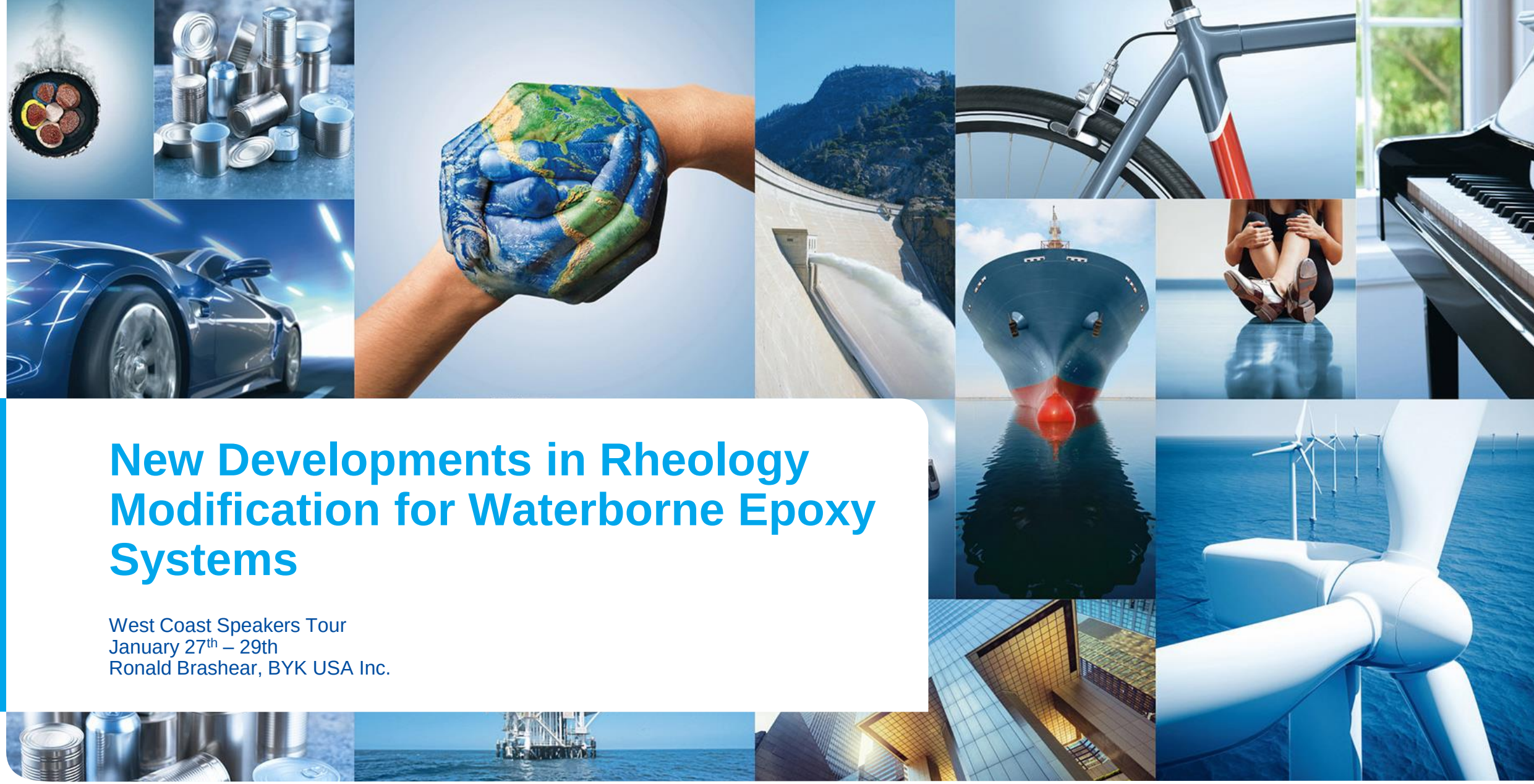


New Developments in Rheology Modification for Waterborne Epoxy Systems

West Coast Speakers Tour
January 27th – 29th
Ronald Brashear, BYK USA Inc.

Outline

Rheology: Brief definition and overview

Viscosity Measurements

Rheology Modifier Classes

Issues seen in WB epoxy systems

Recent Developments

Results

Summary

What is Rheology?

The science of the deformation and flow of matter

Complex fluids do not follow Newton’s Law

Practical:
How a material moves and flows under stress

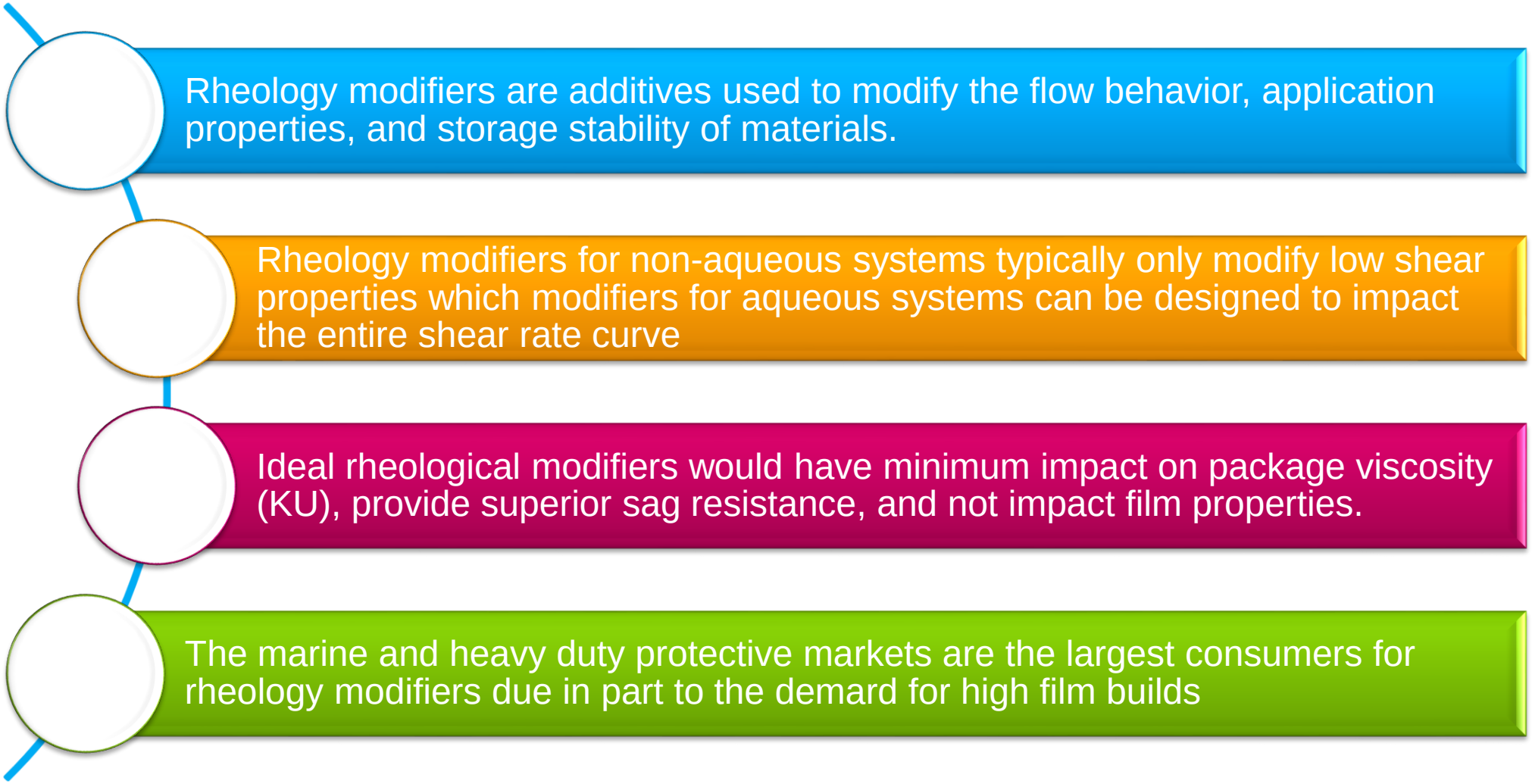
Feel

Flow

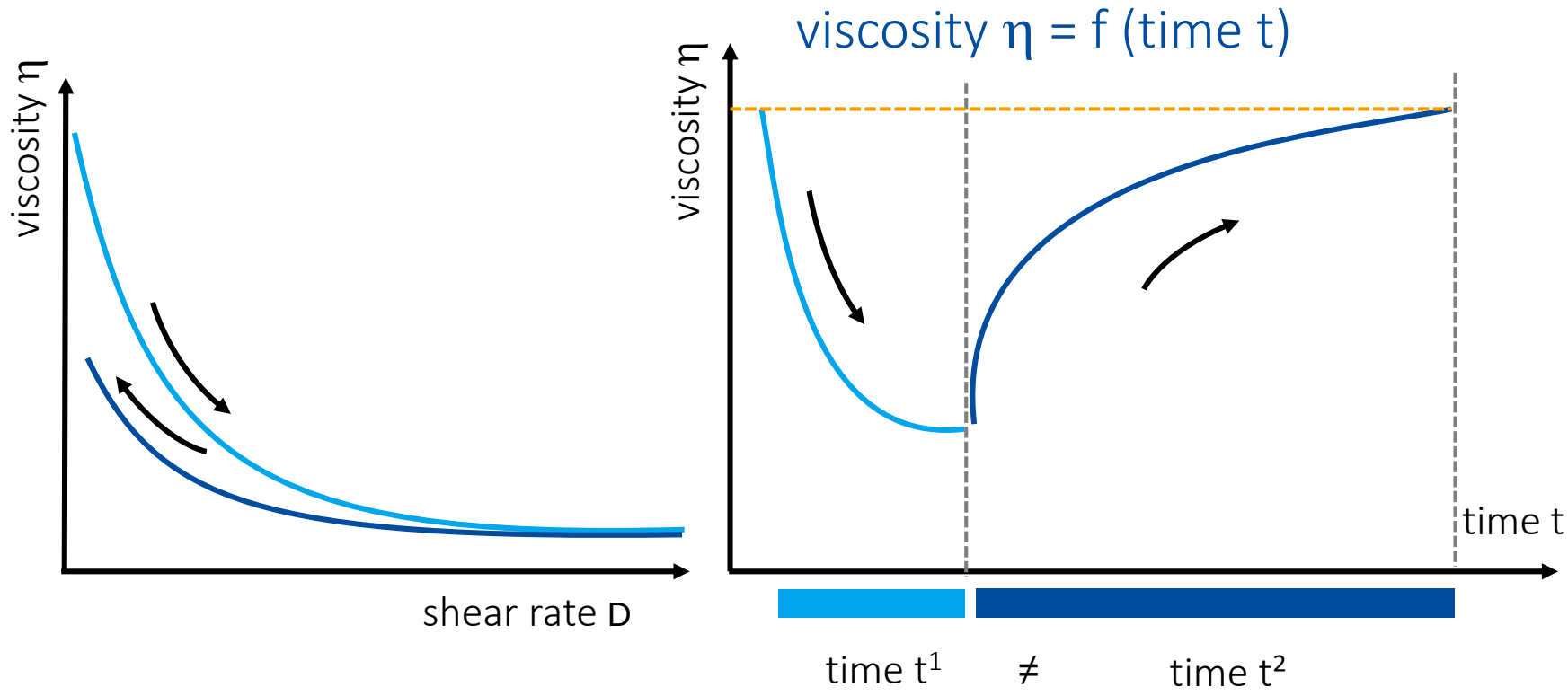
Finish

BYK

Why is Rheology Important



Rheology Thixotropic Flow



Thixotropic liquids show a shear thinning effect and a time dependent recovery effect

