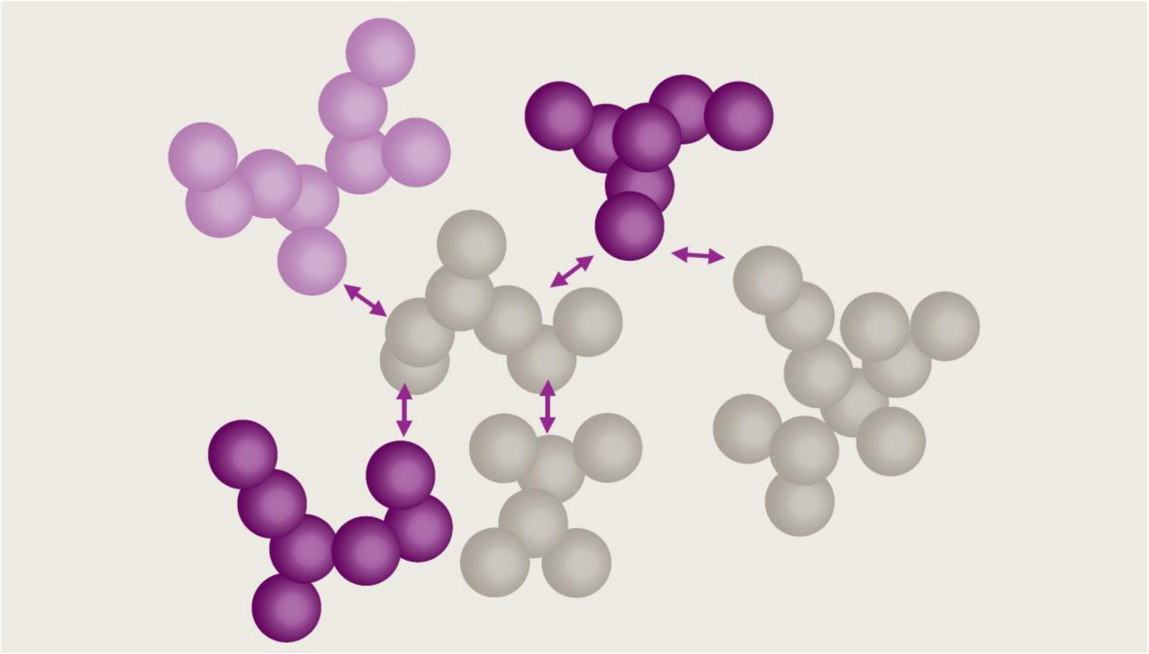
Application: a simple thickening model

As a result of this network formation, components of the coatings can be held in suspension.

For a simple thickening model of fumed silica, it is necessary to consider two properties:

1. **Aggregate Size** of approximately one hundred to several hundred nanometers

2. **Surface Chemistry** that allows the aggregates to build network structures via hydrogen bonds or van der Waals forces – either with one another or with other materials such as pigments, additives, resins, solvents, etc.



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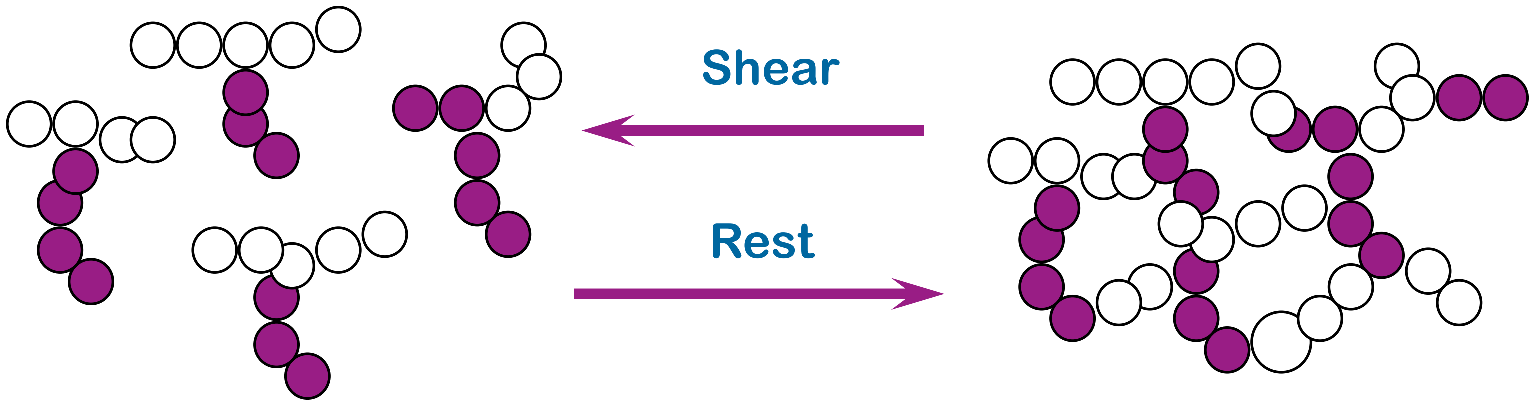
Particle interaction leads to network formation

Interaction of SiO_2 Aggregates

3 - Dimensional Network



– Reversible interaction, in most cases, as long as aggregates not over sheared.

