Inverted ribbon phyllosilicates – a different family of rheology additives

The LEHVOSS Group – from Hamburg to the world – 125 years of innovation

- Inverted ribbon phyllosilicates

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PLASTIC AND RUBBER

High-Performance Compounds

Technical Compounds

Masterbatches and Additives

Products for **Composites**

Rubber Chemicals

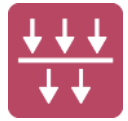
SPECIAL CHEMICALS AND INDUSTRIAL MINERALS

Magnesium Compounds

Rare earth / Zirconium Compounds, Inorganic Raw Materials

Raw Materials for **Coatings**

Raw Materials for **Functional Fluids**



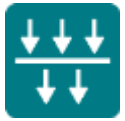
Products for **Filtration and Separation**

LIFE SCIENCE

Raw Materials for **Personal Care**

Raw Materials for **Nutritional Supplements and Foods**

Pharmaceutical Ingredients



Products for **Filtration and Separation**

● Inverted ribbon phyllosilicates

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Raw materials for coatings

Raw materials for paints/coatings, inks, construction chemicals, adhesives/sealants, and industrial applications

- Rheology Modifiers
- Saturated Polyester Resins
- Lightweight Functional Fillers

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Raw materials for coatings

Main technical activities in Wandsbek (Hamburg):

→ Testing, Development and Application

Comprehensive testing methods

- Mechanical Materials Testing
- Thermal Analysis (TGA, TMA, PDSC)
- Optical Methods (Colorimetry, PSD)
- Particle Analysis
- IR Spectroscopy
- Anti-wear Friction (VKA, SRV)
- Corrosion Tests (Salt Spray, Humidity)
- Titration, Viscosity, Filtration, Demulsibility, Penetration

What are coatings?

- Coating are fluids that when applied to a surface form a solid, continuous, adherent film or barrier
- This film is designed to enhance, beautify, or protect the surface to which it has been applied
  - Substrate protection
  - Aesthetics
  - Durability

What is in a coating?

- Binders
- Pigments
- Extenders or Fillers
- Solvents
- Rheology Modifiers
- Miscellaneous Additives

What is in a coating?

- Binders
- Pigments
- Extenders or Fillers
- Solvents

- Rheology Modifiers
  - Raw materials that can change the flow characteristics of a liquid coating
    - The coating must be easy to mix/pump/package…
    - …and it cannot settle in the can…
    - …and it must be fluid enough to spray/roll/brush...(brush resistance, no spatter)
    - …and it cannot sag/drip once applied…
    - …and it must for a nice-looking film…(good levelling)

- Miscellaneous Additives

Focus on rheology modifiers

- In addition to modifying viscosity and structure, these additives may affect
  - water demand (total solids)
  - open time
  - wet adhesion to substrates
  - dry adhesion
  - durability of contact materials
  - bleeding
  - water resistance
  - water vapor permeability
  - freeze/thaw resistance
  - crack bridging or prevention

- The most common types of rheology modifiers are:
  - fumed silica
  - **clays** (Phyllosilicates)
  - castor oil derivatives
  - polyamides
  - cellulosics
  - associative thickeners and alkali swellable polymers

Inverted ribbon phyllosilicates

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Clays for waterborne coatings

- Phyllosilicate clays used as rheology modifiers for waterborne systems are of various types:
  - Lamellar structures (plates)
  - Acicular structures (needles)
  - **Ribbon structures**

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Properties of phyllosilicates use in coatings

Characteristic	Plate	Layered	Ribbon	Needle
Cation exchange capacity (meg/100g)	70-120	20-30	10-15	10-15
Surface (m^2/g)	30-100	70-160	280-340	120-150
Swelling	yes	yes	no	no
Whiteness – GEB (%)	30-85	<60	>60	>60
Hardness (Mohs)	1.5-2.0	1.0-2.0	2.0-2.5	2.0-2.5

- Inverted ribbon phyllosilicates

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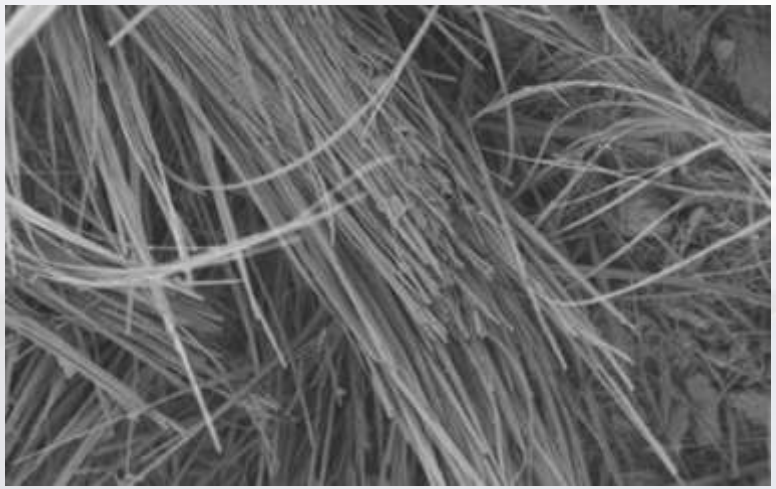
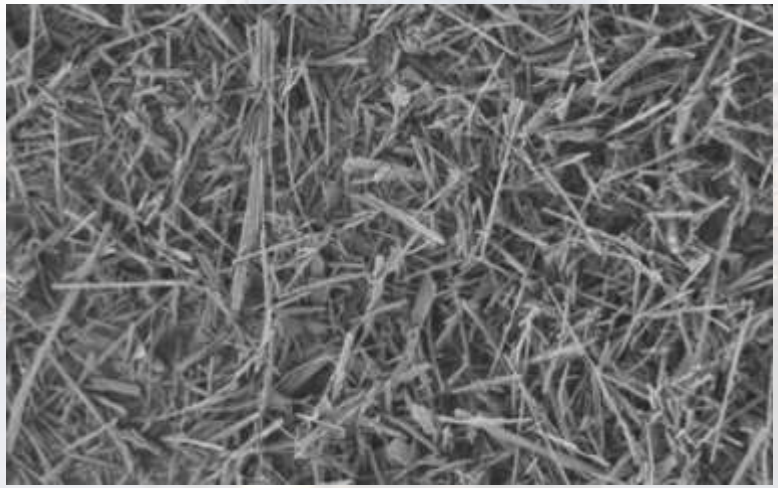
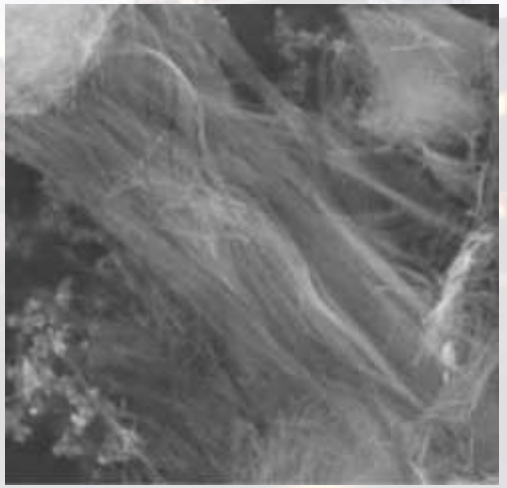
Inverted ribbon phyllosilicates – structure