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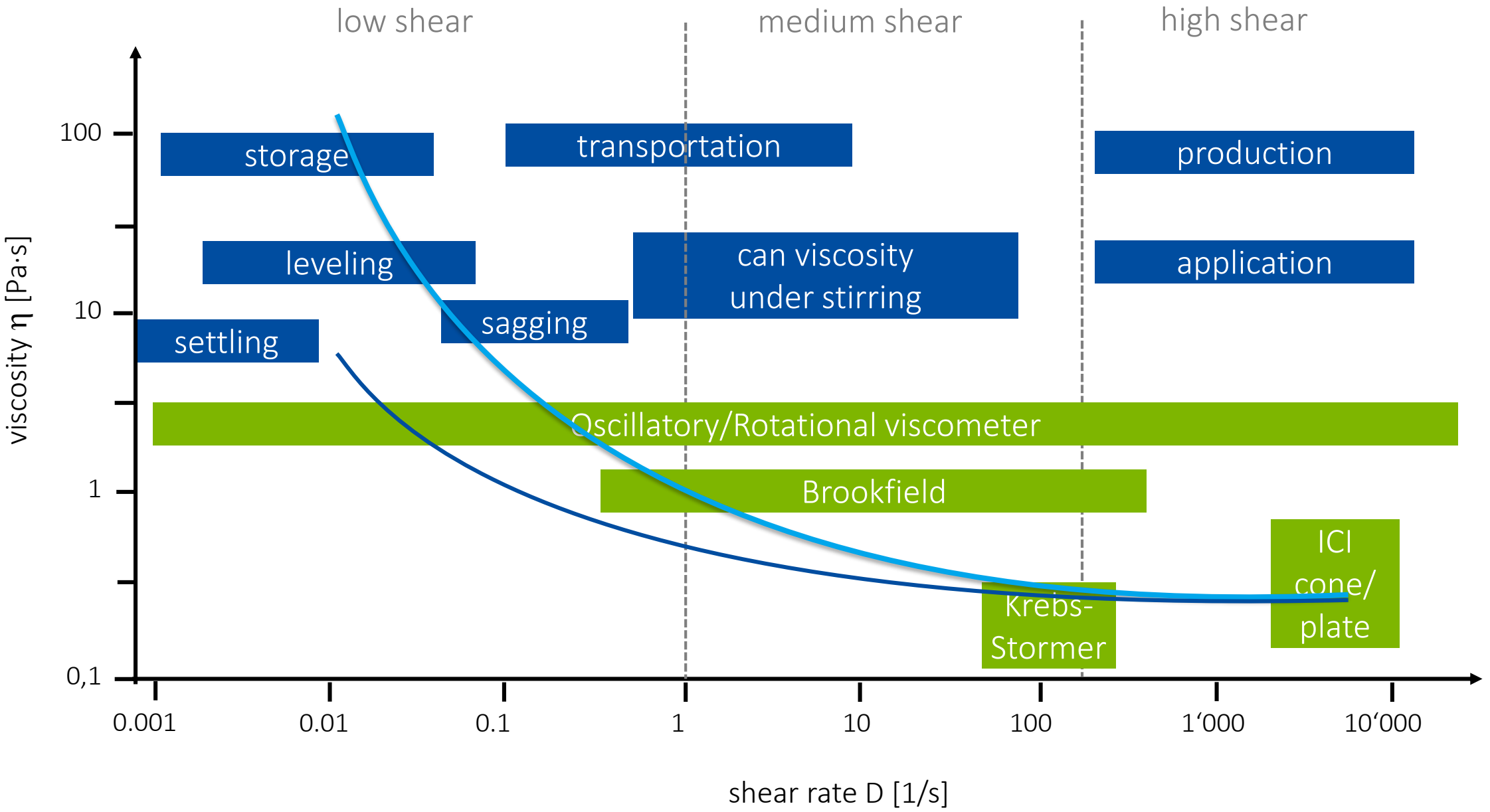
Shear Regions Impacted by Rheolgy Modifiers



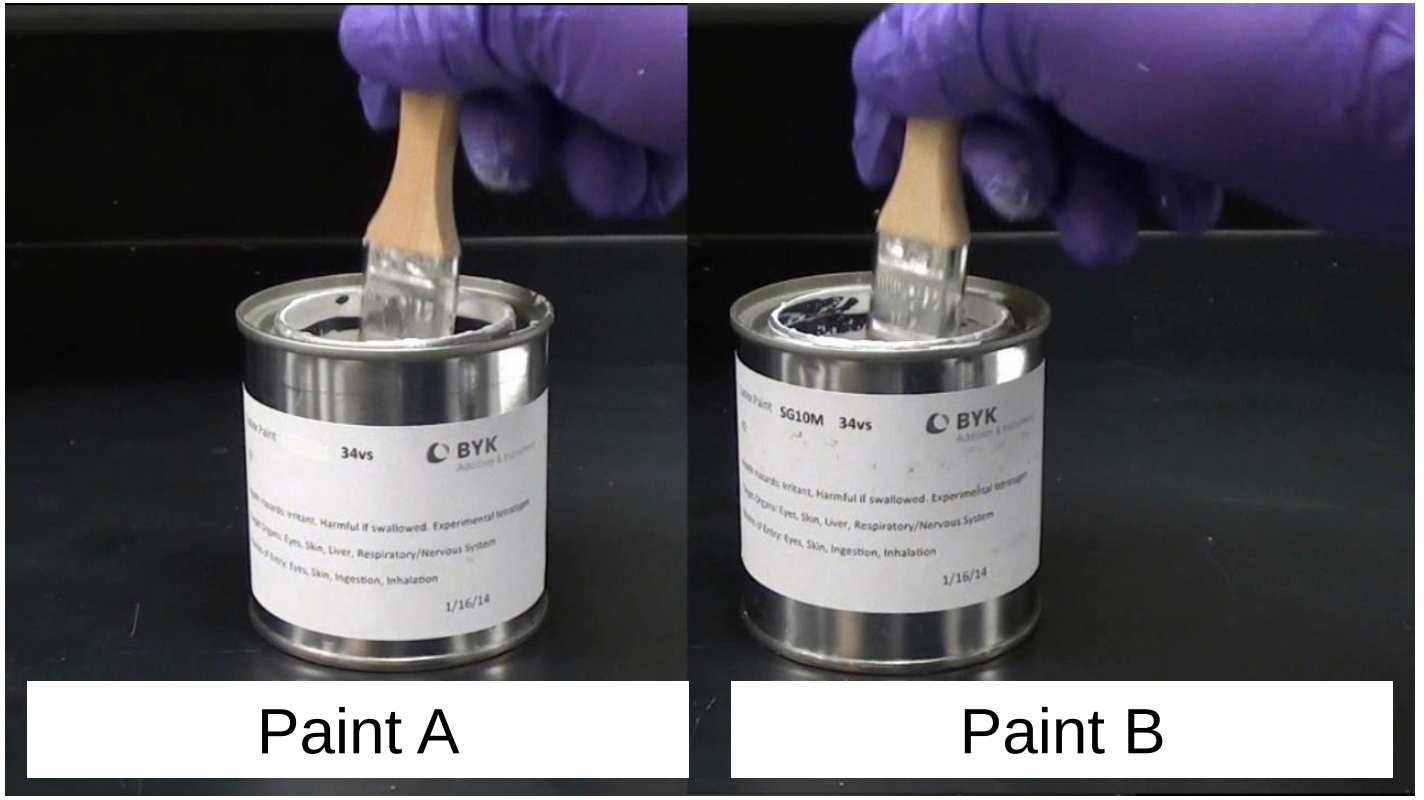
Single Point Viscosity Measurements

	Paint A	Paint B
KU	108.2	107.0

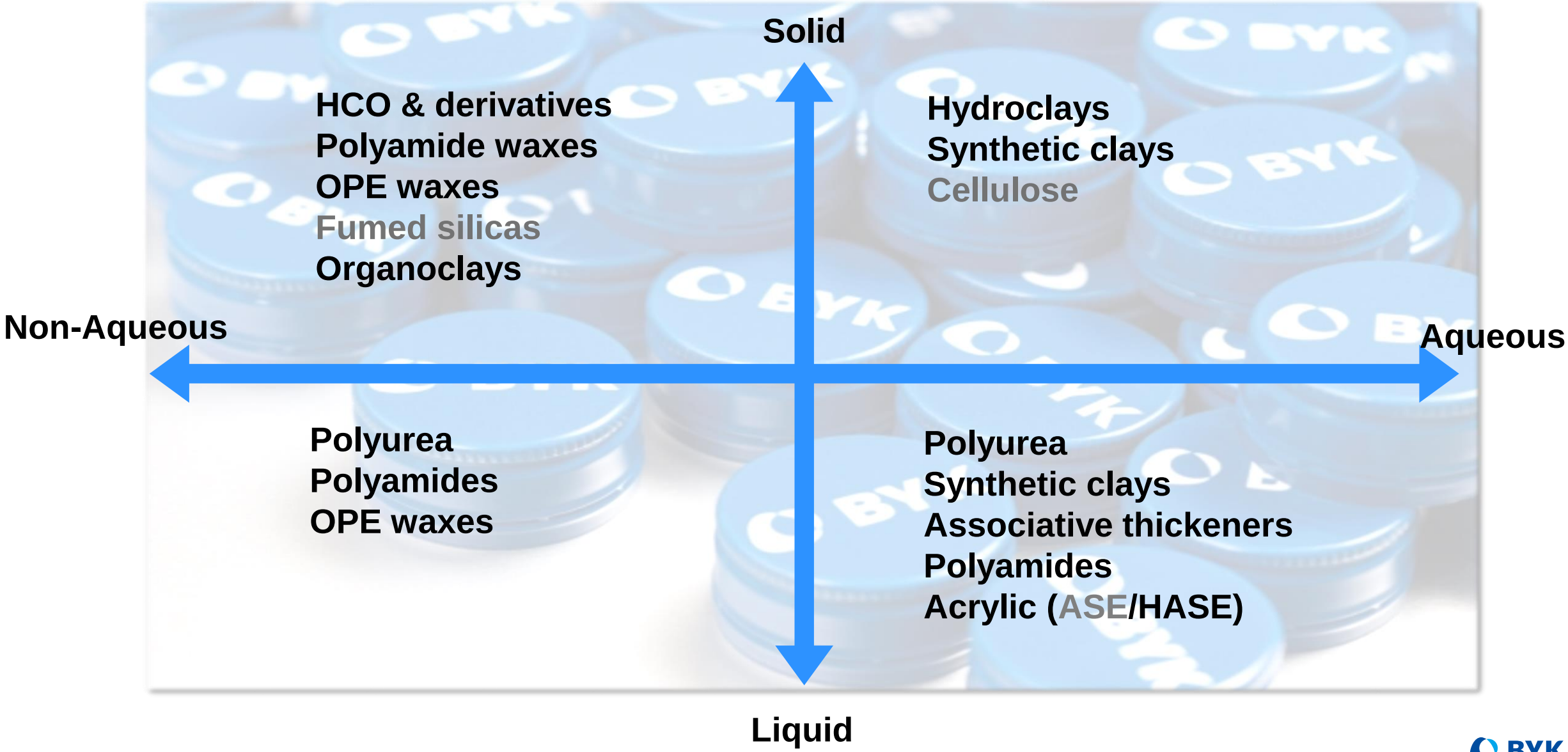
Are Paints A & B the same?