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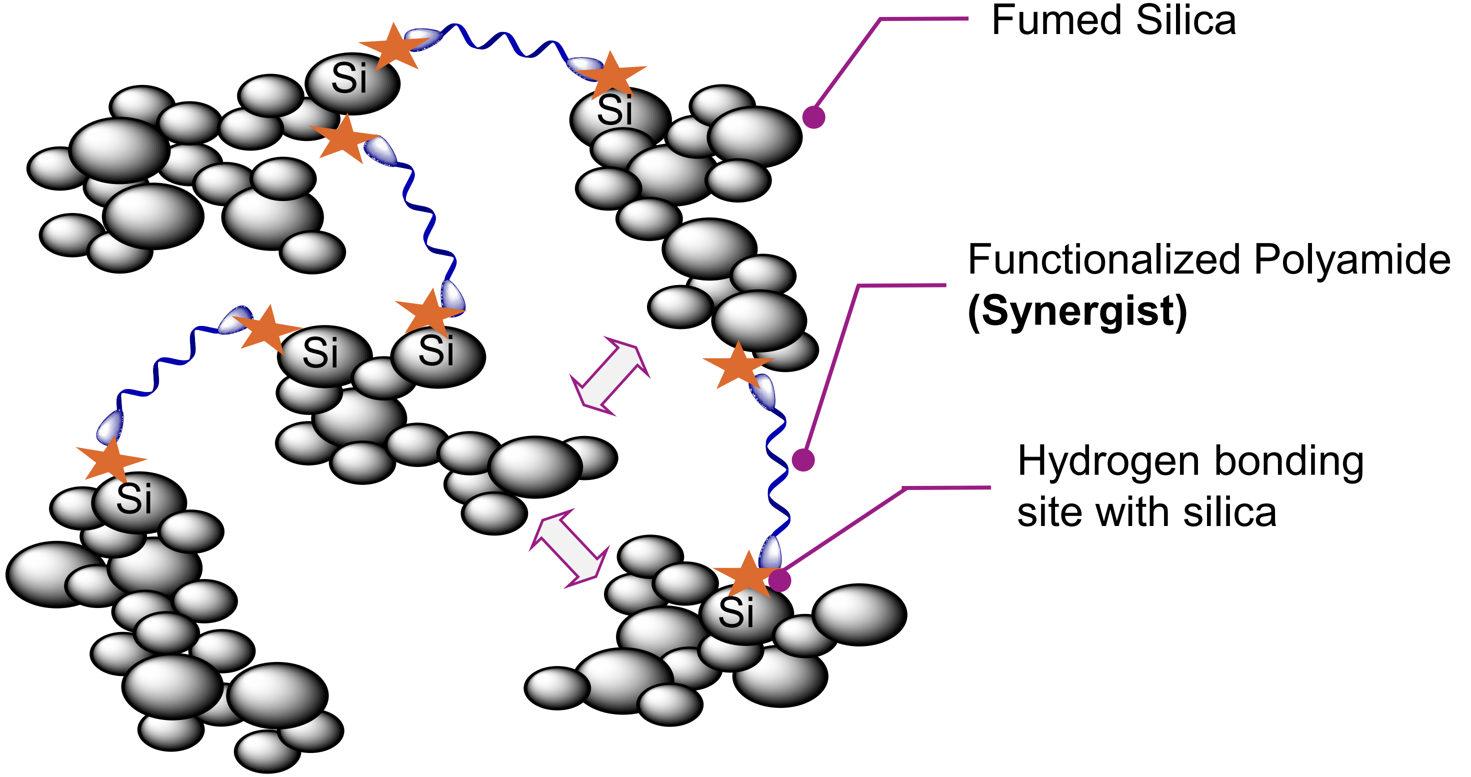
Synergists boost rheology properties of fumed silica

Functionality of a **Synergist**



Solvent-based polyetheramide as synergist for fumed silica

LA-V 1916 synergist structure

Standard functionalized polyamide

- Specifically designed to increase low-shear viscosity of coatings with either hydrophilic or hydrophobic type fumed silica.
- Balance between solubility and effectiveness

Brookfield Viscosity (mPa·s)

	Day 1			Day 14		
	5RPM	**50RPM**	**5 RPM**	**5RPM**	**50RPM**	**5 RPM**
Blank	21600	3912	16400	24000	4102	15760
Standard Synergist	28800	4692	15840	25680	4480	14080
Novel Synergist (LA-V 1916)	**33600**	**5120**	**22400**	**38000**	**5528**	**22000**

System:
UPES resin, 3% A200
10 w% synergist loading on silica

Experimental setup

- Two formulations
  - Gel coat with polar fumed silica
  - Automotive baked clear coat with two different grades of non-polar fumed silica
- Comparison of Standard Synergist and Novel Synergist (LA-V 1916) at same loading leveling (10 w% on active silica)
- Four-step shear test: initial viscosity and thixotropy using a rotational rheometer (Anton Paar Rheocompass 302)

	Surface Treatment	BET (m^2/g)	Hydrophobic Character
A200 polar fumed silica	DDS	~170	Medium
R974 non-polar fumed silica	OCTMO	~150	High
R805 non-polar fumed silica	-	~200	-

