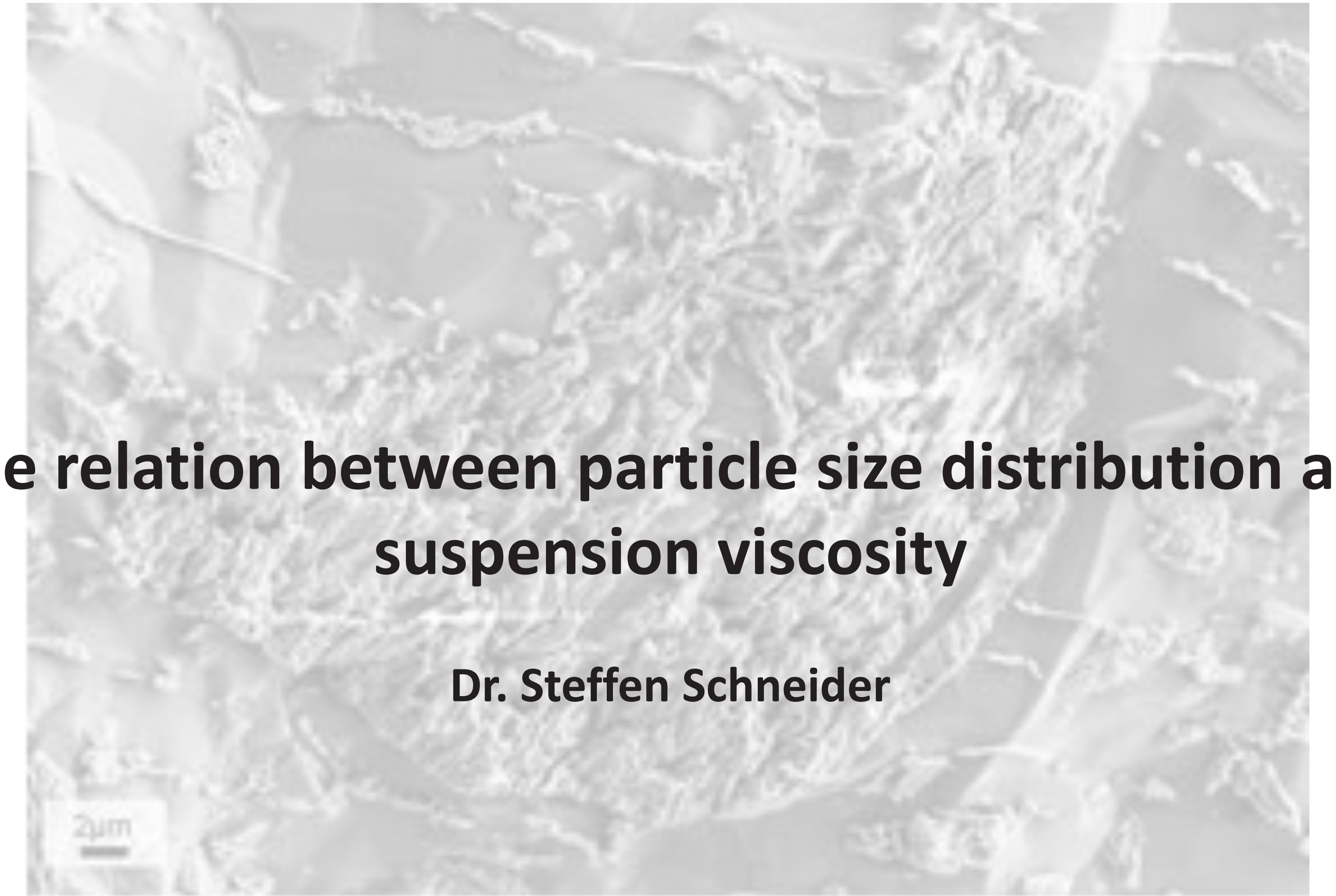

The relation between particle size distribution and suspension viscosity

Dr. Steffen Schneider

Pointner & Rothschädl Ges.m.b.H.
Urstein Süd 17
5412 Puch/Salzburg – Österreich

T +43 662 43 15 41-126
F +43 662 43 15 41-20
E salzburg@poro.eu

agenda

I) intention of project

II) presentation of investigations

III) discussion of results

Pointner & Rothschädl Ges.m.b.H.
Urstein Süd 17
5412 Puch/Salzburg – Österreich

T +43 662 43 15 41-126