Brookfield (mPa▪s)	15,400	124,600
ICI (Poises)	1.60	0.35

Non-Newtonian fluids **cannot be accurately described** *by viscosity measurements in a single shear rate region*

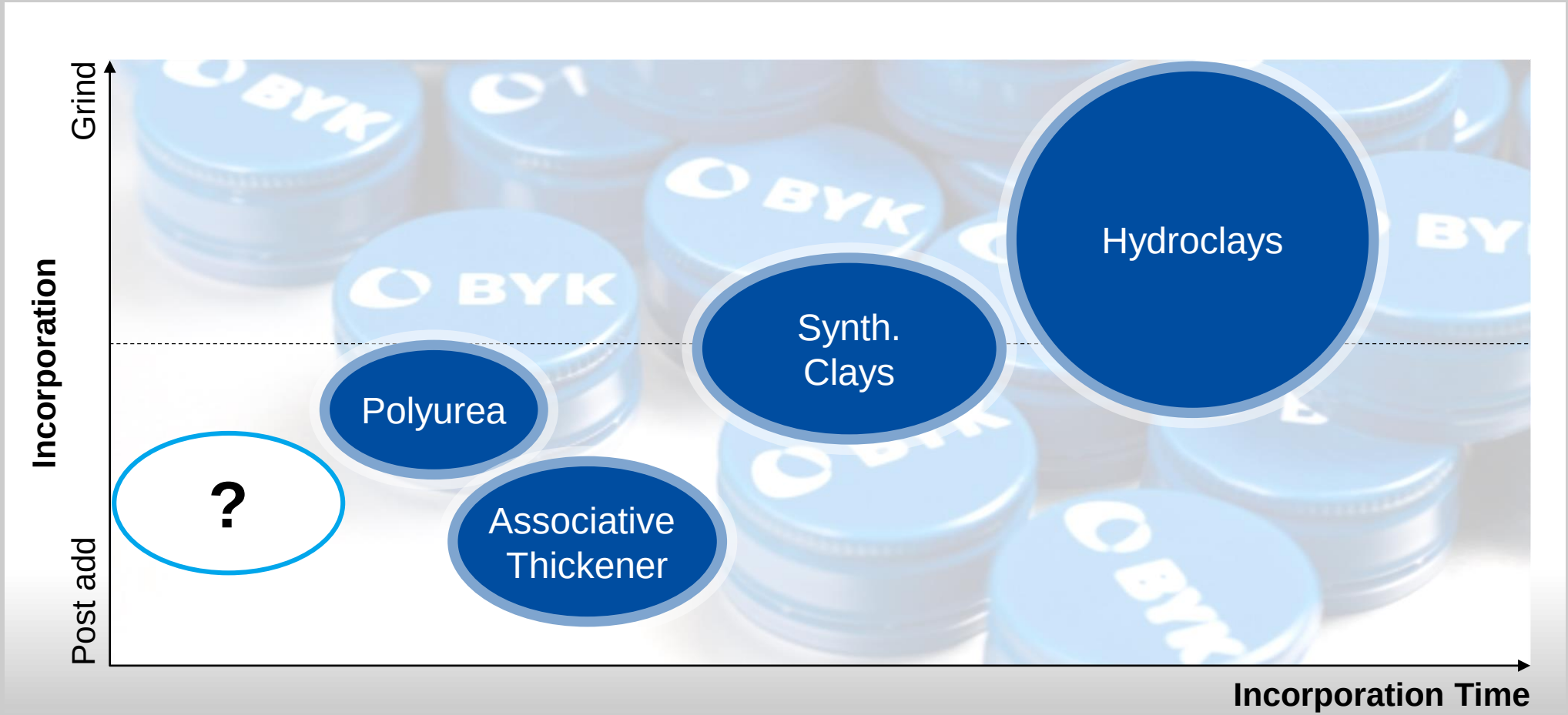


BYK Rheology Additives Portfolio



Incorporation Rheology Additives
Waterborne Coatings

Incorporation Rheology Additives
Waterborne Coatings



Rheology Additives in Waterborne Epoxies

Technologies so far… Undesirable Phenomena

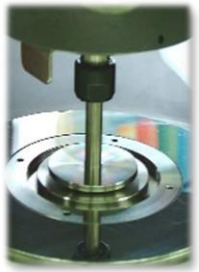
Incompatible

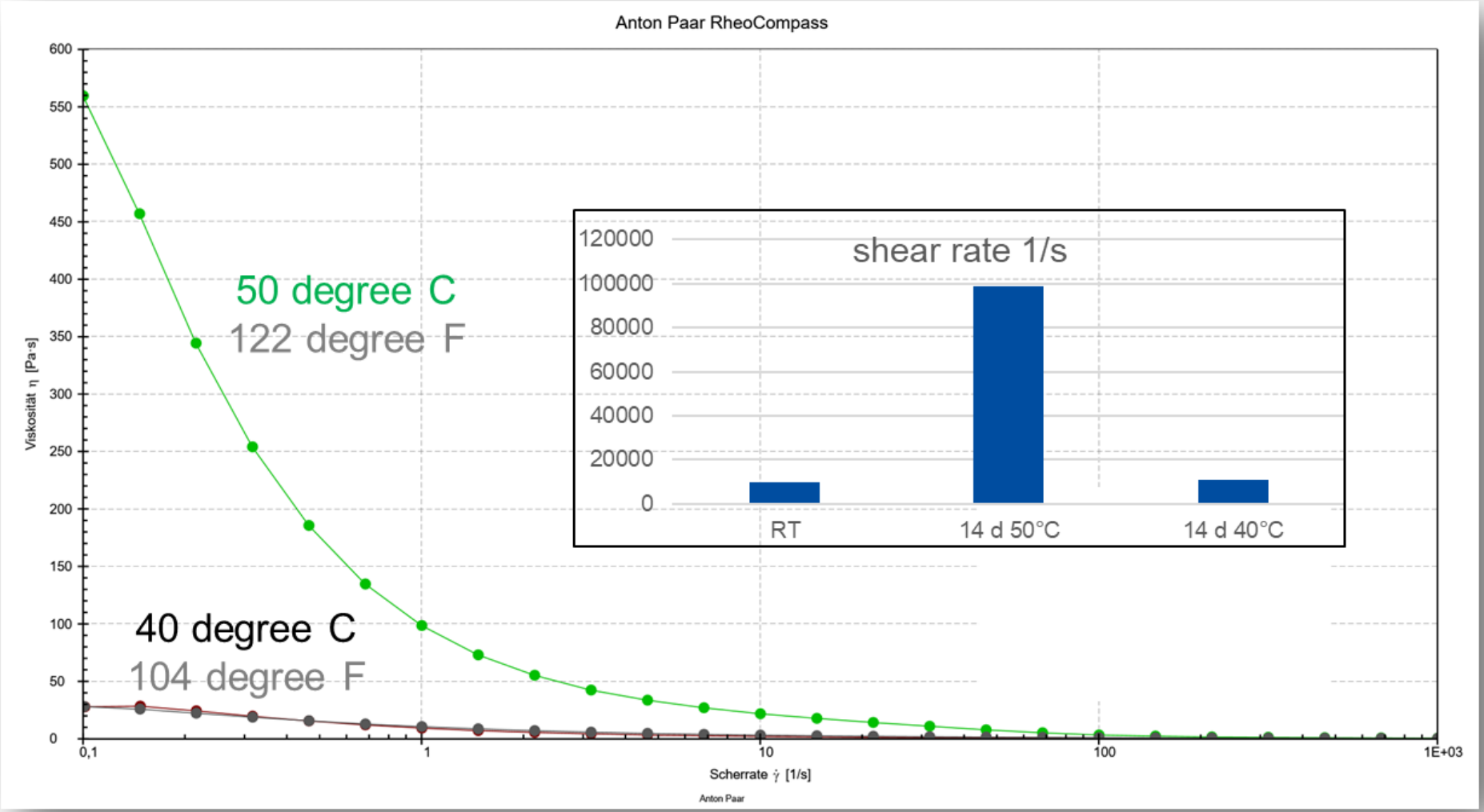
Increase in viscosity
over storage time

High KU-viscosity,
but low sag resistance

BYK

Screening Resin & Storage Stability vs.Temperature



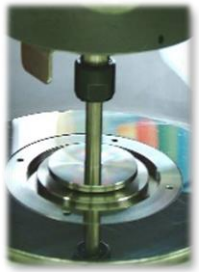


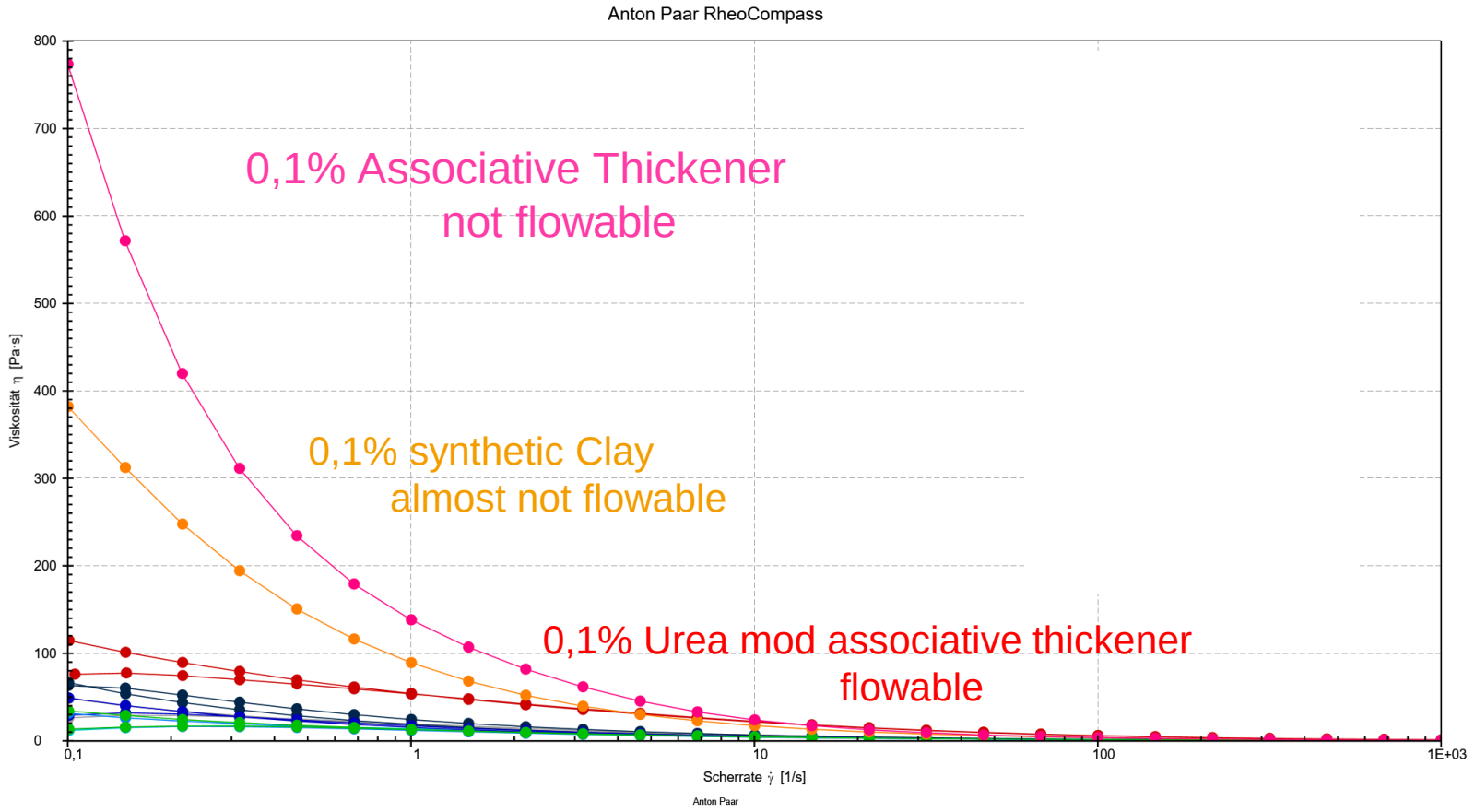
BYK Additives in water borne EP formulation w/o hardener

BYK

Screening Rheology Additives

Dosage/Activity - Screening diff. Technologies (KU Viscosity)





BYK Additives in water borne EP Resin w/o hardener

Project Starting Point

What is the Problem?