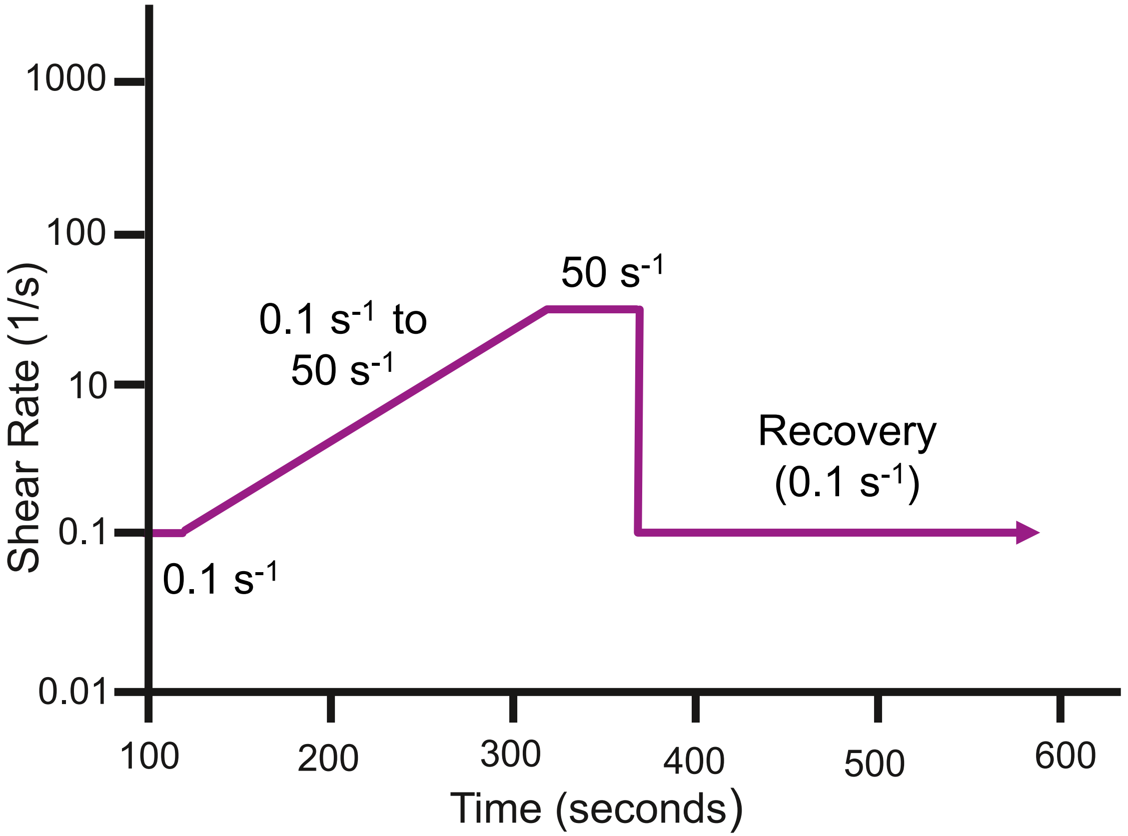
Gel-Coat formulation with polar fumed silica

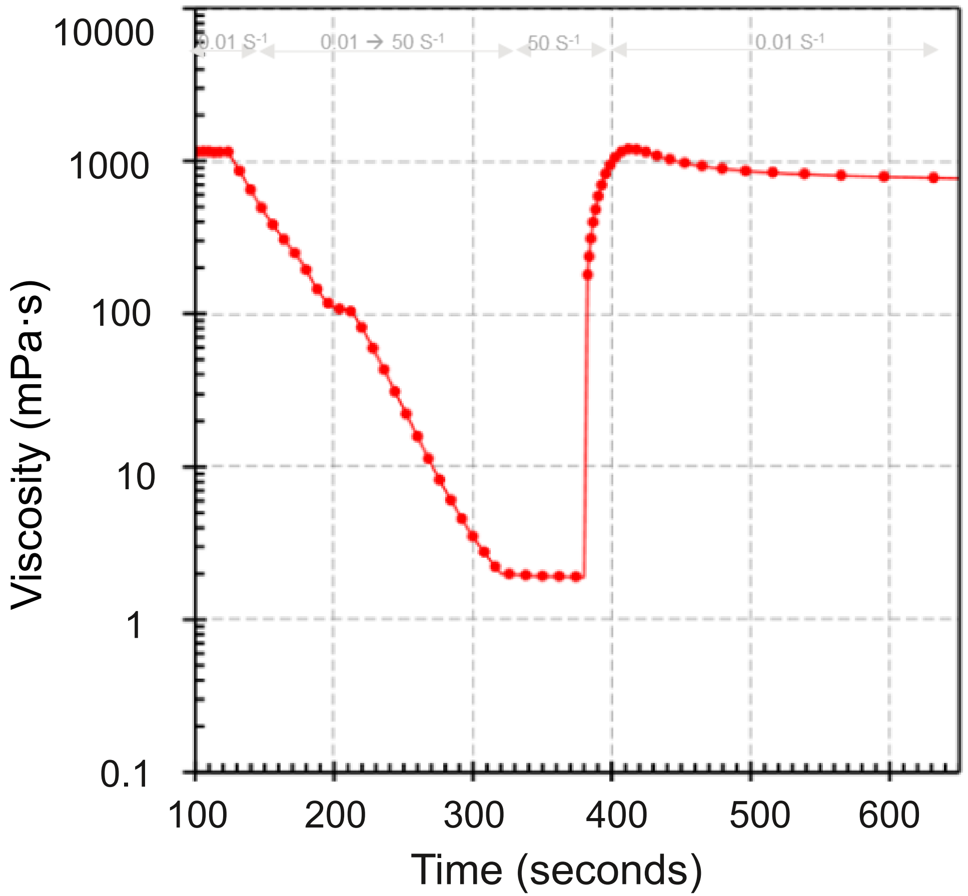
	1	2	3
	Blank	Standard Synergist	Novel Synergist LA-V 1916
Isophtalic unsaturated polyester resin	165.75 g	165.08 g	165.08 g
A200 polar fumed silica	6.75 g	6.75 g	6.75 g
Styrene	52.50 g	52.50 g	52.50 g
Synergist	0.00 g	0.68 g	0.68 g