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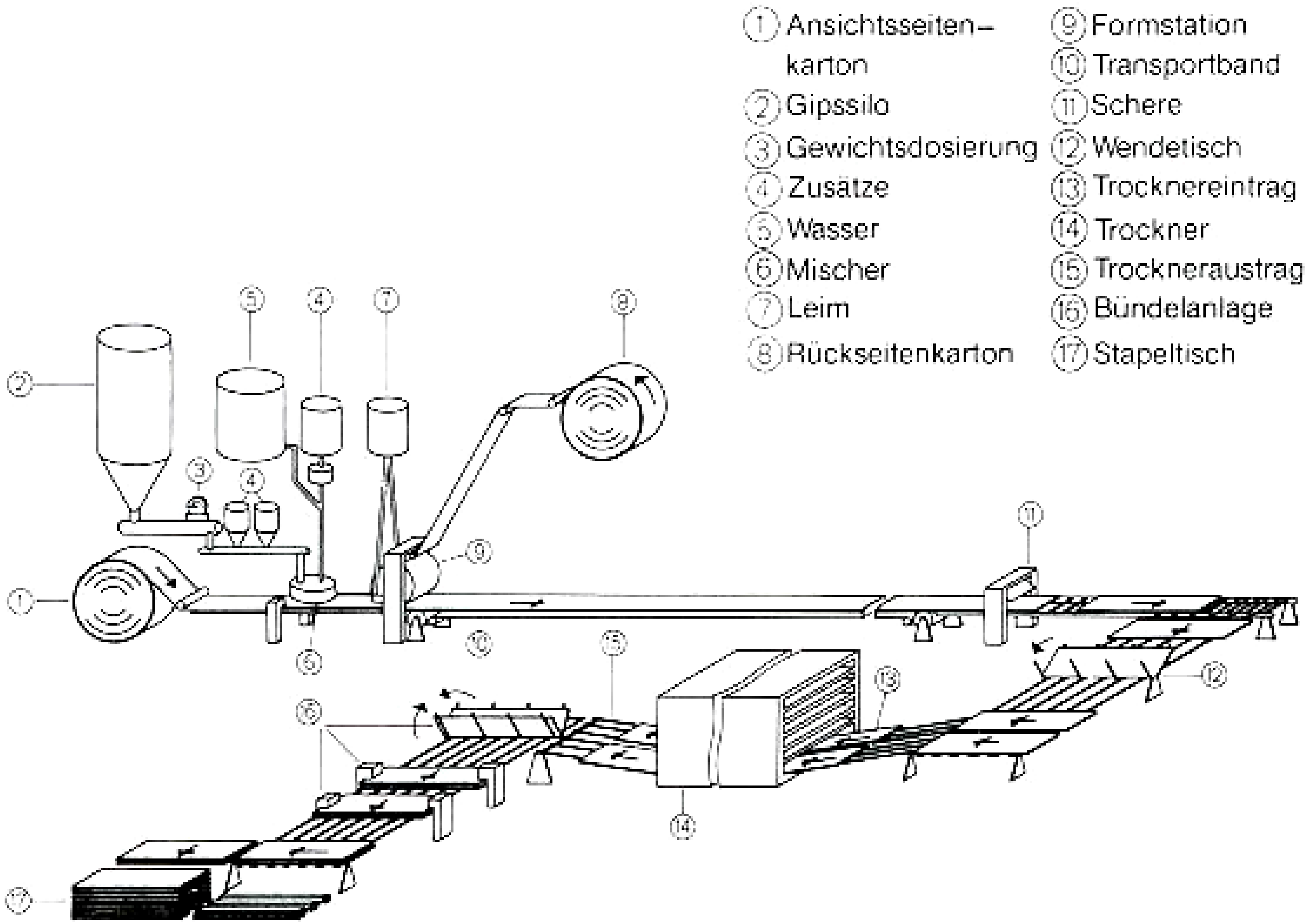
intension of project

<u>Target</u>

optimization of flow and levelling behavior of a gypsum slurry while plasterboard-production



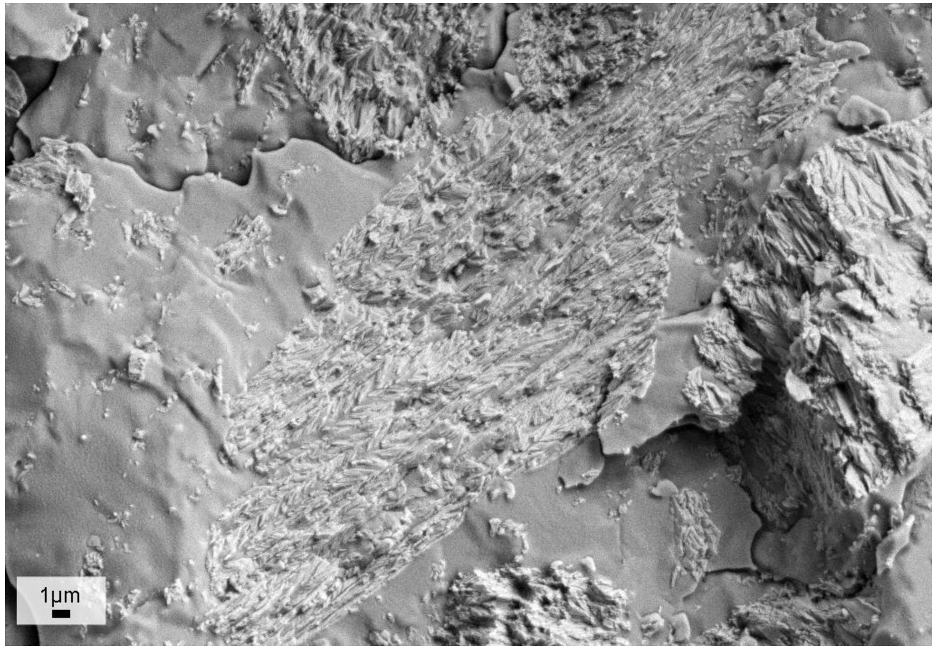
1 Ansichtsseiten-karton
2 Gipssilo
3 Gewichtsdosierung
4 Zusätze
5 Wasser
6 Mischer
7 Leim
8 Rückseitenkarton
9 Formstation
10 Transportband
11 Schere
12 Wendetisch
13 Trocknereintrag
14 Trockner
15 Trockneraustrag
16 Bündelanlage
17 Stapeltisch