Ribbon phyllosilicate *in natura*

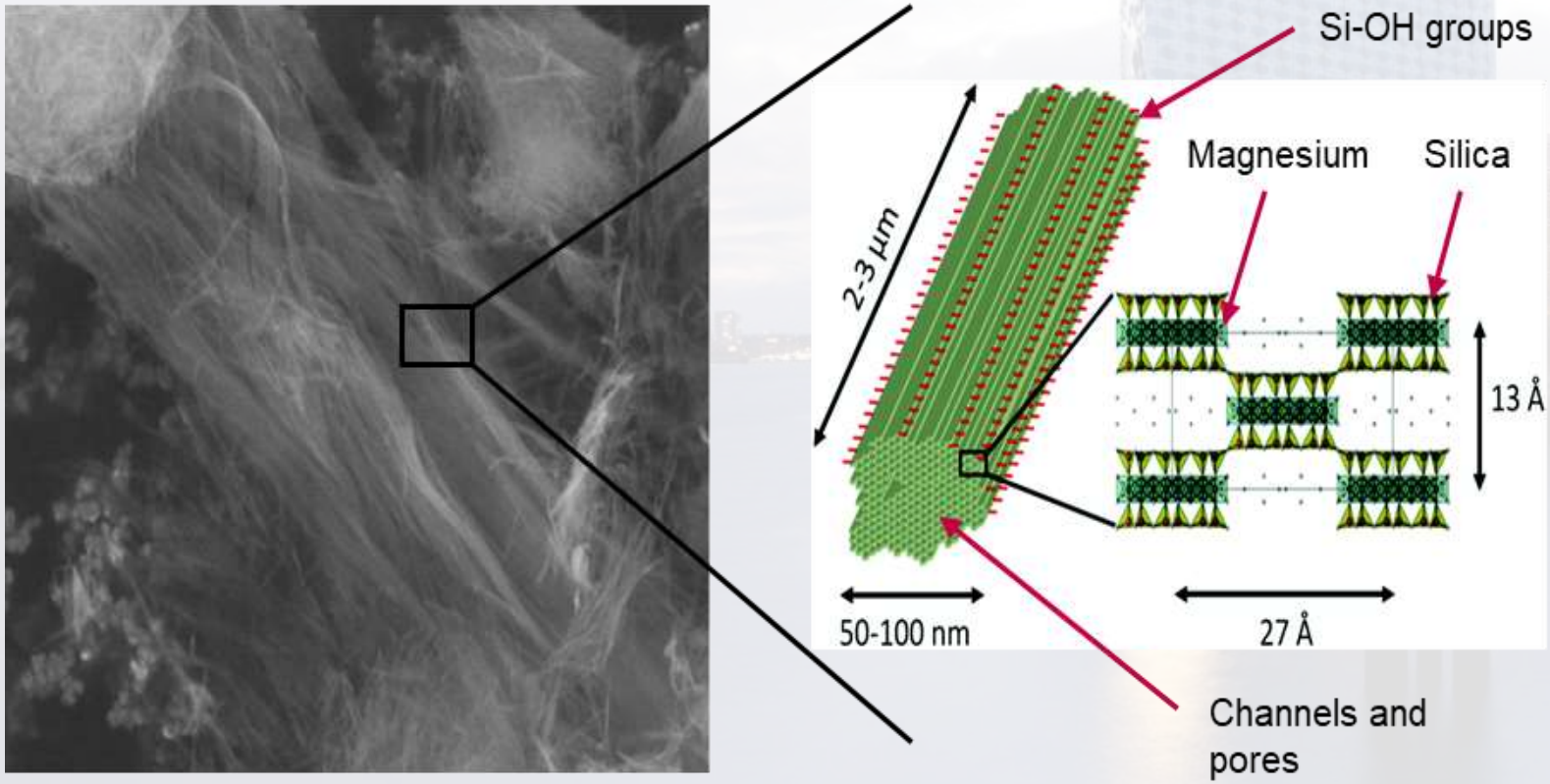


Ribbon phyllosilicate after milling



Ribbon phyllosilicate in water

Inverted ribbon phyllosilicates – structure



Inverted ribbon phyllosilicates – characteristics

- Inverted Ribbon Phyllosilicates (IRP) do not swell in water, unlike other clays
  - **Low water affinity is beneficial after drying (roof and wall coatings)**
- IRP are easy to disperse, even in dry-mix formulations
- The ribbon structure leads to better anti-settling properties
- IRP gel formation is independent of ionic strength – pH changes or presence of salts will not affect the gel
- The gel structure of IRP collapses quickly upon stress (shear-thinning) and the large surface area allows for fast rebuild (thickening) after shear is removed

Inverted ribbon phyllosilicates – water resistance

- Unlike other materials, IRP do not absorb water once the coating is dry
- This is important for applications requiring water resistance, such as roof coatings and walls exposed to humid environments **(enhanced coating and substrate life)**

Inverted ribbon phyllosilicates – characteristics

- Inverted Ribbon Phyllosilicates (IRP) do not swell in water, unlike other clays
- IRP are easy to disperse, even in dry-mix formulations
  - **Easy to process/incorporate**
  - **Easy to reincorporate if settling does occur**
  - **IRP are also used in dry-mix products**
- The ribbon structure leads to better anti-settling properties
- IRP gel formation is independent of ionic strength – pH changes or presence of salts will not affect the gel
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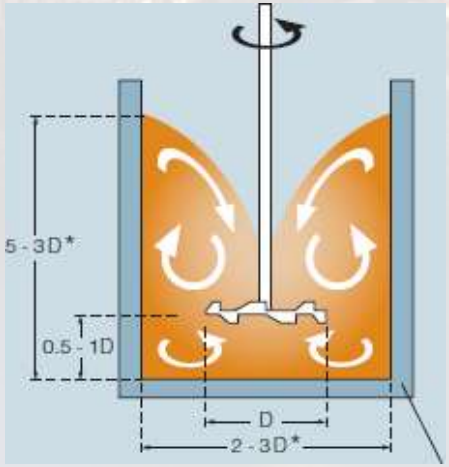
Inverted ribbon phyllosilicates – activation

DRY FORM
5 – 50 µm → AGGREGATES
1 – 5 µm → ELEMENTARY PARTICLES
0.1 – 2 µm

- High speed mixing is best
- The mixing process is speed- and time-controlled (no temperature control needed)
- IRP are fully activated if viscosity does not increase with additional mixing