Baked automotive clear coat

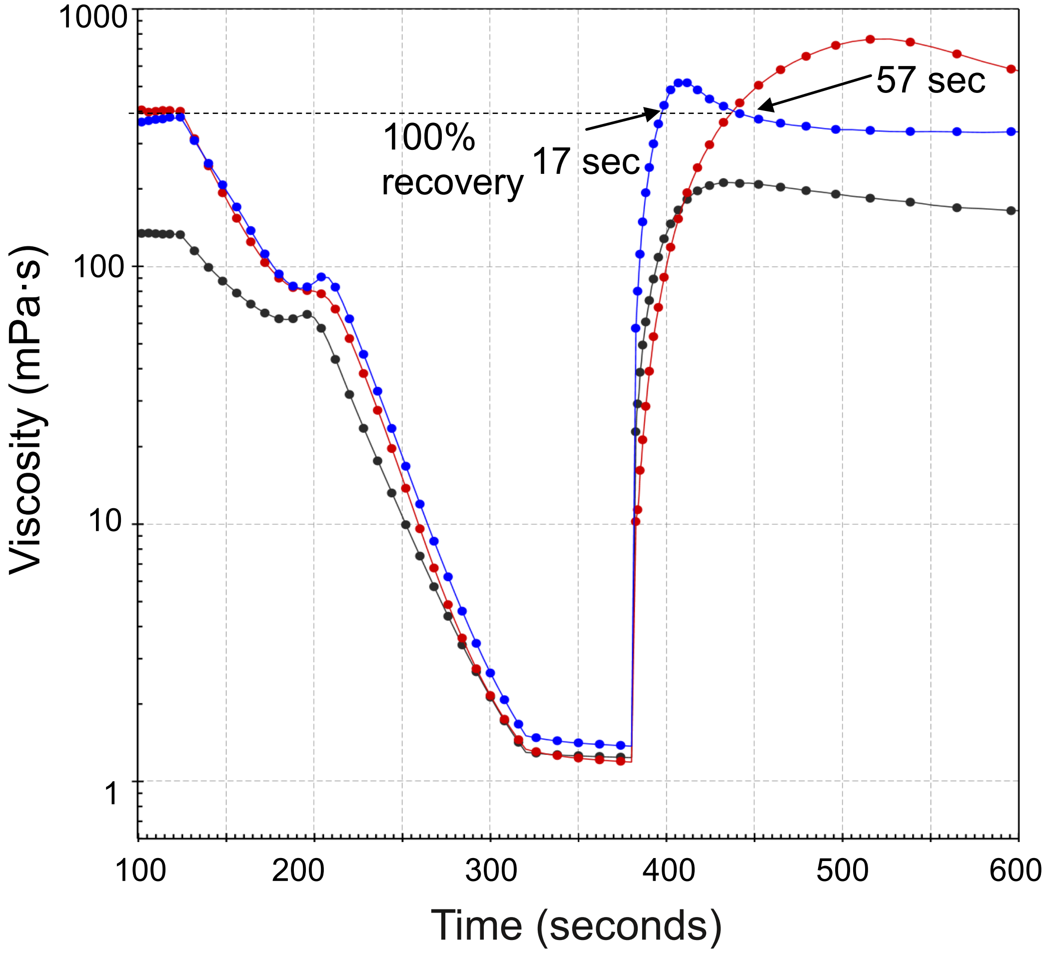
	1	2	3	4	5	6
	Blank	Standard Synergist	Novel Synergist LA-V 1916	Blank	Standard Synergist	Novel Synergist LA-V 1916
Polyester polyol	76.50 g	76.50 g	76.50 g	76.50 g	76.50 g	76.50 g
Melamine resin	5.00 g	5.00 g	5.00 g	5.00 g	5.00 g	5.00 g
R974 non-polar fumed silica	1.00 g	1.00 g	1.00 g			
R805 non-polar fumed silica				1.00 g	1.00 g	1.00 g
PM Acetate	11.14 g	11.14 g	11.14 g	11.14 g	11.14 g	11.14 g
Xylene	11.14 g	11.14 g	11.14 g	11.14 g	11.14 g	11.14 g
Synergist		0.10 g	0.10 g		0.10 g	0.10 g