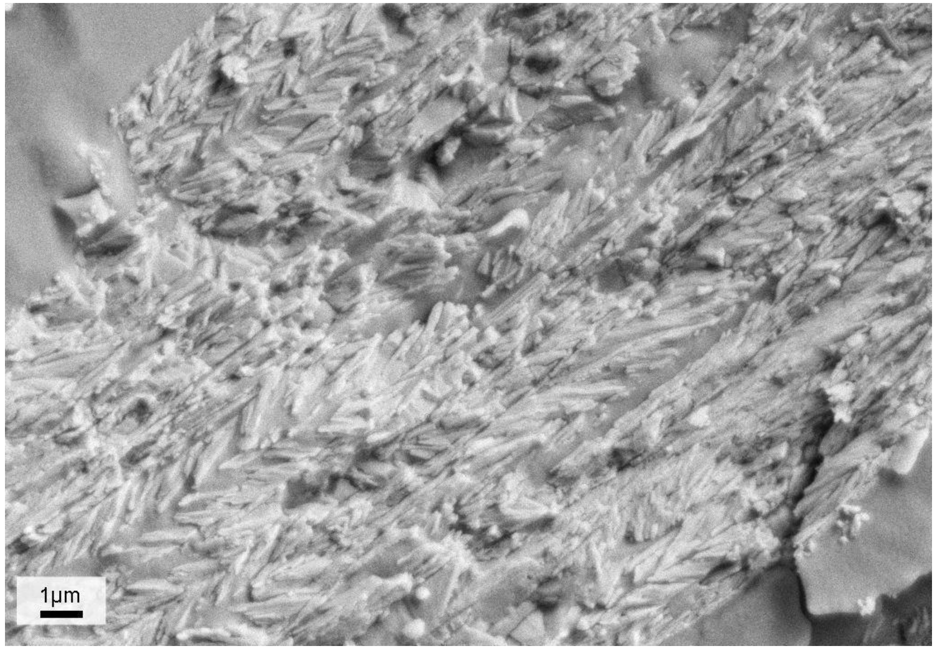
32. Conference – Rheology of Building Materials

setting mechanism of β – semihydrat

$$CaSO_4 \cdot 0{,}5\ H_2O + 1{,}5\ H_2O \leftrightarrow CaSO_4 \cdot 2\ H_2O$$

dispersing in water!





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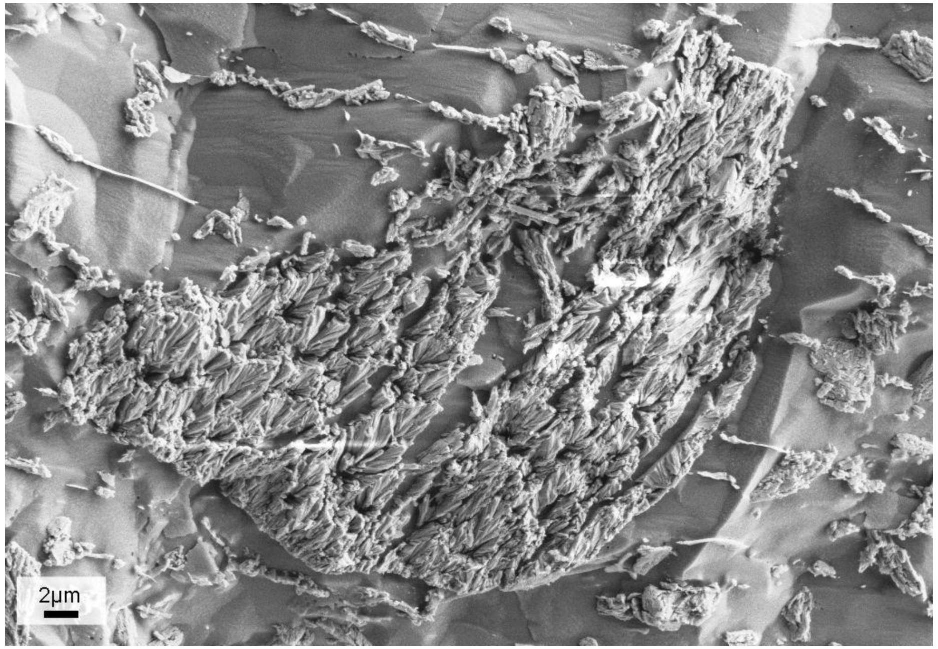