Easy and reproducible incorporation, if time and shear rates are controlled

Inverted ribbon phyllosilicates – characteristics

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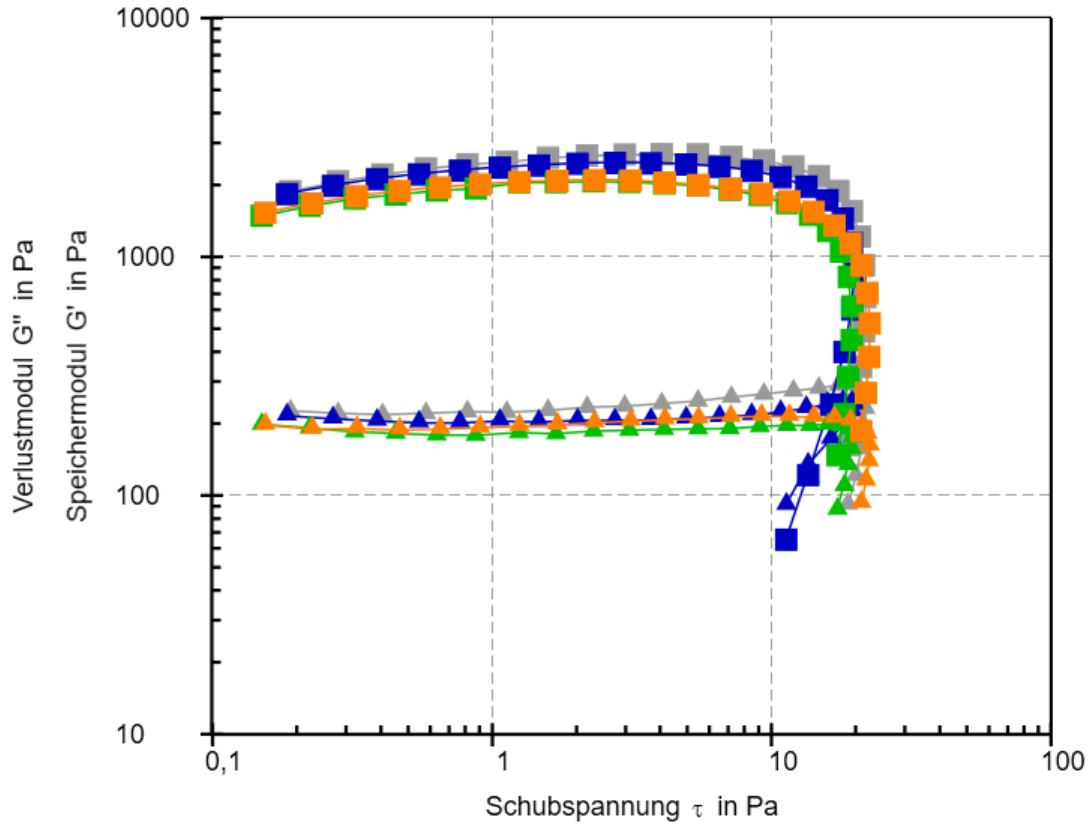
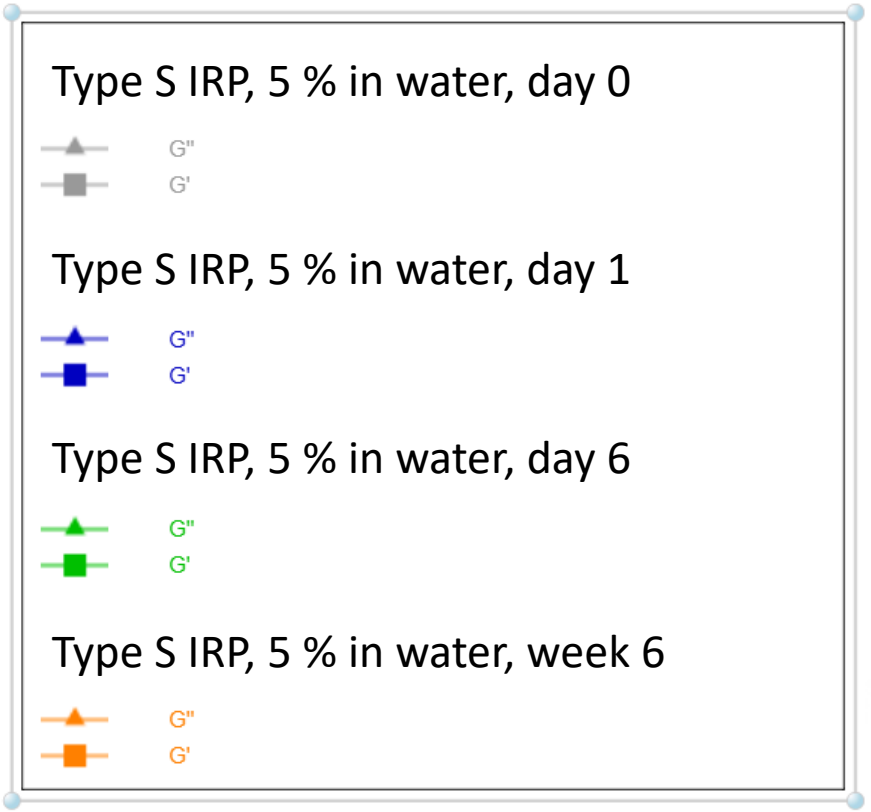
- IRP are easy to disperse, even in dry-mix formulations
- The ribbon structure leads to better anti-settling properties
  - **Very good in-can stability**
  - **Very good storage and transportation stability**
- IRP gel formation is independent of ionic strength – pH changes or presence of salts will not affect the gel
- The gel structure of IRP collapses quickly upon stress (shear-thinning) and the large surface area allows for fast rebuild (thickening) after shear is removed

Inverted ribbon phyllosilicates – stability

Stress Sweep (5% in tap water): gels remain stable, stored for six weeks at ambient temperature





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Inverted ribbon phyllosilicates – characteristics