KU Viscosity

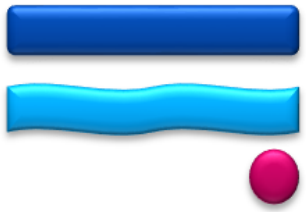
Sag resistance

Water-Borne 2K Epoxy Formulation

BYK

Liquid Polyamide Technology

Liquid, polyamide-based rheology additive for water-borne systems



Polyamide backbone → Hydrogen bonds for rheological effect

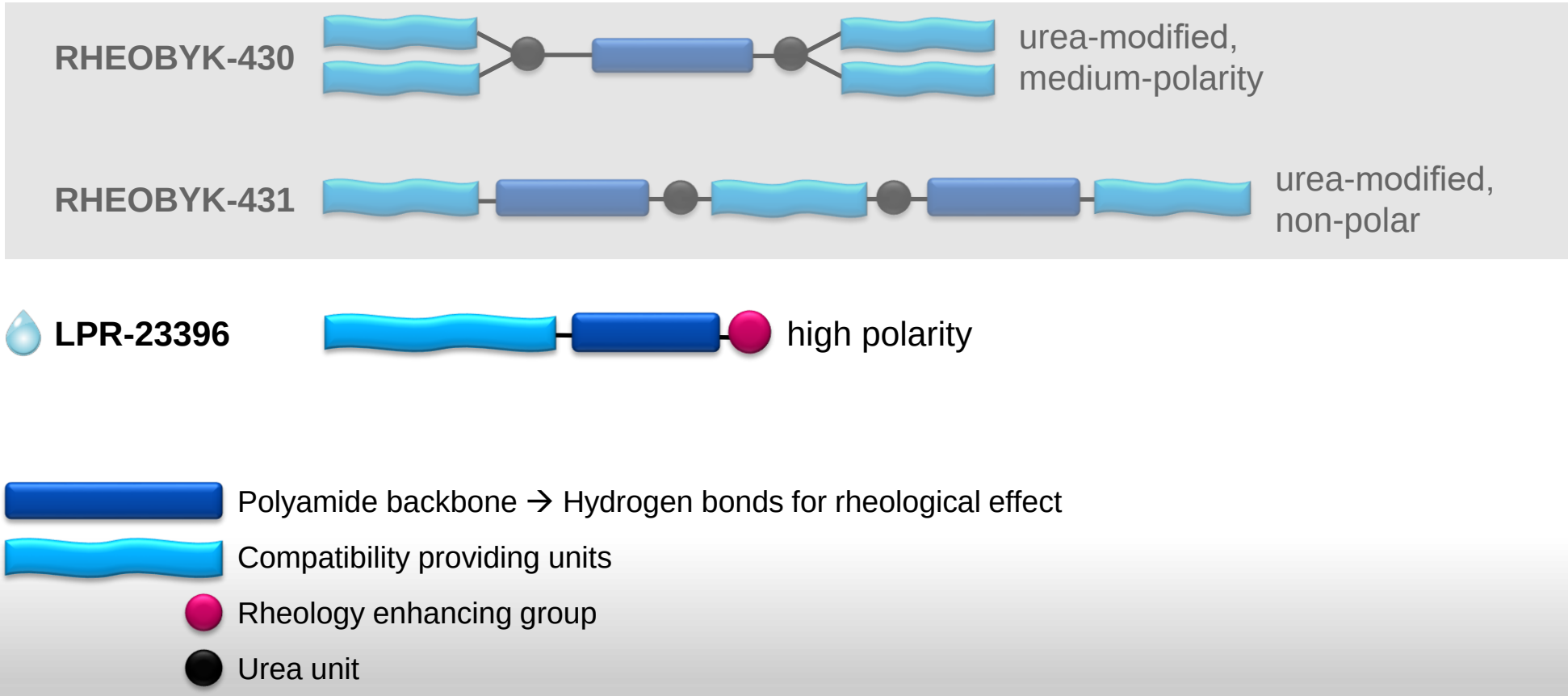
Compatibility providing unit (EO, PO, Alkyl-chains)