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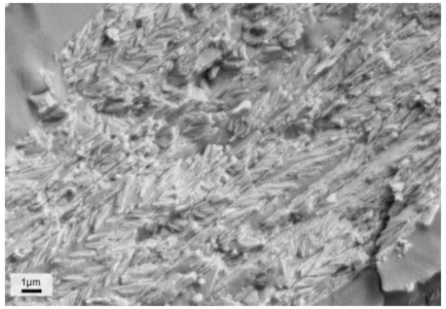
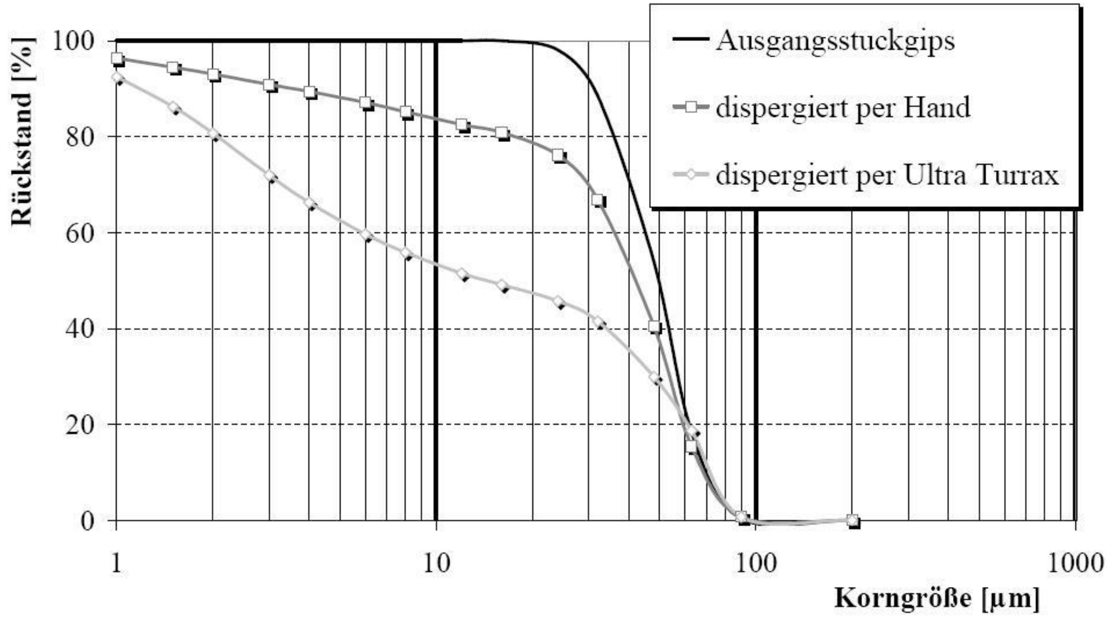


high water demand because of „inner surface“



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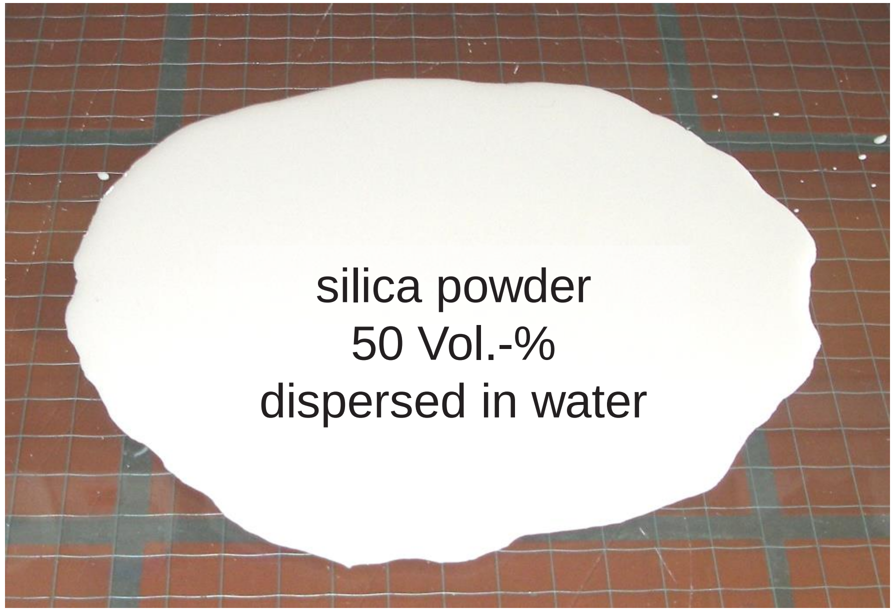