Thixotropy experiments as tool to evaluate network re-formation after shear





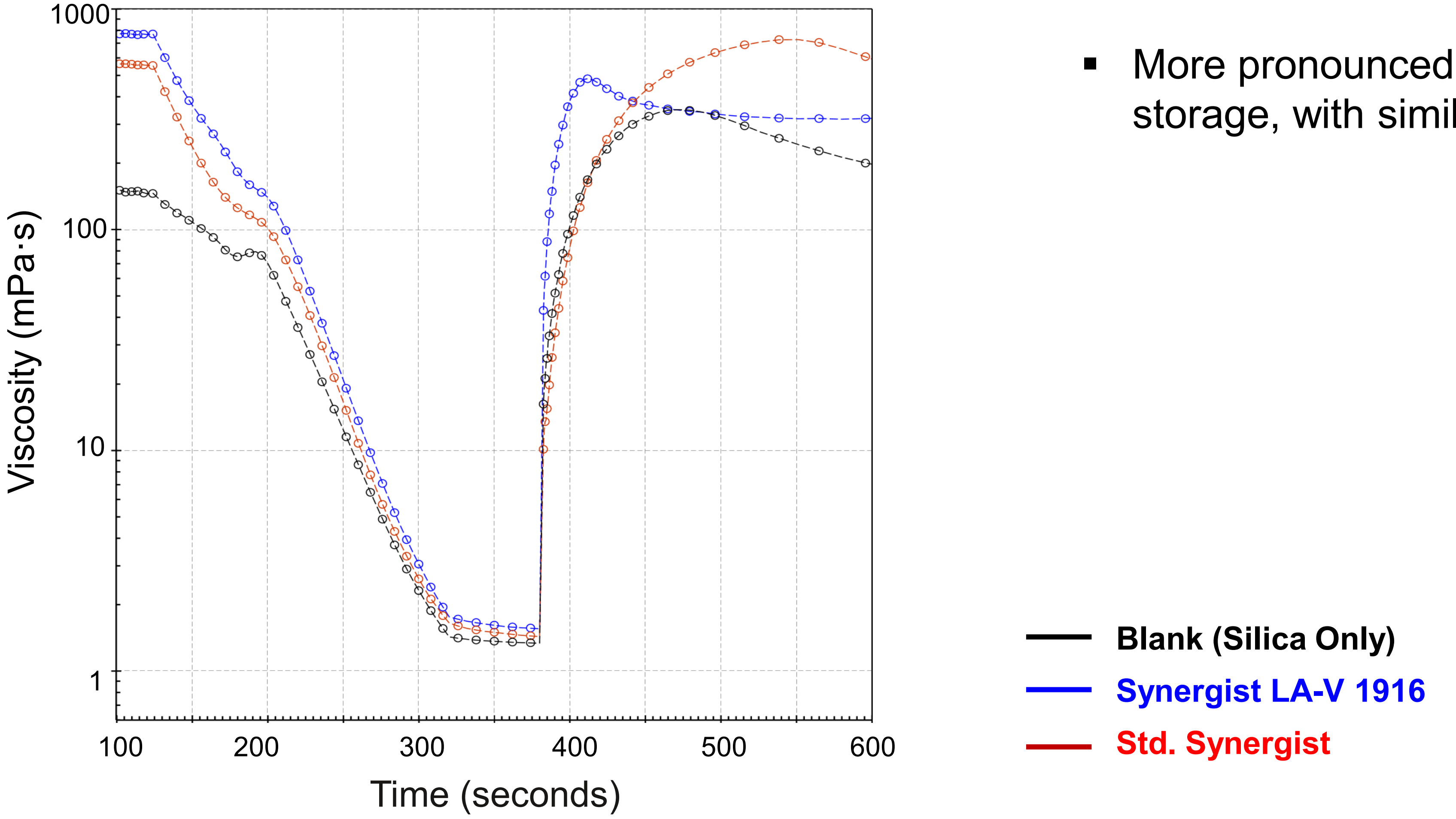
Novel synergist demonstrates faster shear recovery on day 1



- Comparable initial viscosity boost (vs. std.) while much faster shear recovery (40 seconds difference)

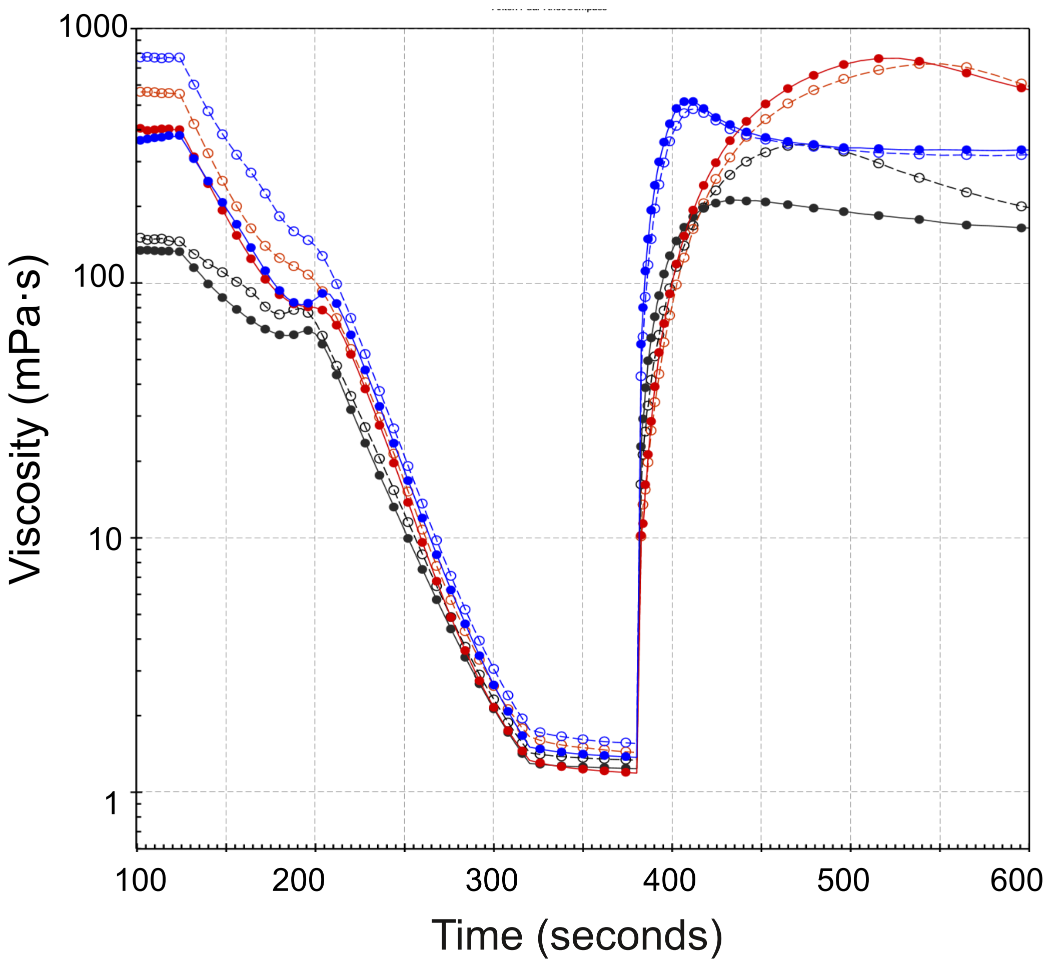
Blank (Silica Only)
Synergist LA-V 1916
Std. Synergist