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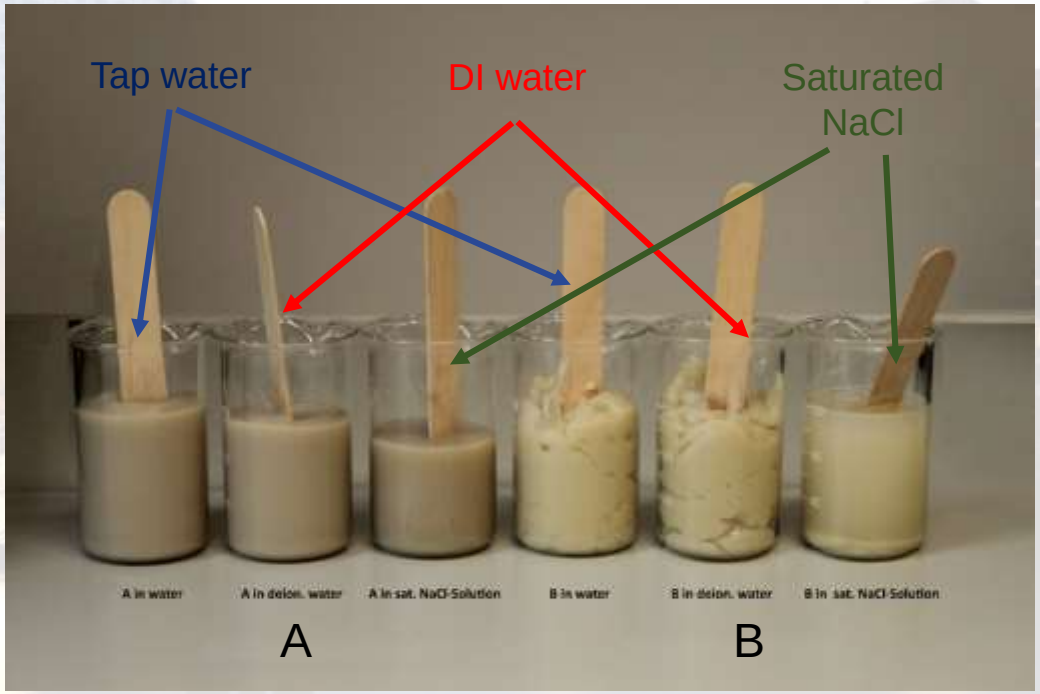
- IRP are easy to disperse, even in dry-mix formulations
- The ribbon structure leads to better anti-settling properties
- IRP gel formation is independent of ionic strength – pH changes or presence of salts will not affect the gel
  - **Allows for formulations with very different pH ranges**
  - **The presence of hard water or salt water does not affect performance**
- The gel structure of IRP collapses quickly upon stress (shear-thinning) and the large surface area allows for fast rebuild (thickening) after shear is removed

Inverted ribbon phyllosilicates – ionic stability

A

B



Influence of electrolytes on 5% gel stability
(A- IRP, B- layered silicates)

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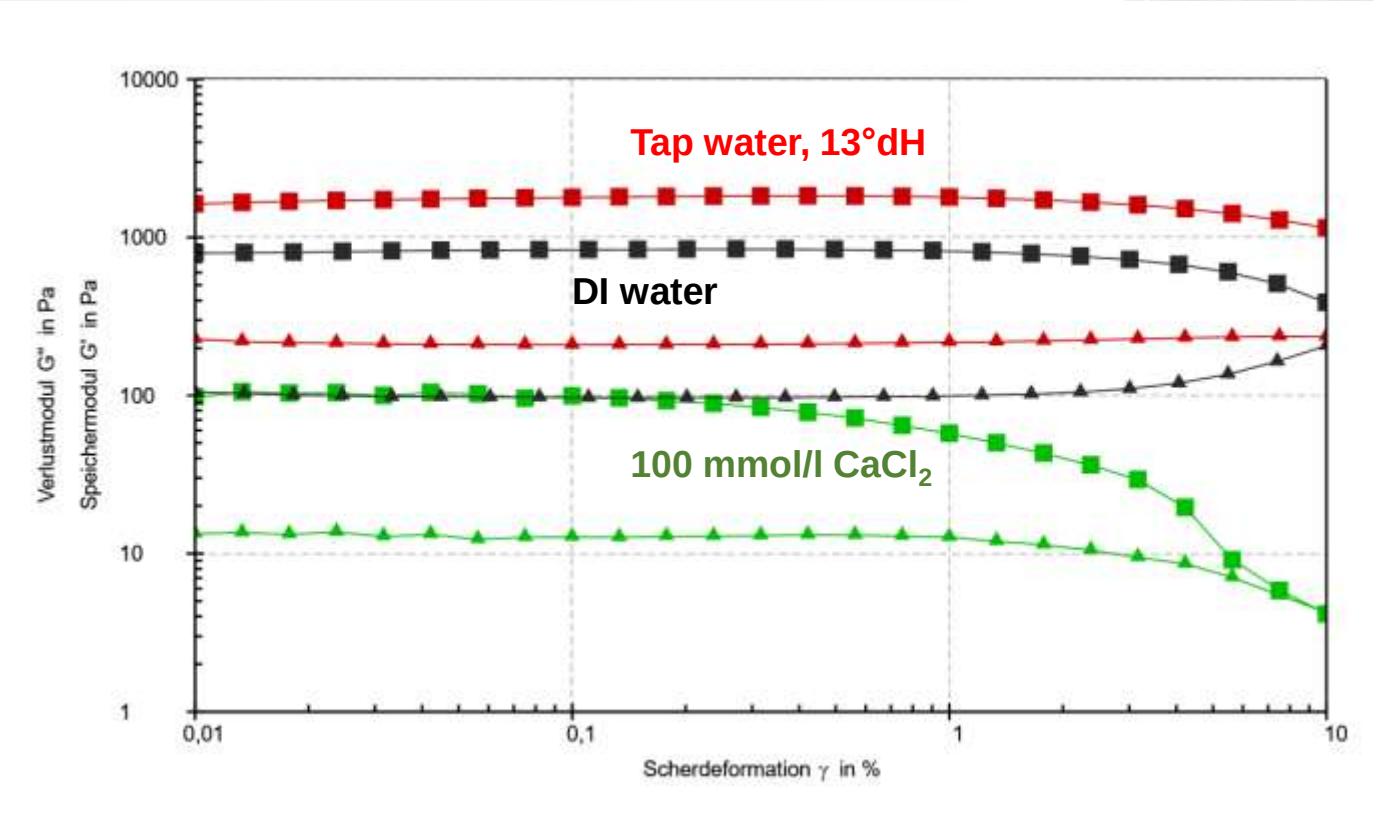
Lamellar phyllosilicates – ionic stability



Amplitude sweep (5% additive): effect of electrolytes on gel stability of lamellar phyllosilicates