Rheology enhancing group

BYK

Completing the Family of Liquid Polyamides

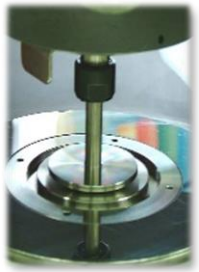
RHEOBYK-430, -431, LPR-23396

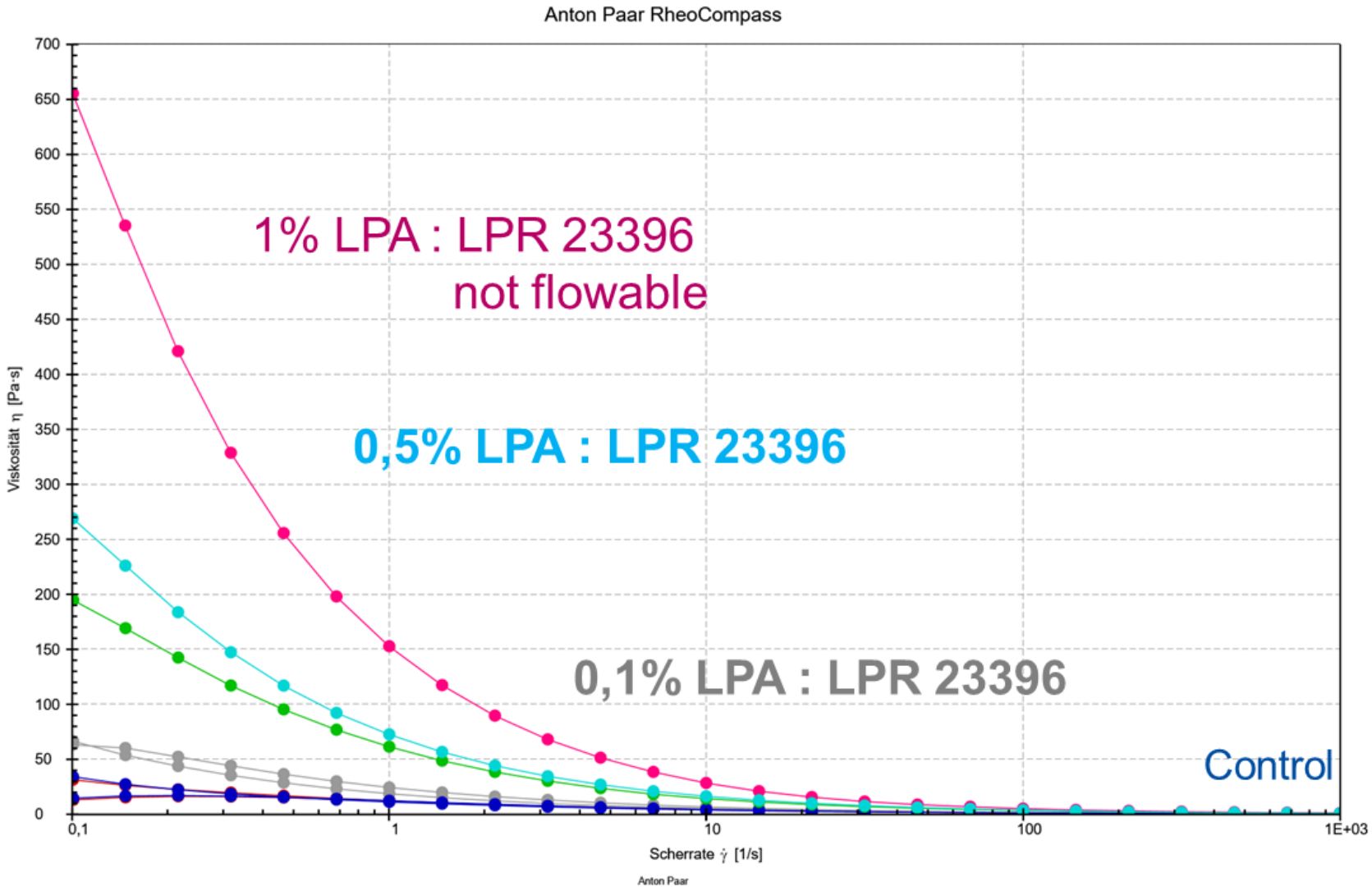


BYK

Screening BYK Rheology Additives

Dosage/Actives –

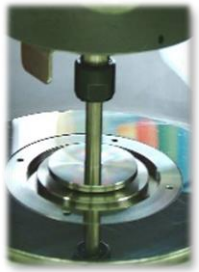


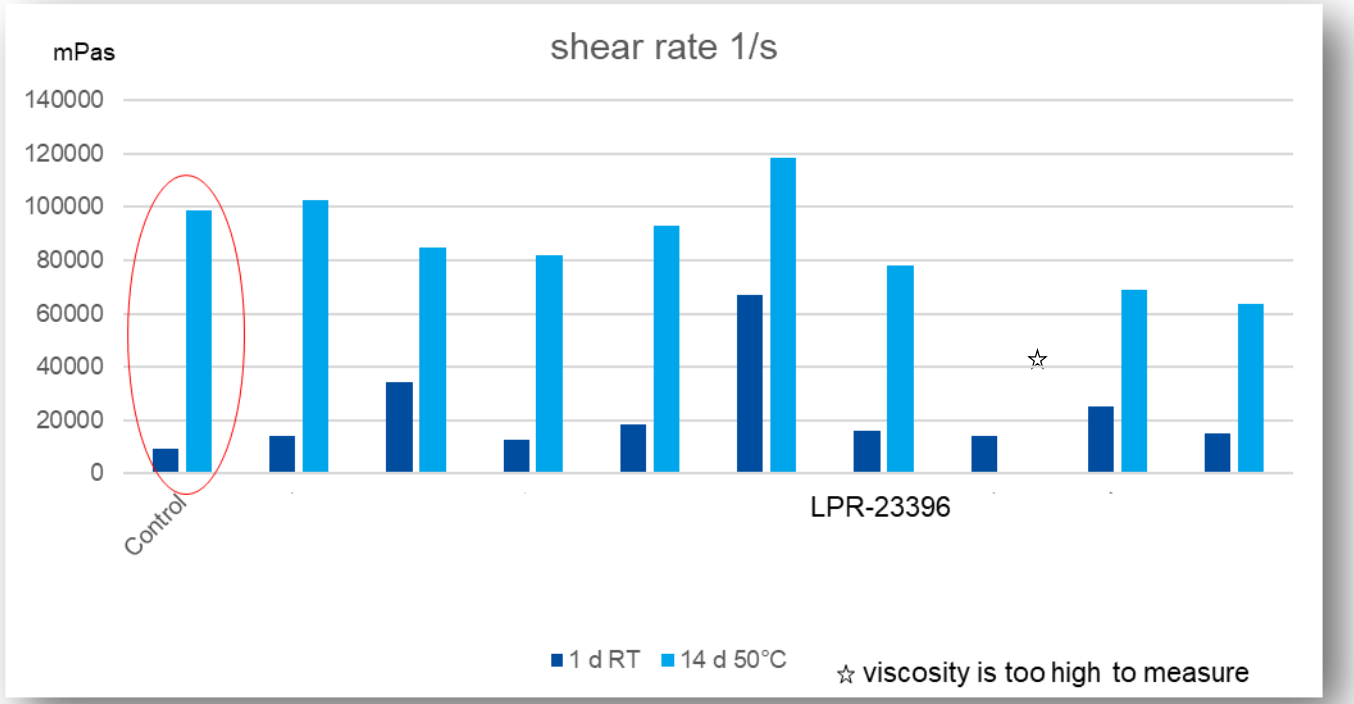


BYK Additives in water borne EP Resin w/o hardener

Additives & Storage Stability

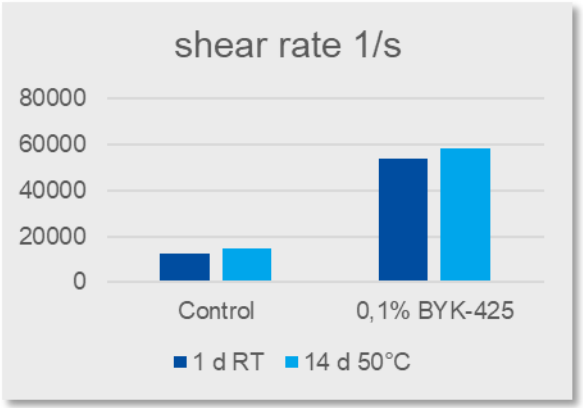
Heat Aged Stability at 50°C 14 days





BYK Additives in water borne EP formulation w/o hardener

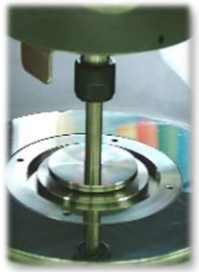
After Storage 14 days 50 degree C

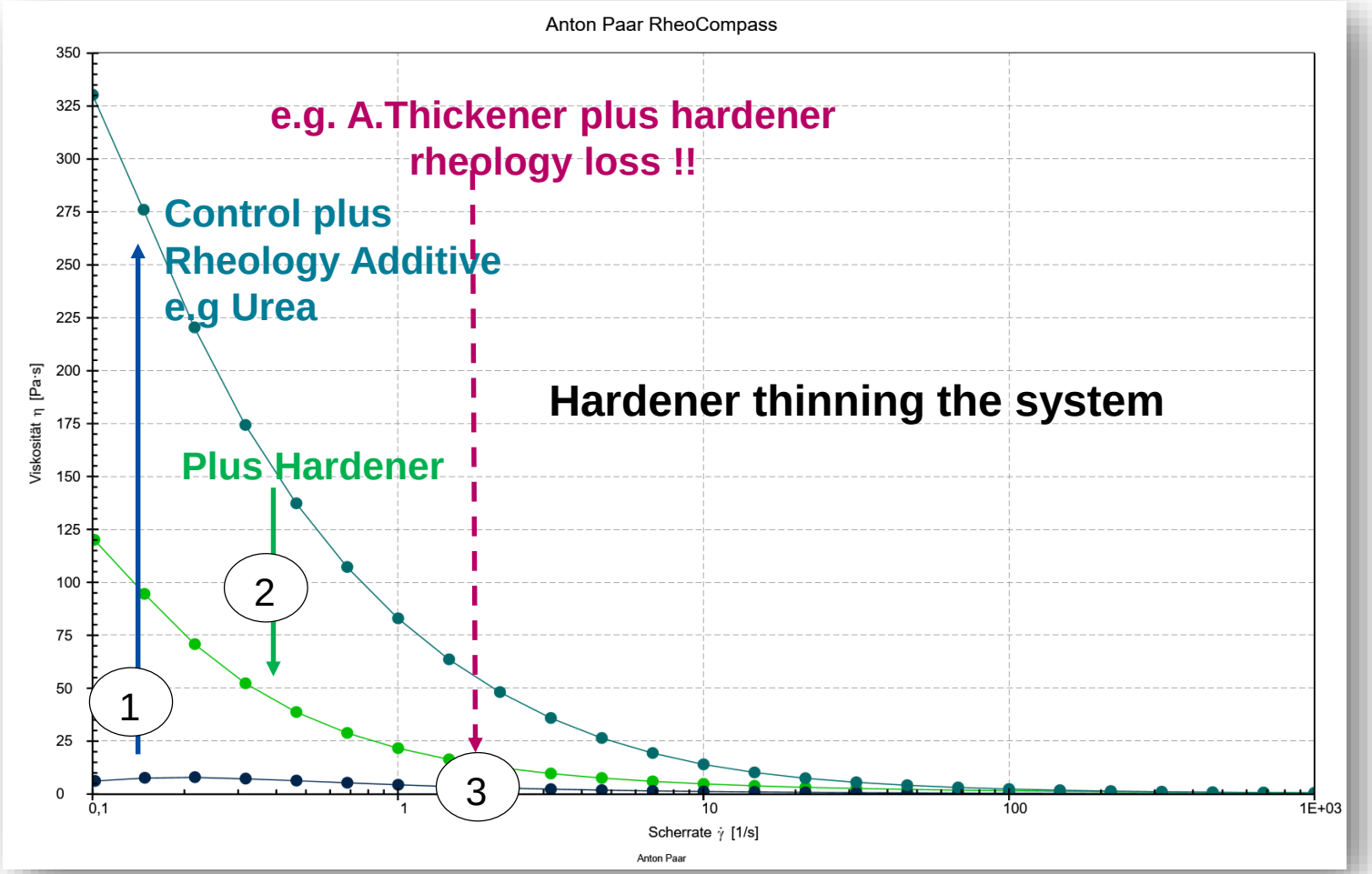


Only resin plus additive

BYK

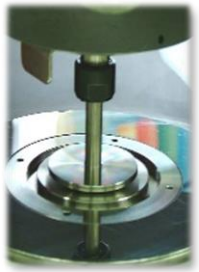
Rheology Additives
Impact of Hardener Phenomena