Novel synergist has higher initial viscosity boost with identical profile



- More pronounced viscosity boost after 14 days storage, with similar rheology profile.

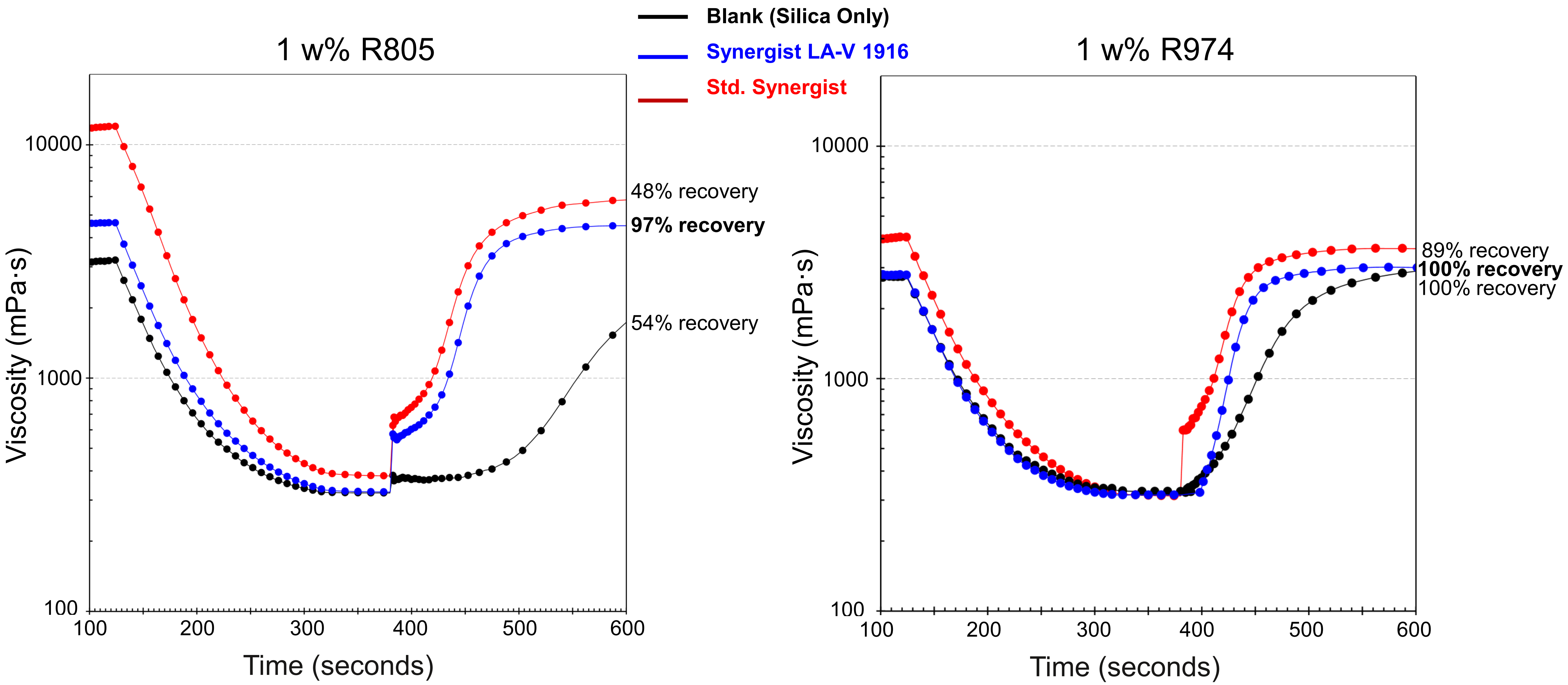
Novel synergist has consistent performance after storage



Day 1
Day 14
Blank (Silica Only)
Synergist LA-V 1916
Std. Synergist

- Very consistent performance, even after storage vs standard synergist and blank.

Novel synergist has consistent performance with different hydrophobic silica



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Novel synergist improves sag control and air entrapment

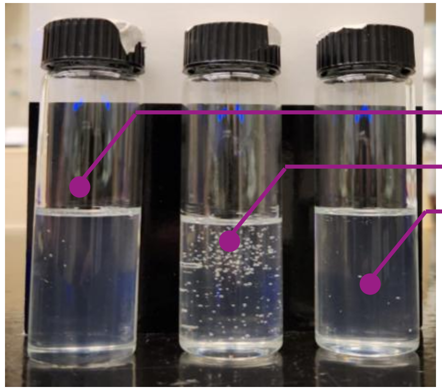
Standard Synergist

Control

Novel Synergist LA-V 1916

Novel synergist LA-V 1916 demonstrates…..