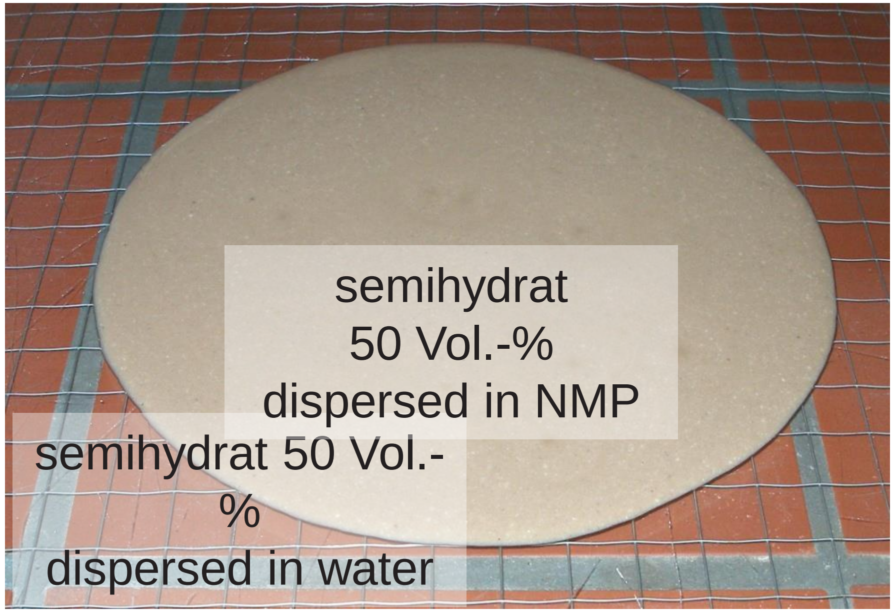

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Urstein Süd 17
5412 Puch/Salzburg – Österreich
62 43 15 41-126
F +43 662 43 15 41-20
E salzburg@poro.eu

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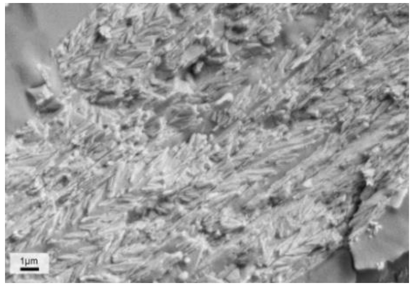

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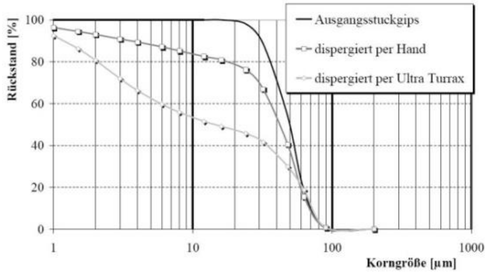

Hygro-mechanical instabilities

interparticle forces

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Urstein Süd 17
5412 Puch/Salzburg – Österreich

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E salzburg@poro.eu

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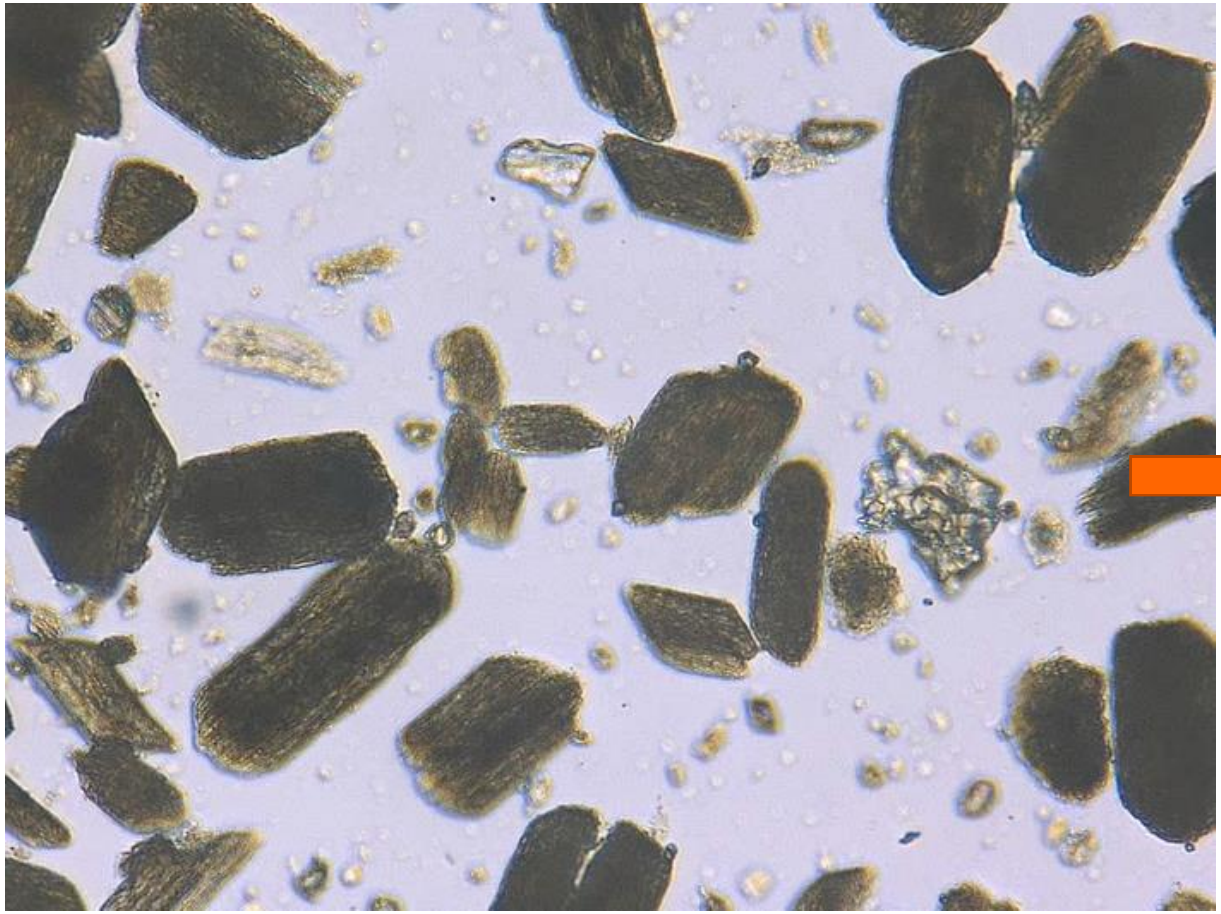