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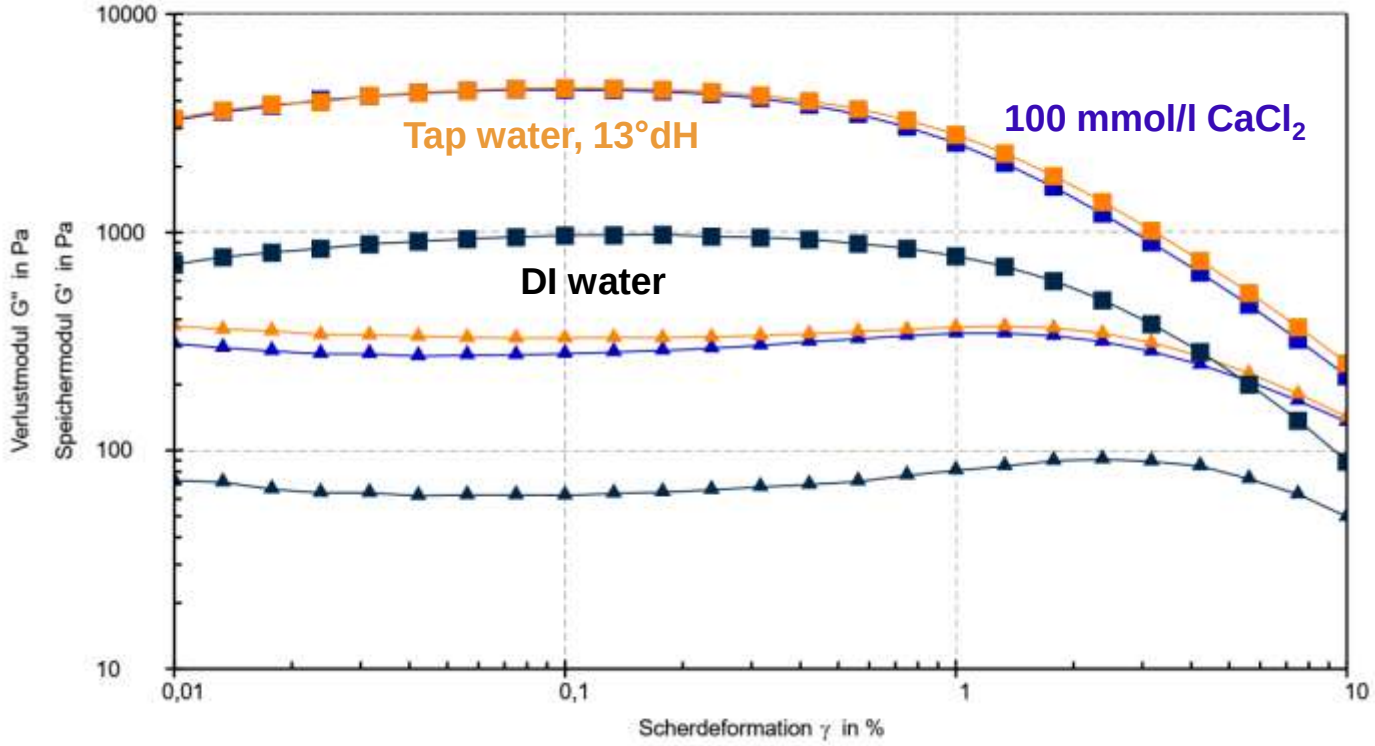
Inverted ribbon phyllosilicates – ionic stability



Amplitude sweep (5% additive): effect of electrolytes on stability of IRP gel

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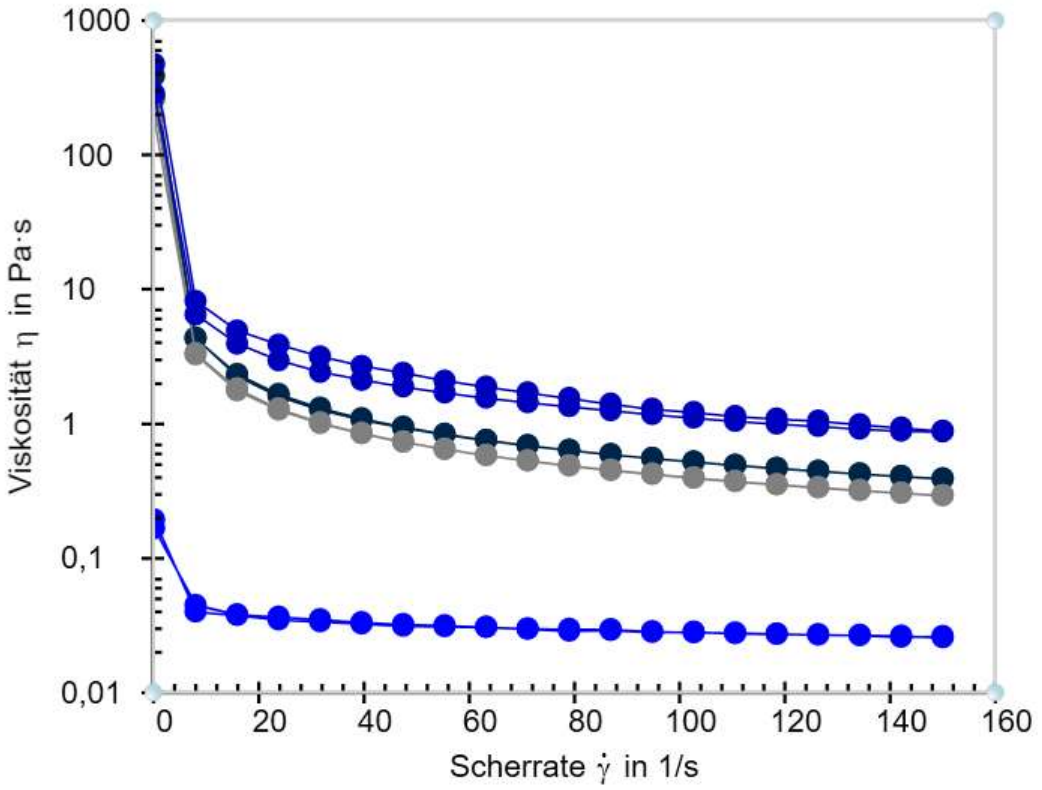
Inverted ribbon phyllosilicates – ionic stability



Viscosity curves (5% in saturated NaCl solution): viscosity of bentonite is reduced, while viscosity of IRP remains unchanged

Type S IRP 5 % in water

η

Type S IRP 5 % in saturated NaCl

η

Synthetic Hectorite 5 % in water

η

Synthetic Hectorite 5 % in saturated NaCl

η

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Inverted ribbon phyllosilicates – characteristics