- Improved sag resistance compared to blank without synergist
- No impact on transparency
- Less air trapped due to lower initial viscosity



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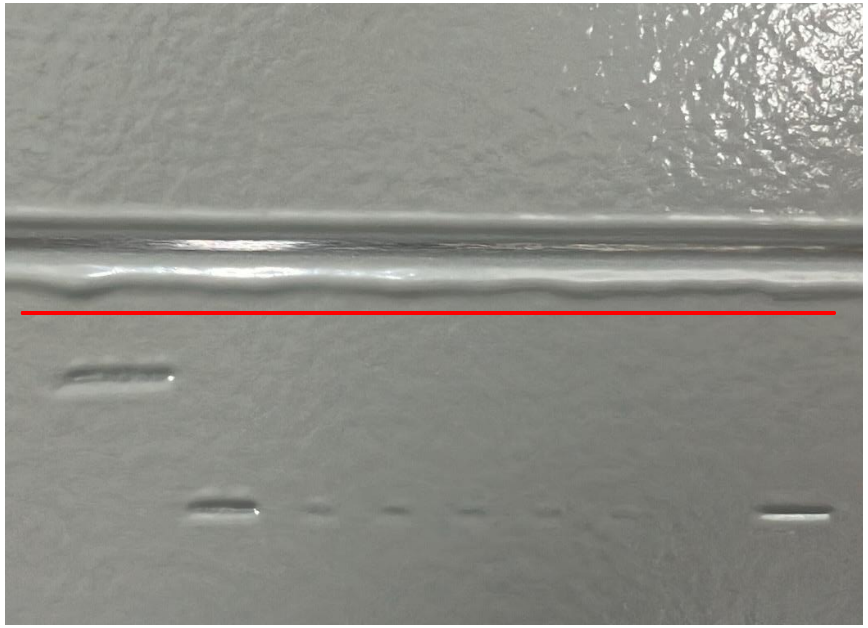
Novel Synergist can enable higher wet film thickeness while maintaining sag

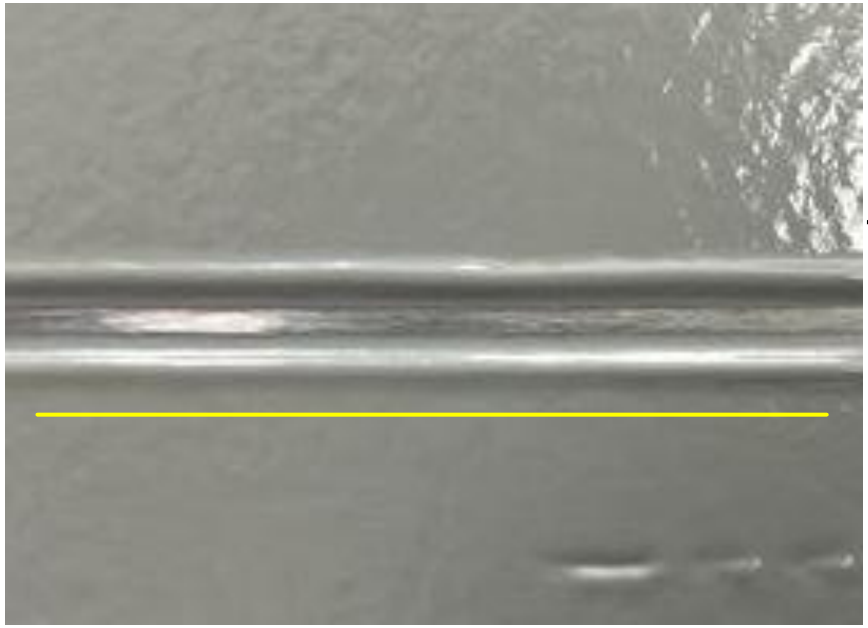
E805 Silica (0.5 w%)

12 mils wet



E805 Silica (0.5 w%)

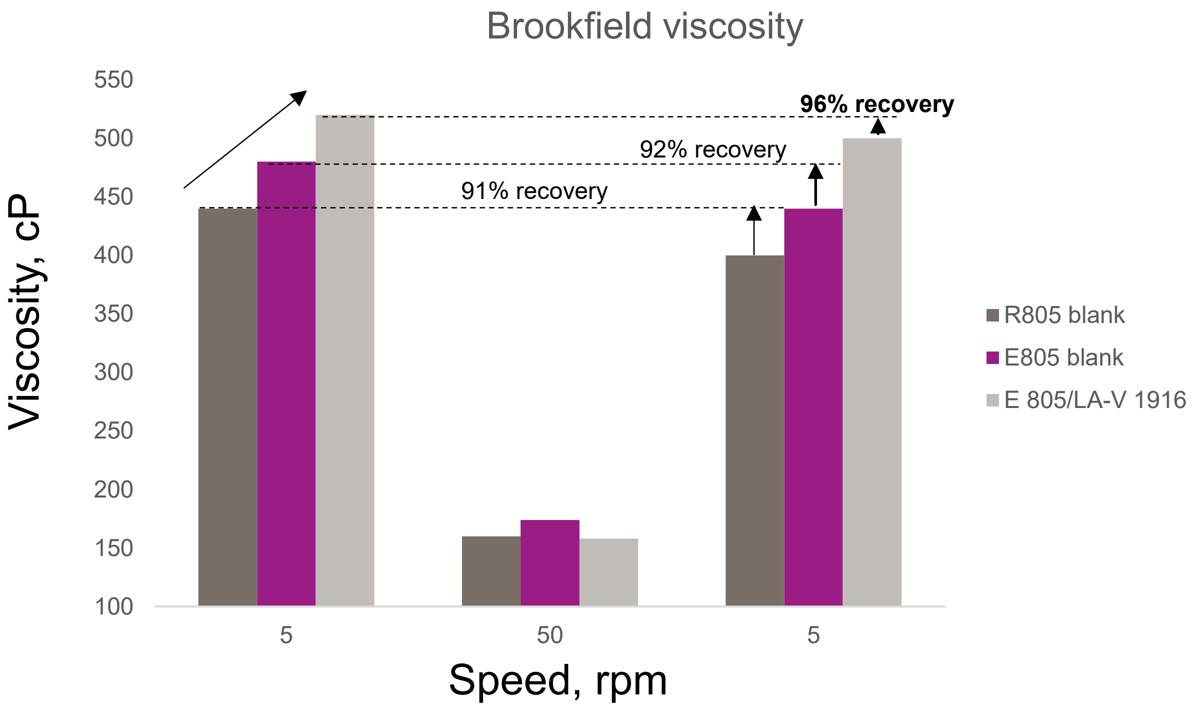
Experimental Synergist (15 w% on silica)