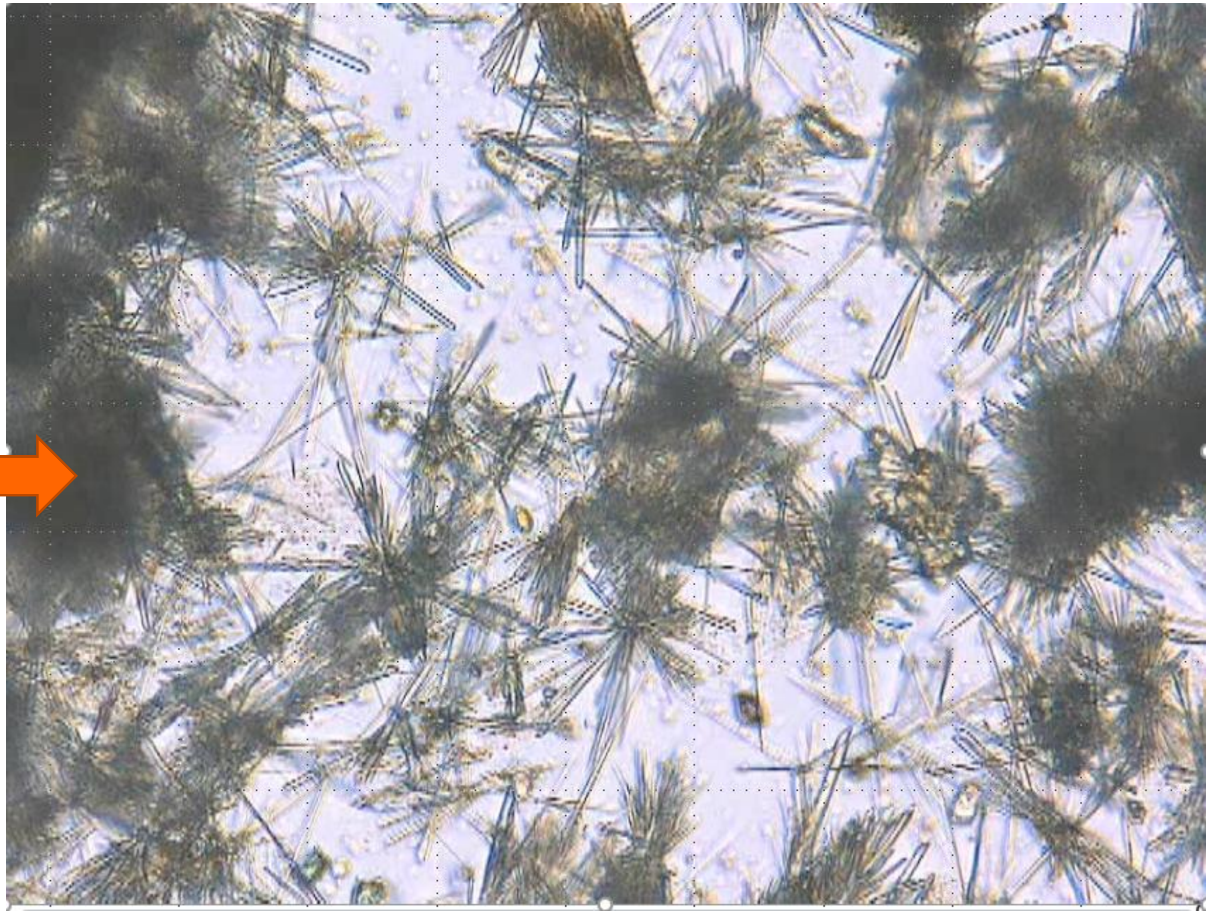

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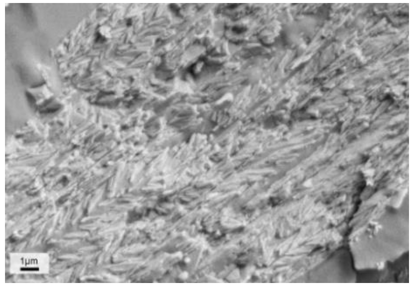
Determination the flow and yielding properties of gypsum slurry = rheology!