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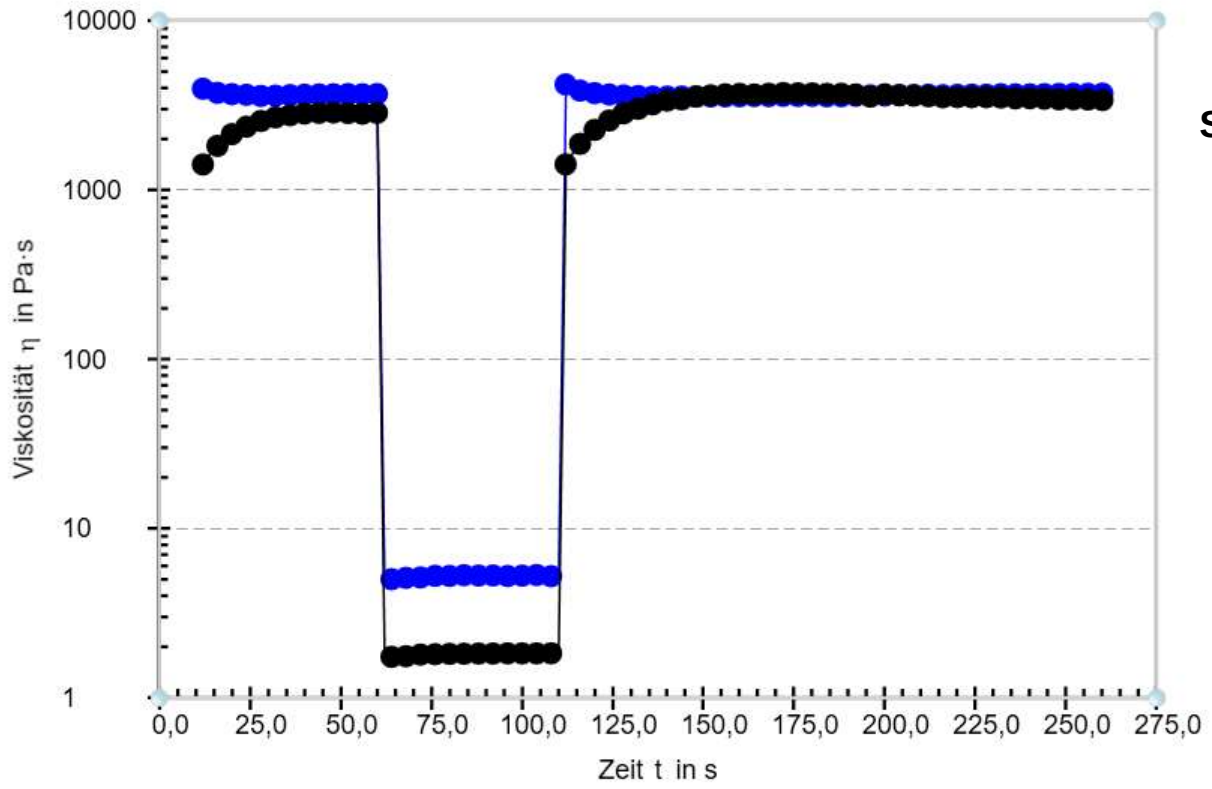
- IRP are easy to disperse, even in dry-mix formulations
- The ribbon structure leads to better anti-settling properties
- IRP gel formation is independent of ionic strength – pH changes or presence of salts will not affect the gel
- The gel structure of IRP collapses quickly upon stress (shear-thinning) and the large surface area allows for fast rebuild (thickening) after shear is removed
  - **Very stable structure at rest**
  - **Shear causes thinning, thus good pumpability/rolling/brushing**
  - **Low viscosity translates as good flow on substrate**
  - **Once shear is removed, gel rebuilds quickly, thus no sagging/dripping**
  - **Ideal for spray applications**

Inverted ribbon phyllosilicates – effect of shear



Shear jump (5% in tap water): viscosity reduction of IRP is stronger

Synthetic Hectorite 5 % in water

η Viskosität

Type S IRP 5 % in water

η Viskosität

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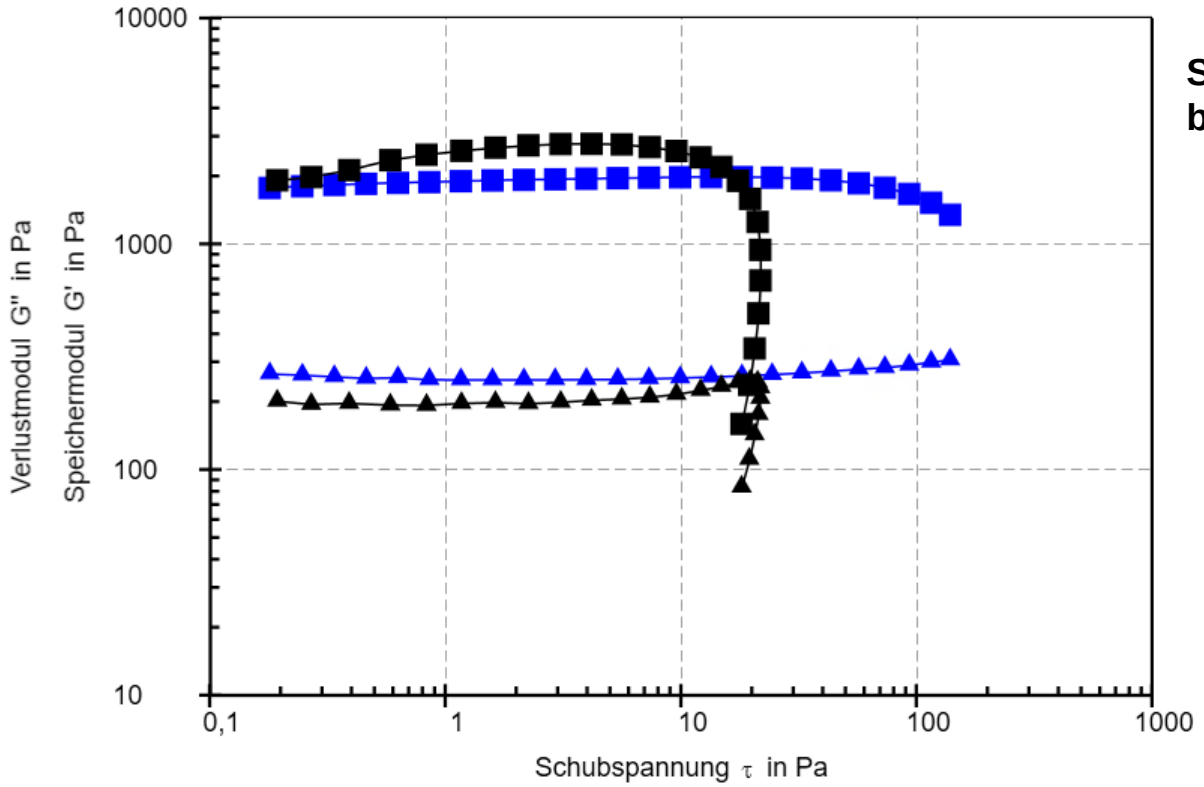
Inverted ribbon phyllosilicates – effect of shear



Stress sweep (5% in tap water): gel structure at rest is similar, but bentonite shows higher yield stress

Synthetic Hectorite 5 % in water
G"
G'

Type S IRP 5 % in water
G"
G'