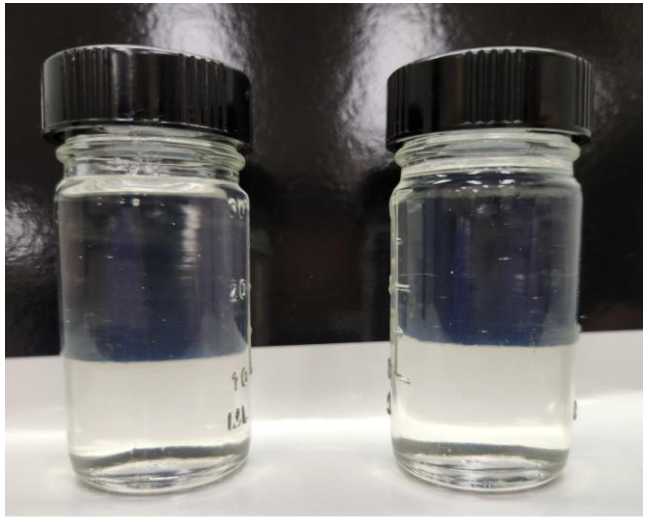
12 mils wet

Commercial 2-pack epoxy system typical 6-9 mils wet film thickness

Novel synergist boosts efficiency of both regular and easy-to-disperse silicas



- Spindle 3
- 2 minutes each @ 5, 50, 5 rpm
- 20 w% synergist loading on silica (1 w% silica on total formulation)



E805/blank E805 / **LA-V 1916**

- Fastest viscosity recovery with LA-V 1916
- LA-V 1916 boosts efficiency of both regular and easy-to-disperse hydrophobic fumed silica types
- No impact on transparency in Auto clear coat systems

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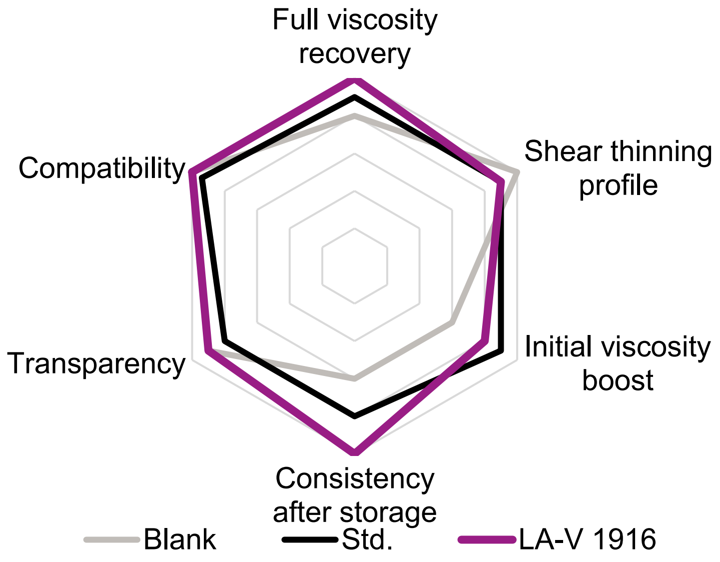
Conclusions

Viscosity boost	▪ Low-shear viscosity boost with pseudoplastic profile ▪ Very consistent performance, even after storage (14 days) with both hydrophilic and hydrophobic fumed silica grades
Sag control	▪ Excellent shear thinning viscosity and fastest recovery ▪ Full viscosity recovery after shearing, up to 40% better than std synergist.
Transparency	▪ No impact on transparency, on multiple systems with different polarities ▪ Very compatible with hydrophilic and hydrophobic treated fumed silica grades

Market(s) and Application(s)

- Solvent based coatings using fumed silica as a thixotrope
- Unsaturated polyesters for marine and gel coats
- Auto clear coats SB/HS/100% solids.



Acknowledgments

- **Co-authors:**
  1. **Dr. Bin Cao – Evonik Corporation.**
  2. **Dr. Kerh Li Liu – Evonik GmbH.**
  3. **ShengLan Cheng – Evonik GmbH.**
  4. **Maria Nargiello – Evonik Corporation.**

- **Contributors:**
  1. **Peter Carter – Evonik Corporation.**
  2. **Joe Abrantes – Evonik Corporation.**

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