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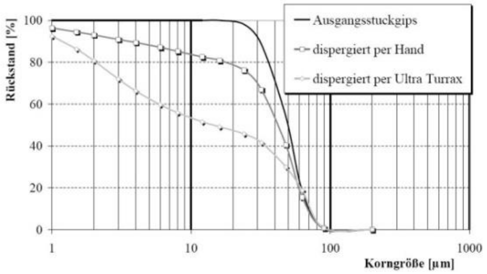
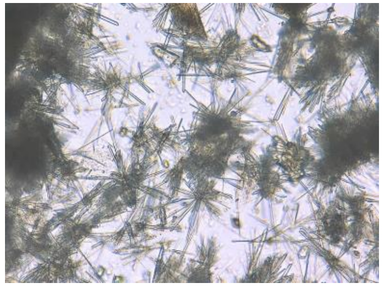


Hygro-mechanical instabilities

interparticle forces



formation of hydrates

Pointner & Rot
Urstein Süd 17
5412 Puch/Salzburg – Österreich
62 43 15 41-126
F +43 662 43 15 41-20
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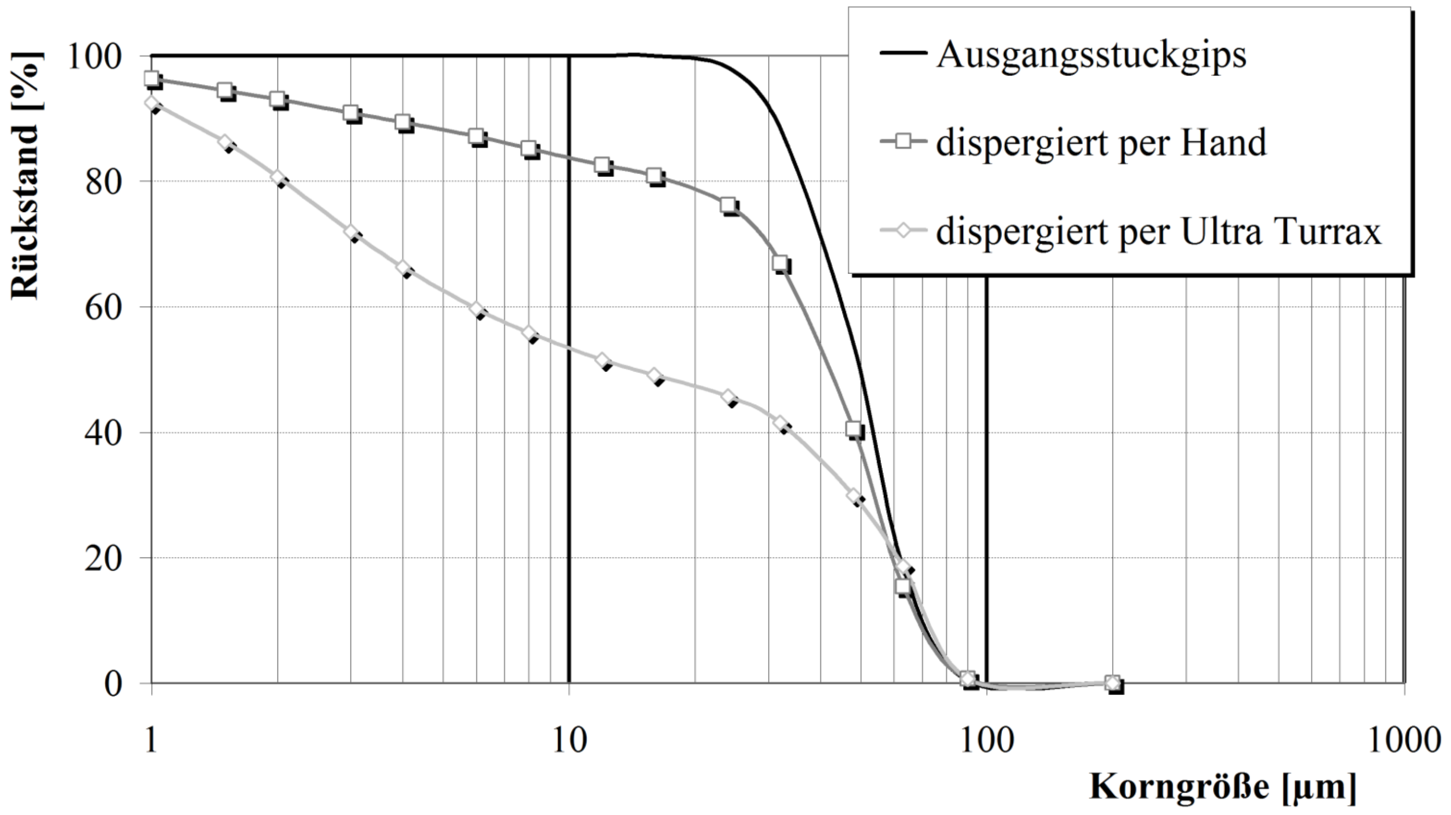
setting mechanism of β – semihydrat