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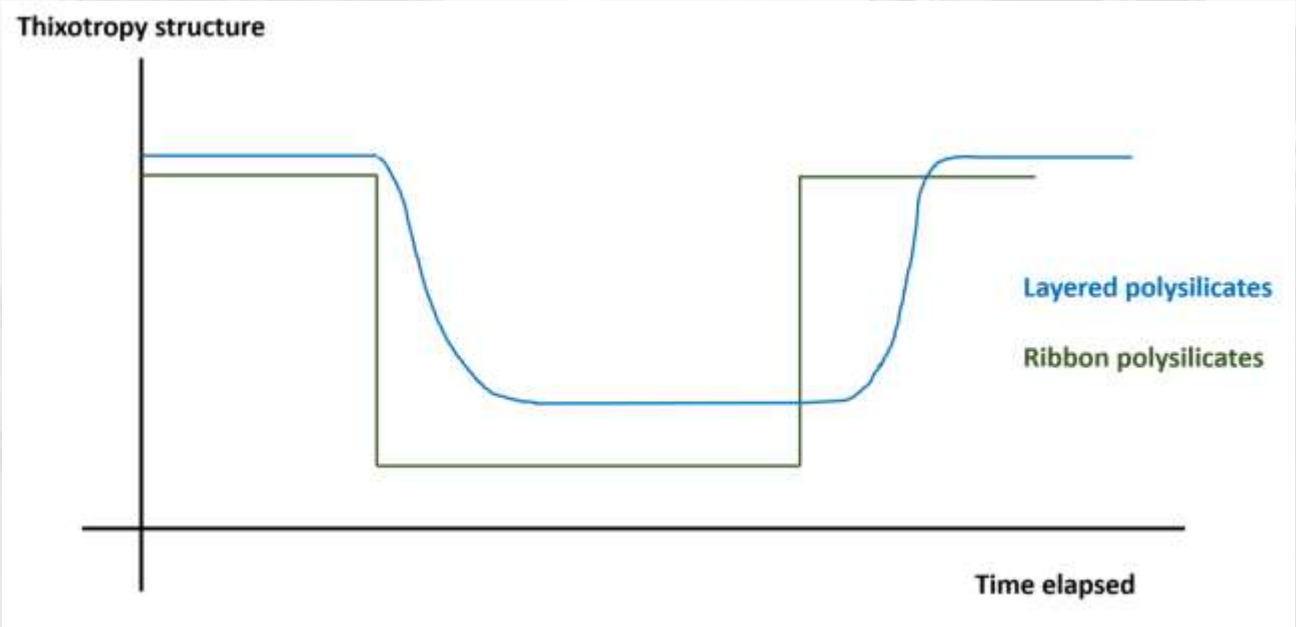
Inverted ribbon phyllosilicates – effect of shear

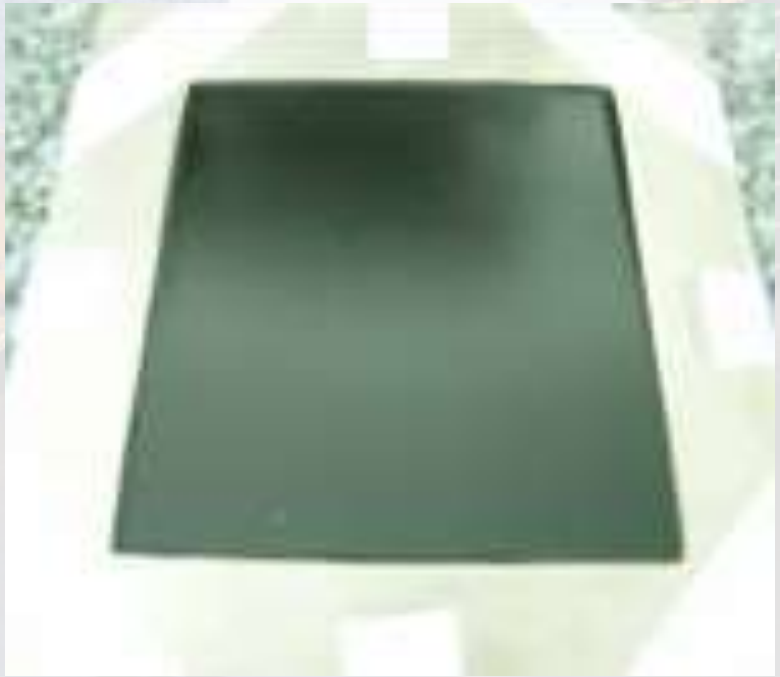
Very fast response to changes in shear

- Ideal additive for applications such as airless spraying, roller coating, troweling