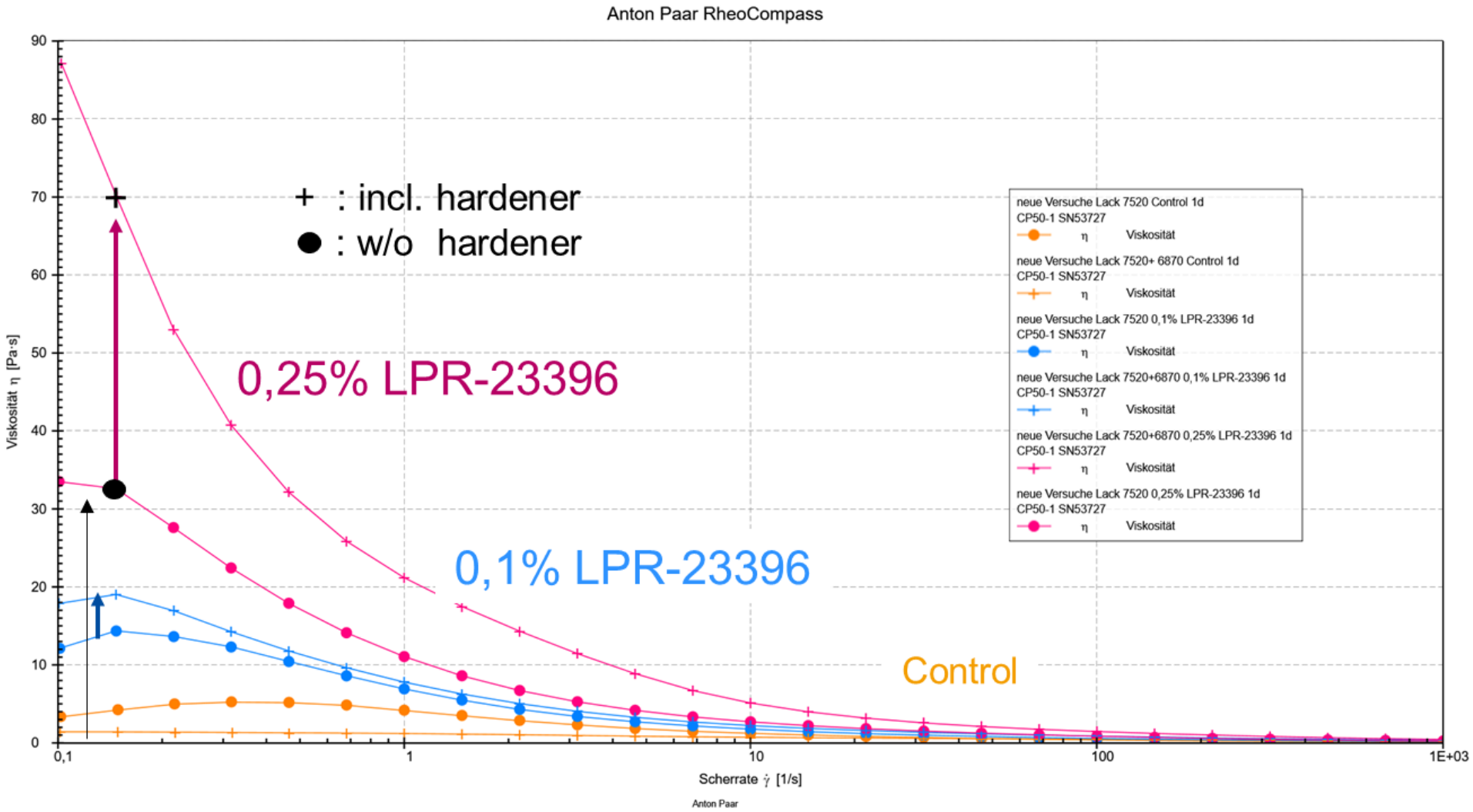




BYK Additives in waterborne EP Resin plus hardener

LPR-23396 - Liquid Polyamide
Impact of Hardener Phenomena

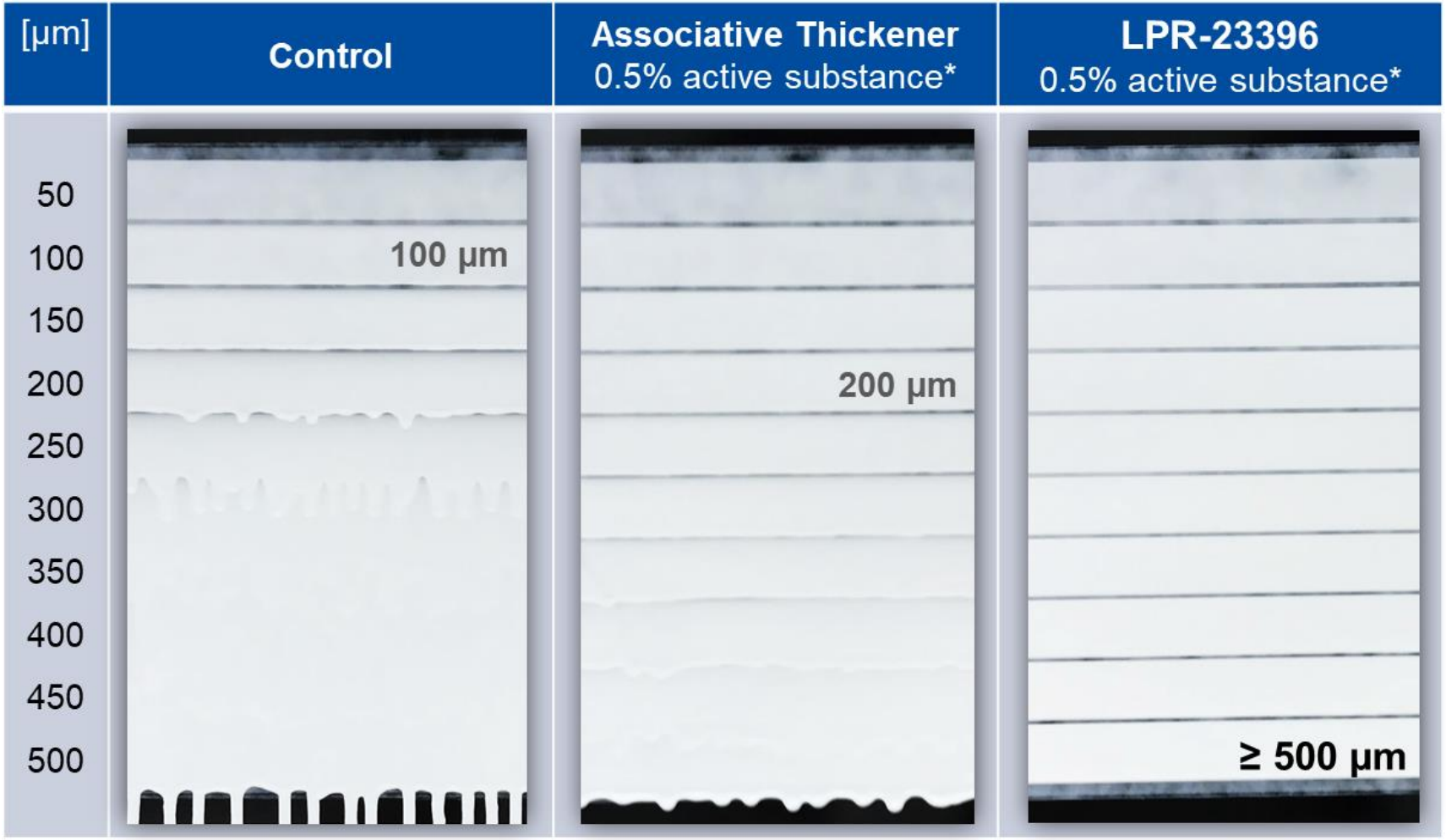




BYK Additives in waterborne EP Resin plus hardener

LPR-23396 in Waterborne Epoxies

High Sag Resistance



* = 3% as supplied on total formulation

* = 2% as supplied on total formulation

BYK Additives in waterborne 2K EP Formulation (2)

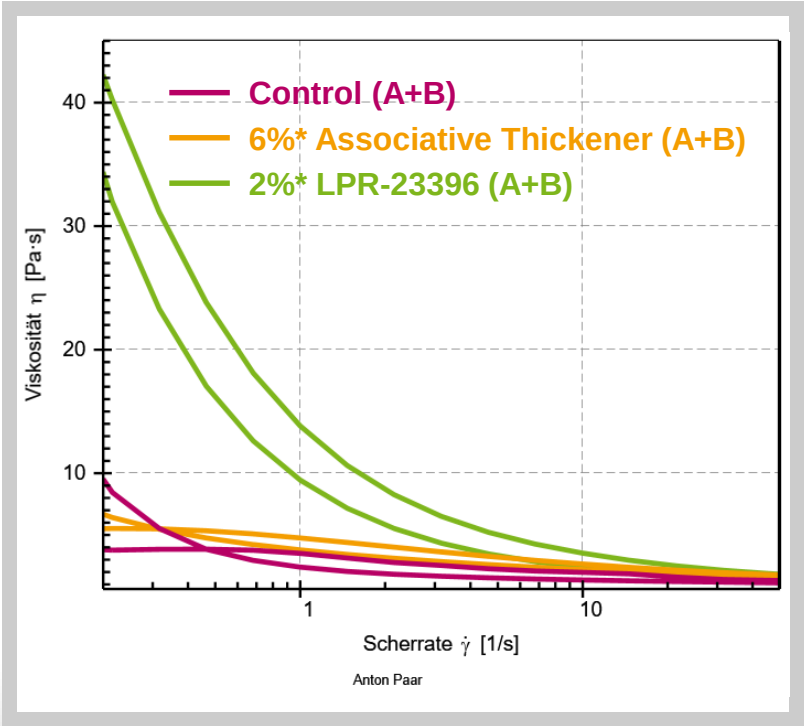
LPR-23396 in water-borne epoxies
Post Added in Amine Formulation

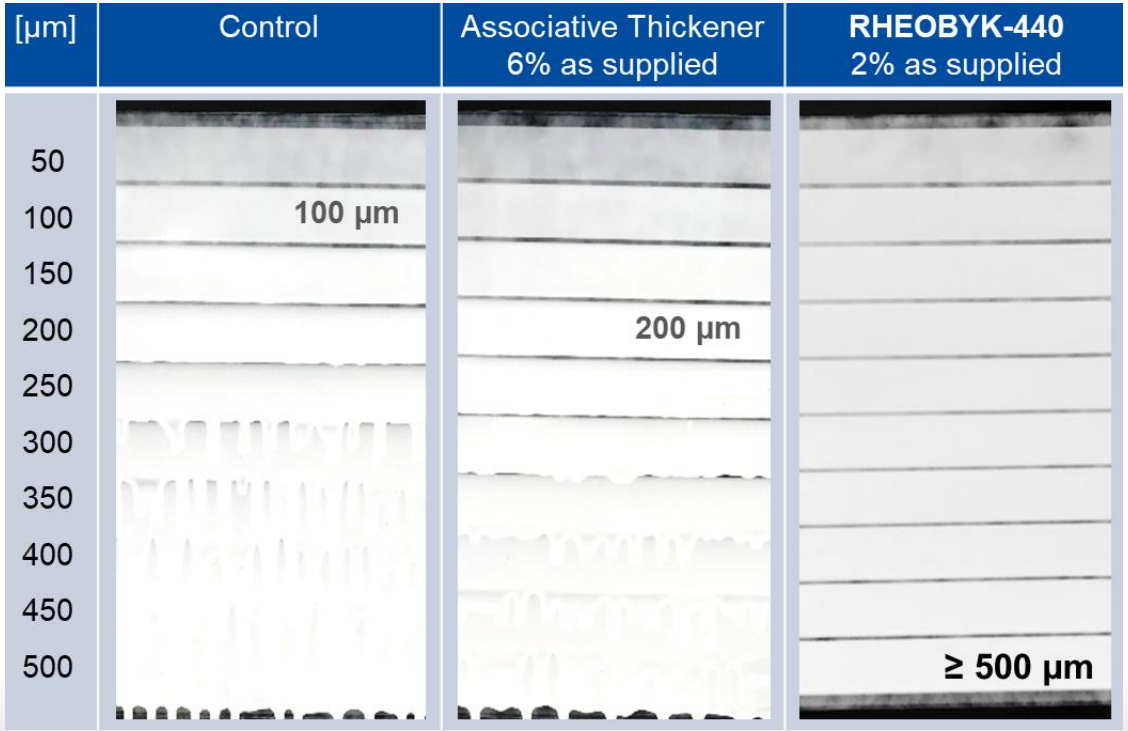
Test method:
WB 2-pack Epoxy

CSR measurement:
Anton Paar Rheometer MCR 302

Sag resistance:
directly after mixing
A and B

* as supplied on total formulation





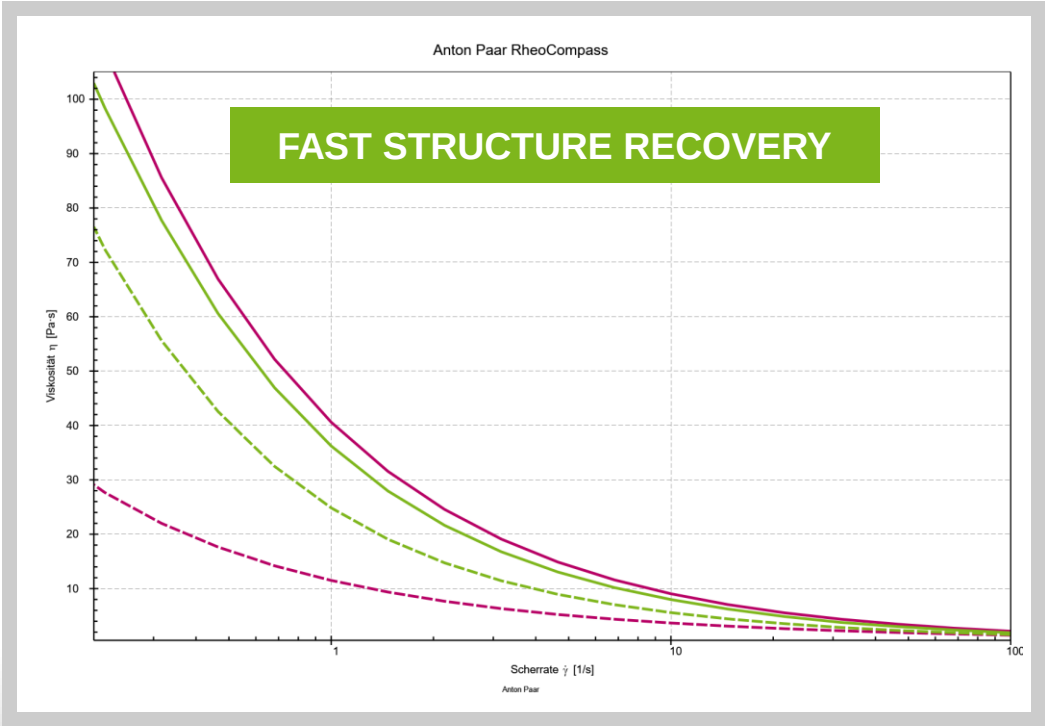
→ **LPR-23396 – Post added in amine grind formulation**

LPR-23396 in Water-borne Epoxies

Excellent anti-sag & anti-settling

Test method:
WB 2-pack Epoxy

Viscosity:
measurement with amine hardener



Thixotropic Additive*

LPR-23396

— Up-curve

--- Down-curve

* No storage stability 40o C - 14 days

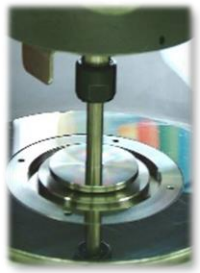
→ **LPR-23396 – Fast structure recovery – more pseudoplastic behaviour**

LPR-23396 in Waterborne Epoxies

3-Interval Thixothropy Test (Osc.Rot.Osc.)