Inverted ribbon phyllosilicates – appearance

Bentonite

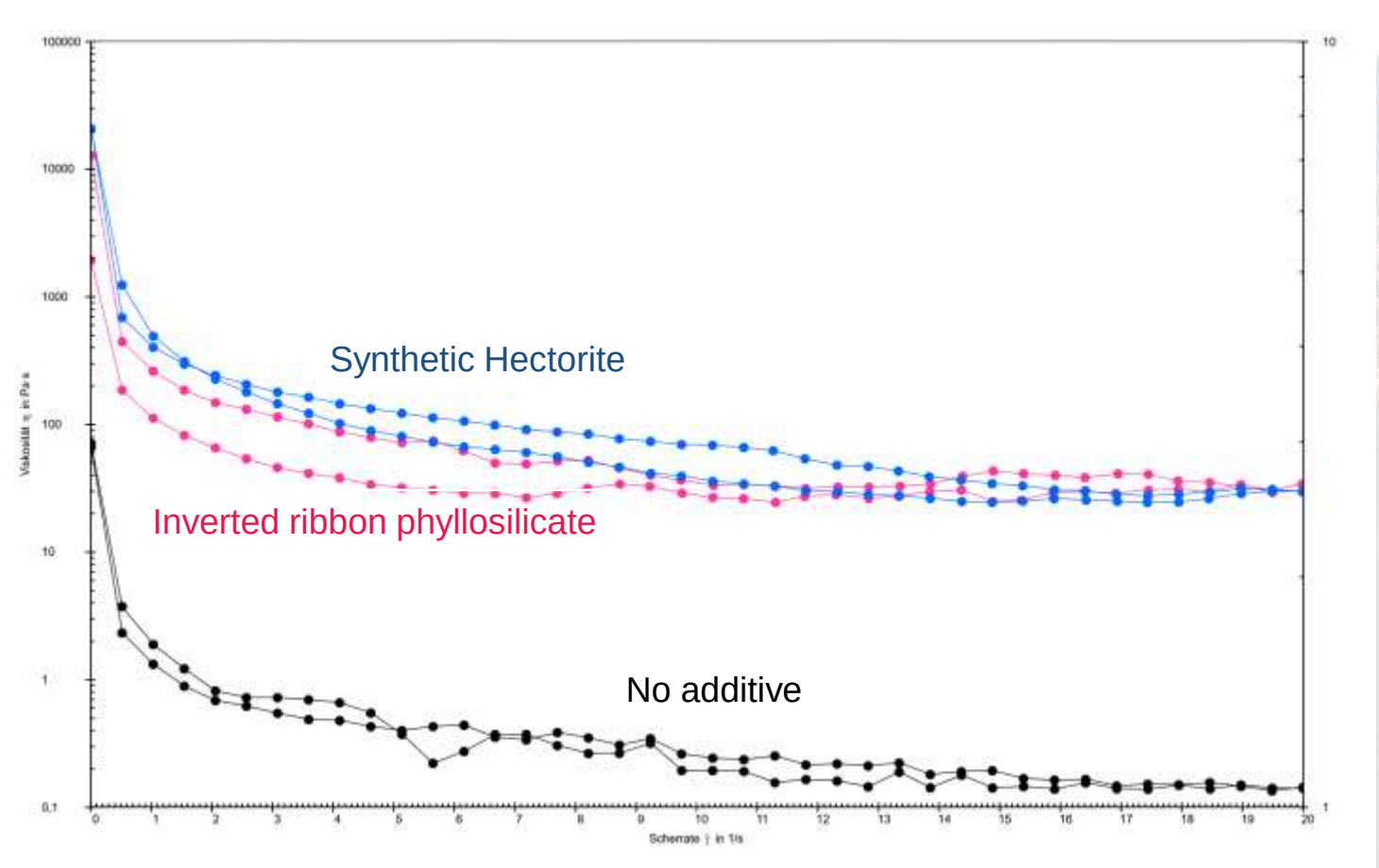


IRP

Inverted ribbon phyllosilicates – matte topcoat

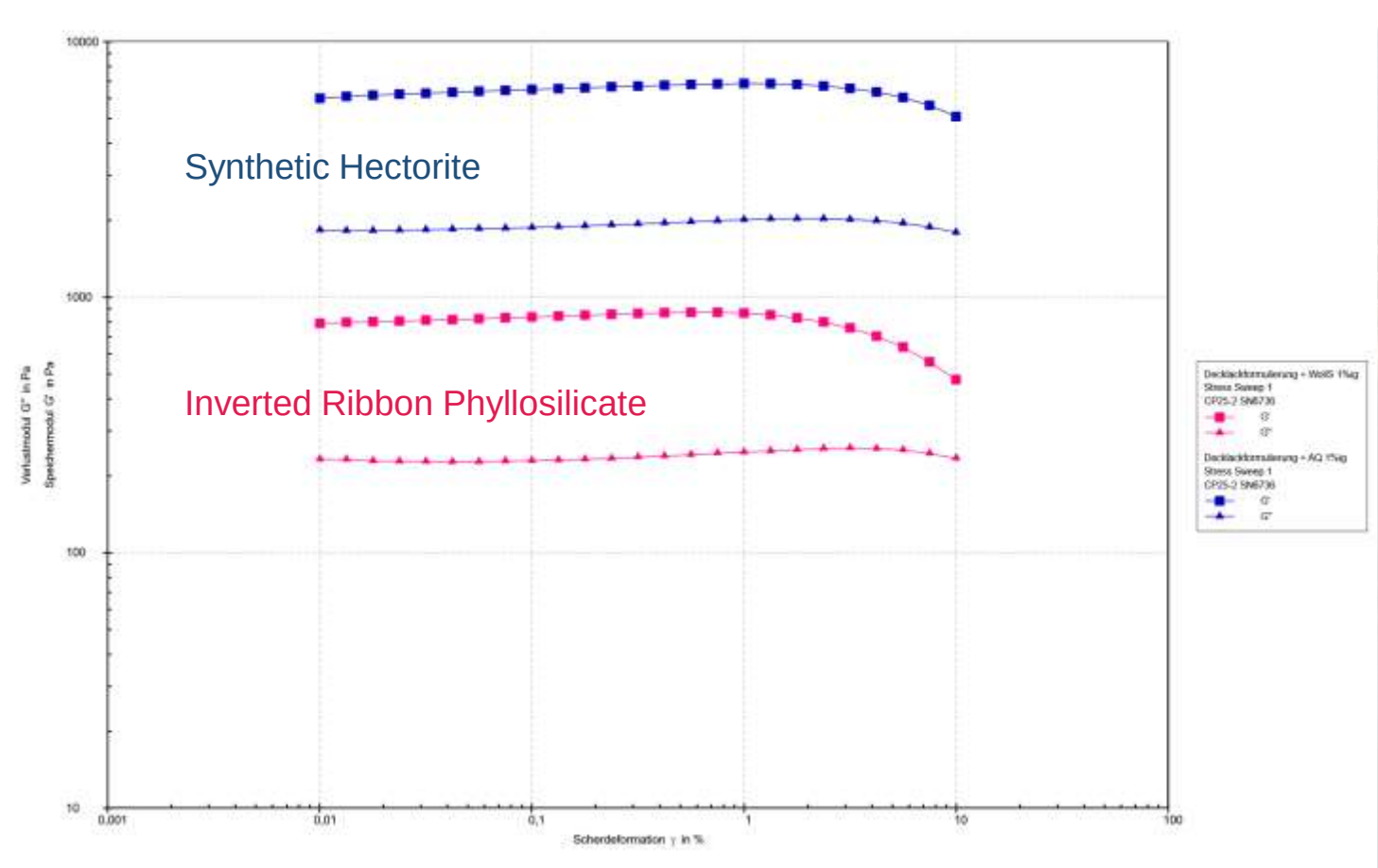
Matte topcoat	Mass (g)
DI water	20
Rheology modifier	1
Acrylic resin	25
Isobutanol	2
Dispersant	0,7
TiO_2 pigment	7,9
$BaSO_4$ filler	25
Resin	12,4
Butyl glycol	2
DI water	3,2
Defoamer	0,8

Inverted ribbon phyllosilicates – matte topcoat



Viscosity curves

Inverted ribbon phyllosilicates – matte topcoat



Amplitude sweep

Inverted ribbon phyllosilicates – matte topcoat

No additive
Whiteness: 86.8
Viscosity: 0.3 Pa·s

Synthetic Hectorite
Whiteness: 89.6
Viscosity: 2.0 Pa·s

Ribbon phyllosilicate
Whiteness: 87.1
Viscosity: 3.0 Pa·s

Inverted ribbon phyllosilicates vs. other additives

Characteristic	Bentonite	Cellulosics	Starch ethers	Ribbon
Water retention	High	Very high	Very high	**Very low**
Swelling	High	None	None	**None**
Shear thinning	High	Low	Low	**Very high**
Thickening	High	Very high	Very high	**High**
Anti-settling	High	Low	Medium	**Very high**
Anti-sagging	Very high	Medium	Very high	**Very high**
Heat resistance	High	Medium	Medium	**Very high**
Salt resistance	Low	High	High	**Very high**
pH working range	4-14	6-14	6-14	**2-14**

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Inverted ribbon phyllosilicates – types

- S
- SE (easier incorporation)
- LV (organically modified, higher viscosity build)
- S/240 (gap bridging)

Back to coatings…with IRP

- Inverted ribbon phyllosilicates are highly effective inorganic rheological additives
- IRP have a strong shear thinning flow profile and thixotropic properties
  - Easy incorporation
  - Easy application
  - Excellent appearance
  - Low sagging and dripping
- IRP form soft stable viscoelastic gels in a wide range of waterborne formulations
- Stable over a wide pH range (2-14) stable and even in presence of high electrolyte concentrations

Thank you!

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