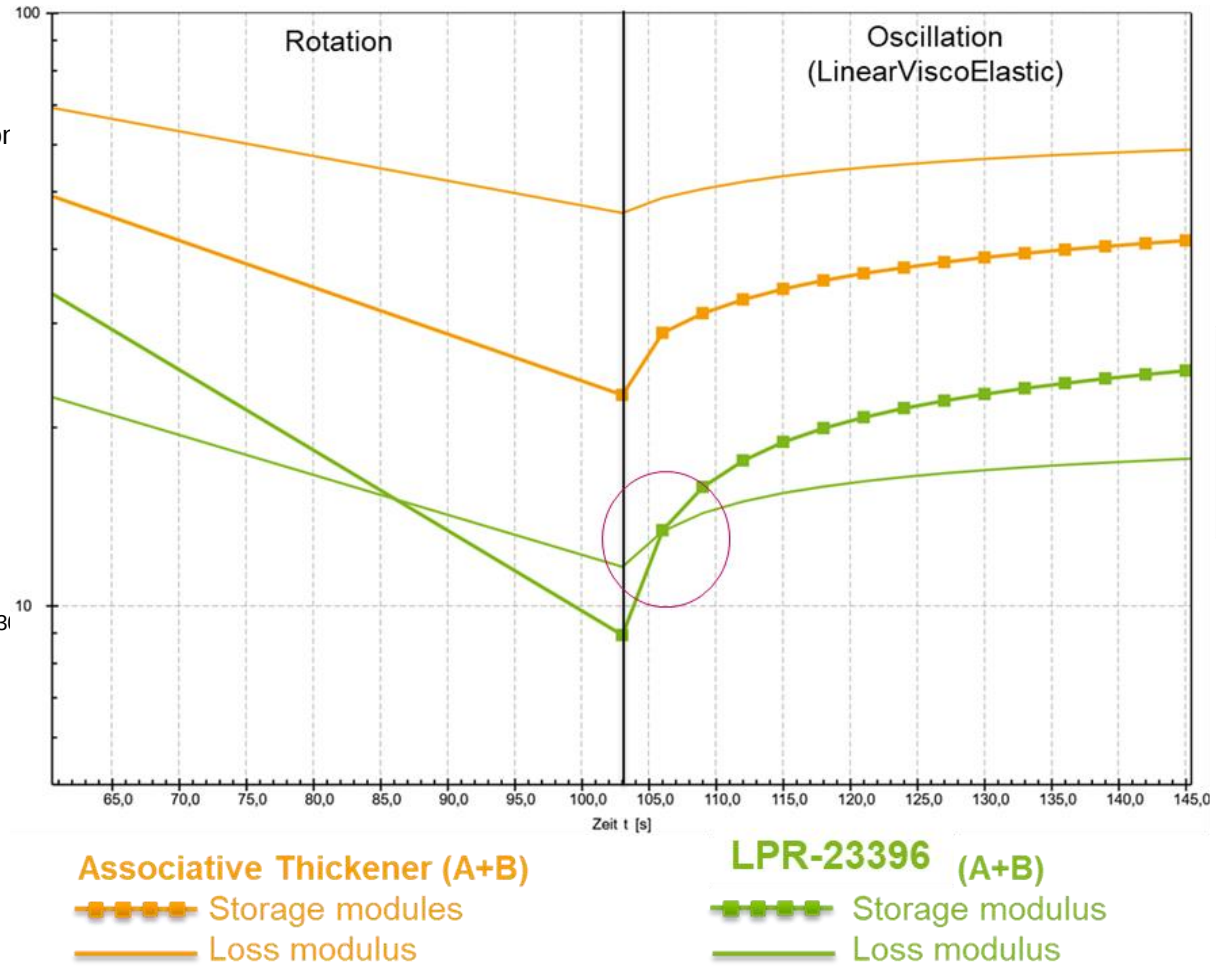
Test System
WB 2-pack Epoxy :

Additive Dosage
0.5% active substance or component A



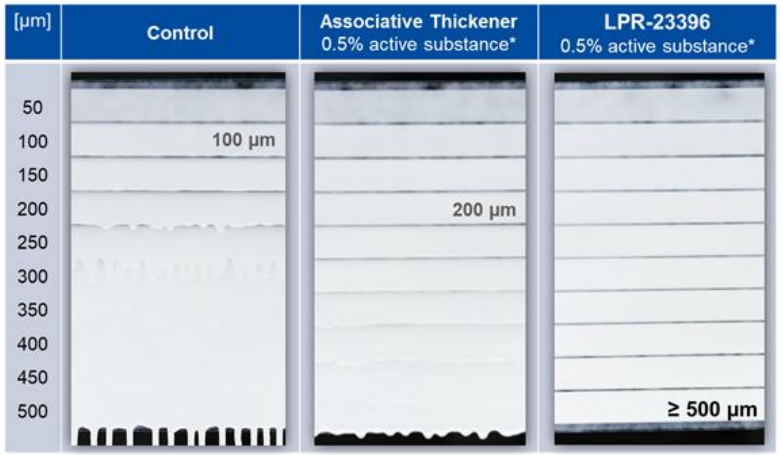
Anton Paar Rheometer MCR 3

Viscosity measurement
Oscillation:
ɣ= 1%
f = 1Hz
Rotation:
γ̇= 1000 1/s



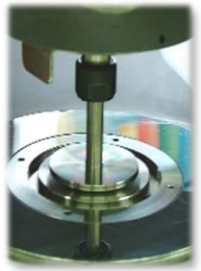
Higher viscosity, but…
→ More viscous than elastic parts
= **Less sag resistance**

Storage modulus higher than loss modulus after deformation, means…
→ More elastic than viscous parts
= **High sag resistance**



Application Results: Dip Application

Smooth Al and Metal



Samples	Zahn cup #2 (viscosity right before application)	DFT(mils)	
		Aluminum	metal
Blank	32	0.60	0.53
0.5% Hydroclay + 0.5% HEUR	60	0.92	0.93
0.5% LPR-23396	56	1.26	1.16

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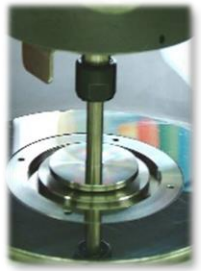
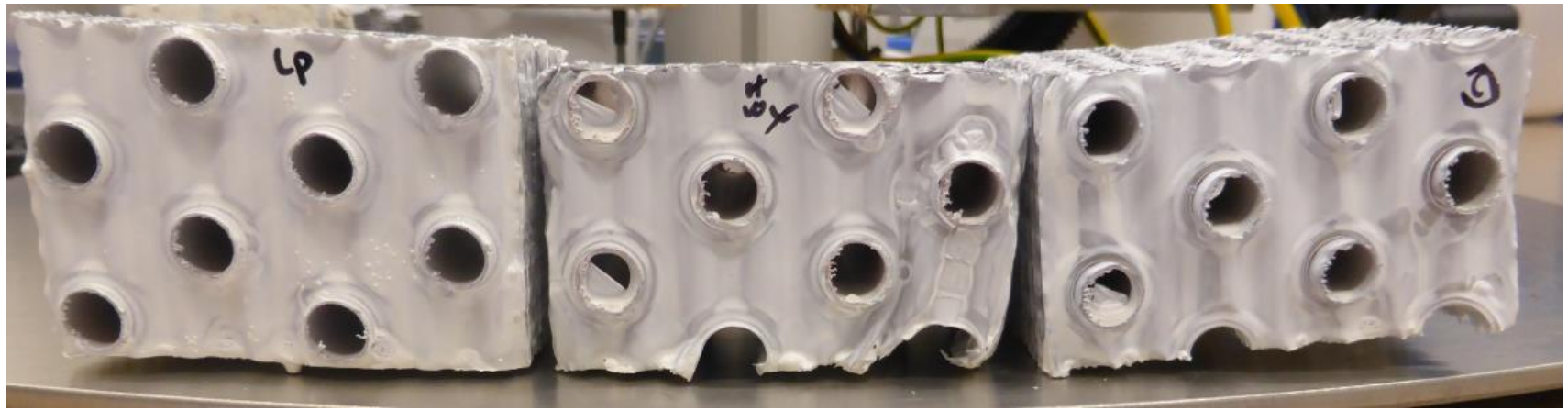
RHEOBYK 440 Application Results:
One Pack Phenolic Epoxy Baking System



Sample ID:	Weight before dip (g)	Weight after dip (g)	Weight difference (g)
Control	62.72	67.30	4.58
0.5% Hydroclay+0.5% HEUR	75.23	80.40	5.17
0.5% LPR-23396	75.34	85.13	9.79



0.5% LPR-23396 Actives

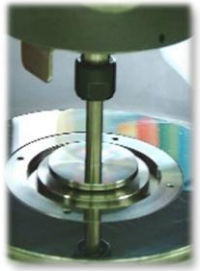
0.5% Hydroclay, 0.5% HEUR

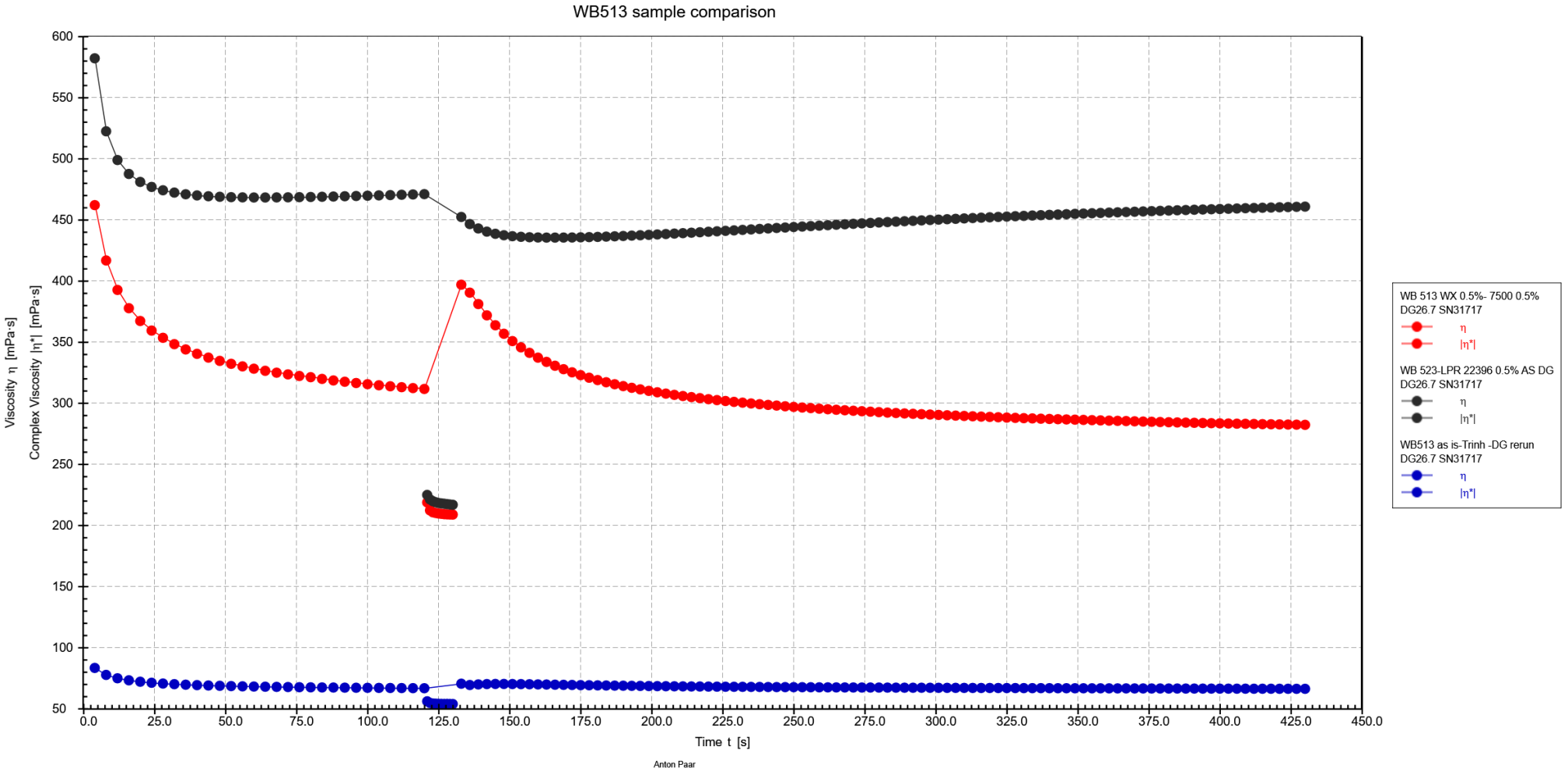
Blank

BYK

LPR-23396 in Waterborne Phenolic Epoxy Baking System

Fast structure recovery – good anti-sag/drip properties



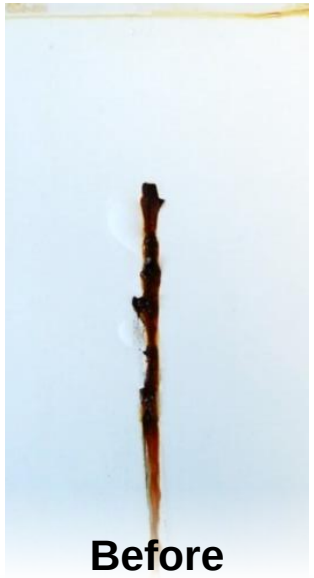


LPR-23396 in Water-borne Epoxies
No Negative Influence on Salt Spray Resistance and Adhesion

Corrosion tests in artificial atmospheres – Salt spray tests
(ISO 9227:2006)

Test formulation:
WB 2-pack Epoxy

Substrate:	smooth steel
DFT:	80 µm
Drying:	7 d ambient
Duration:	360 h

No rheology additive		Other liquid rheology additive		LPR-23396	
					
Before scratching	After scratching	Before scratching	After scratching	Before scratching	After scratching

→ **LPR-23396 – No negative impact on corrosion**

BYK

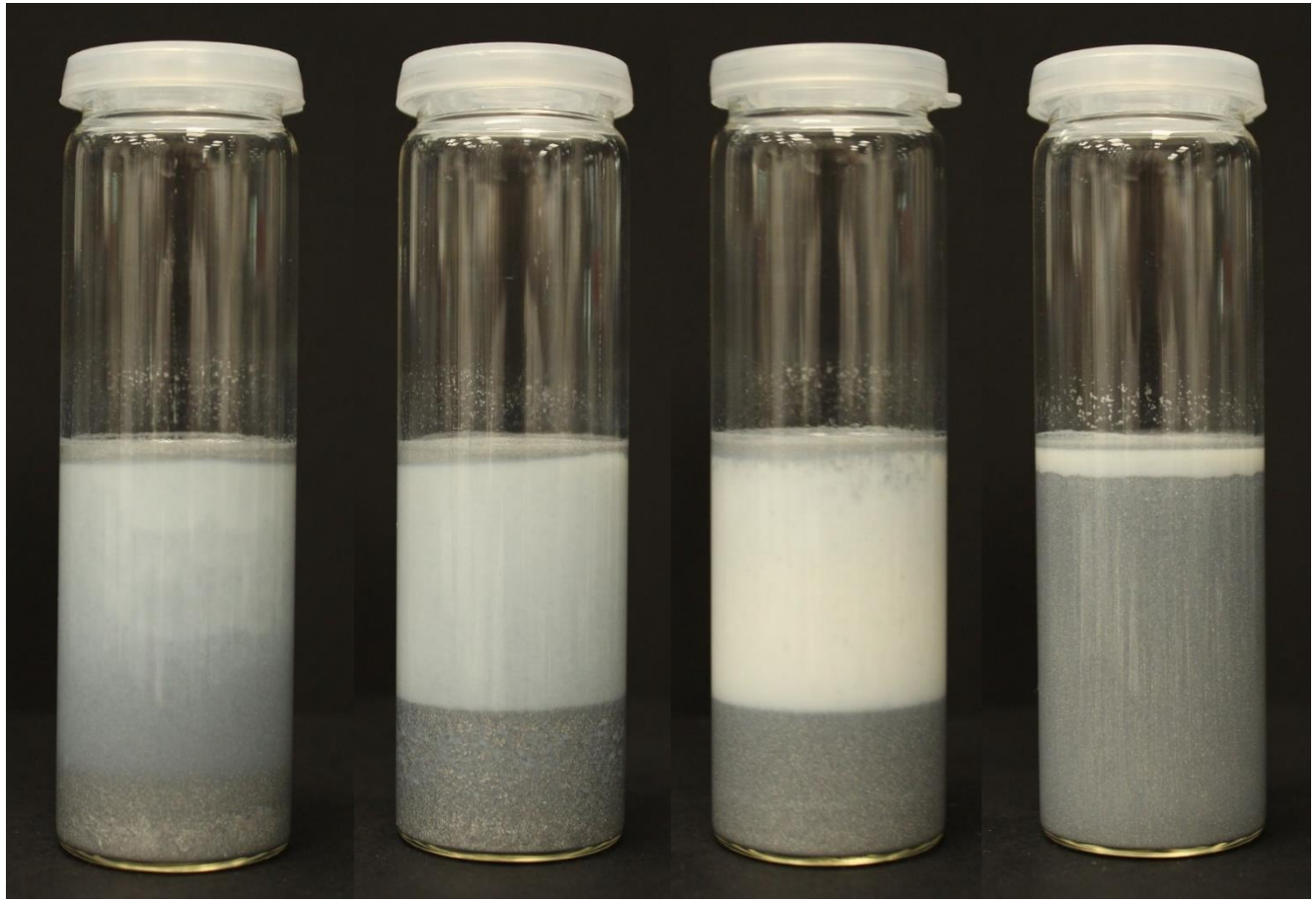
LPR-23396 in 2-pack Acrylic

Excellent Anti-Settling Properties

Test System
2-pack Acrylic
Metallic Topcoat
STAPA® IL HYDROLAN 2154

Additive Dosage
0.1% active substance on total formulation

Storage
7 days at room temperature



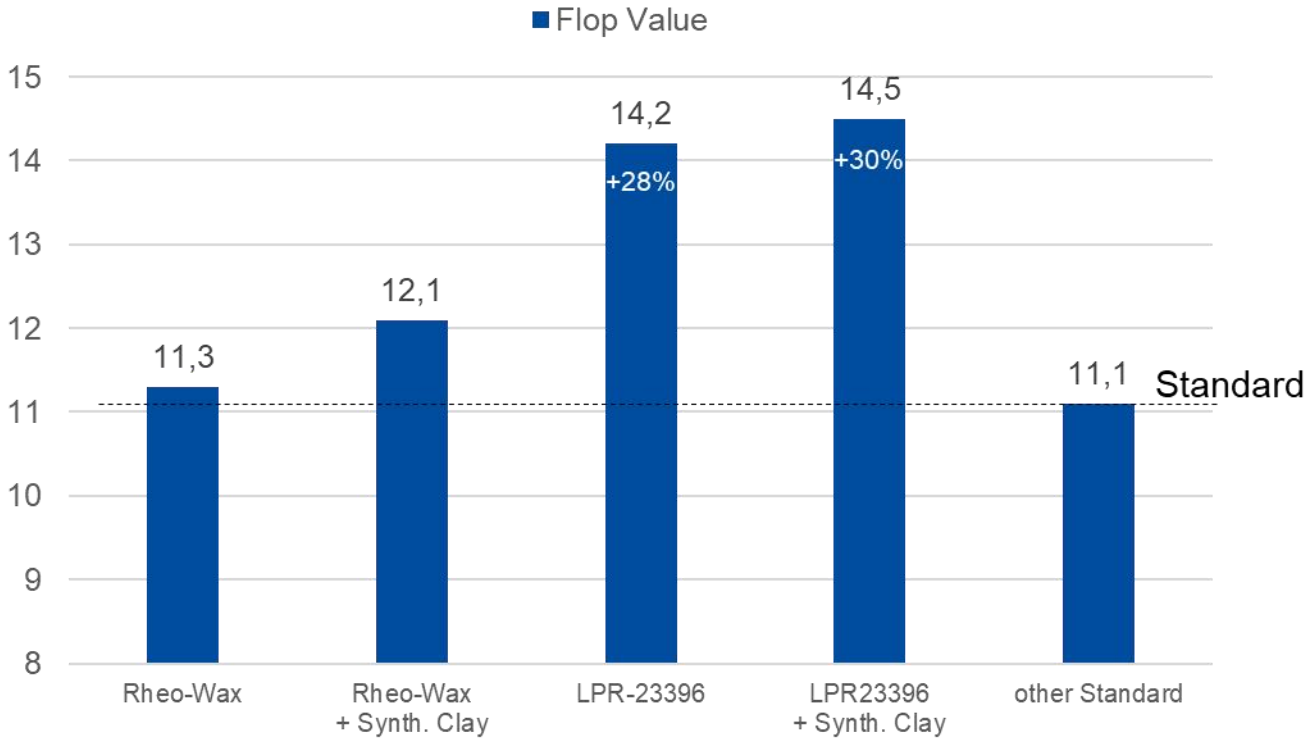
Control LAPONITE-RDS RHEOBYK-D 420 LPR-23396

LPR-23396 – Water Borne Metallic Base Coats

Metallic Orientation

System:
Acrylic Copo. Disp.
Plus met. pigment

Film thickness
10 µm



Flop Value Results- OEM Basecoat - ESTA Spray Application

BYK-Gardner – cloud-runner

LPR-23396 (RHEOBYK-440)
Special – Extraordinary – Unique

Especially designed for the latest water-borne epoxy systems

- ✓ Improves anti-sagging and anti-settling properties.
- ✓ Provides fast structure recovery. Highly shear thinning.
- ✓ Stable rheology when mixed when hardener.
- ✓ No gelling or viscosity increase over storage.

Easy to handle and to incorporate

- ✓ Pre-activated, liquid product
- ✓ Post-addition recommended
- ✓ pH independent rheology

Final coating properties are not affected (e.g. corrosion resistance, adhesion, …)

Rheobyk 440 Liquid Polyamide Technology

Not only for 2K Water Borne Epoxy Coatings

Suitable Water-borne Systems e.g.

- 2-pack Epoxy
- 2-pack PUR
- Acrylate / Melamine
- 1-pack Acrylics
- 1-pack PUR

BYK

Thank you for your time & attention.

DISCLAIMER

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