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Urstein Süd 17
5412 Puch/Salzburg – Österreich

T +43 662 43 15 41-126
F +43 662 43 15 41-20
E salzburg@poro.eu

presentation of investigations

elimination of side effects while gypsum setting in respect of suspension viscosity

- non reactive system
  → using silica powder
- formation of interparticle forces
  → using a certain amount of $AlCl_3$
- creating of defined particle size curves
  → using the RRSB particle size distribution theory

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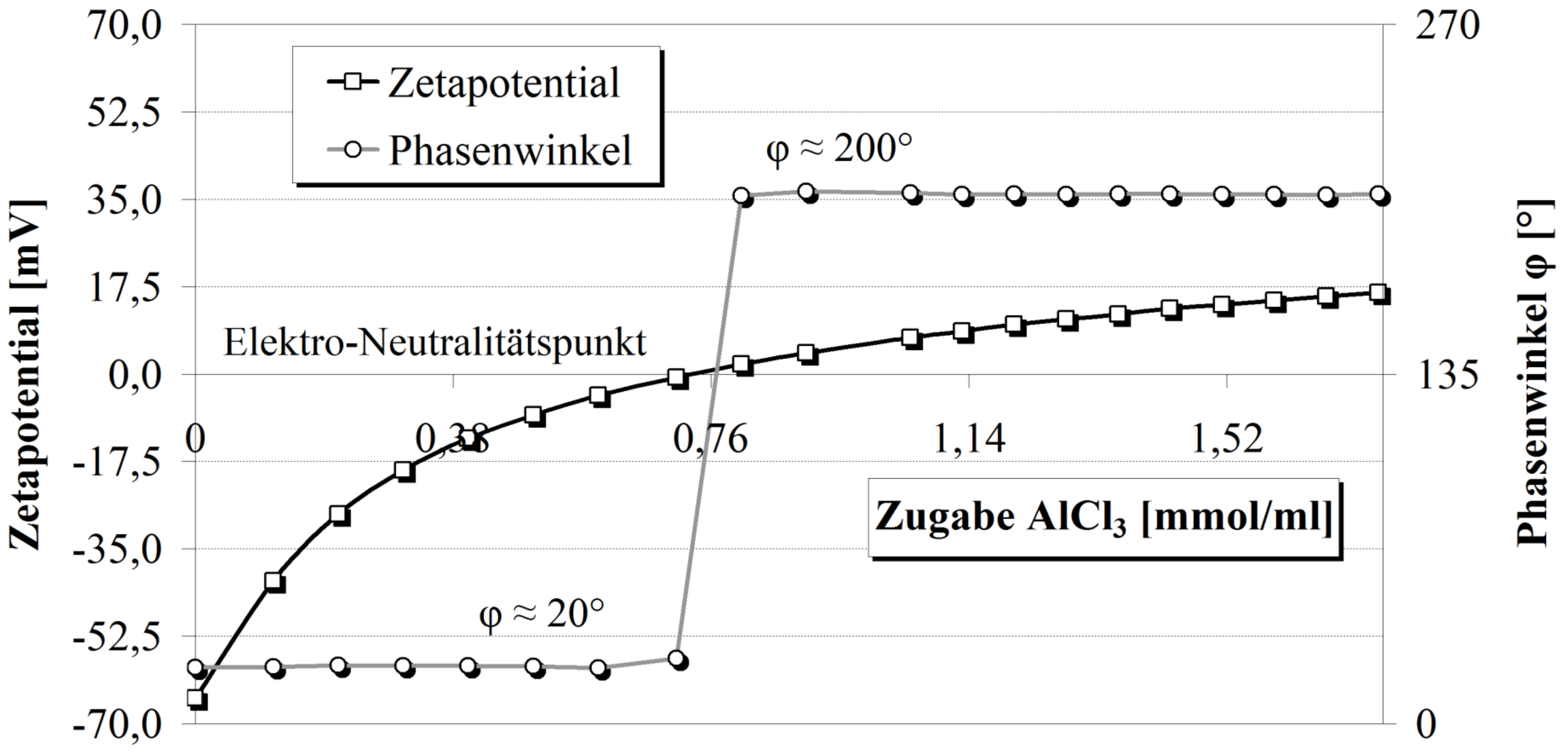

zeta-potential of silica powder depending on concentration of Al^{3+} (ϕ_{FS} = 0.335)

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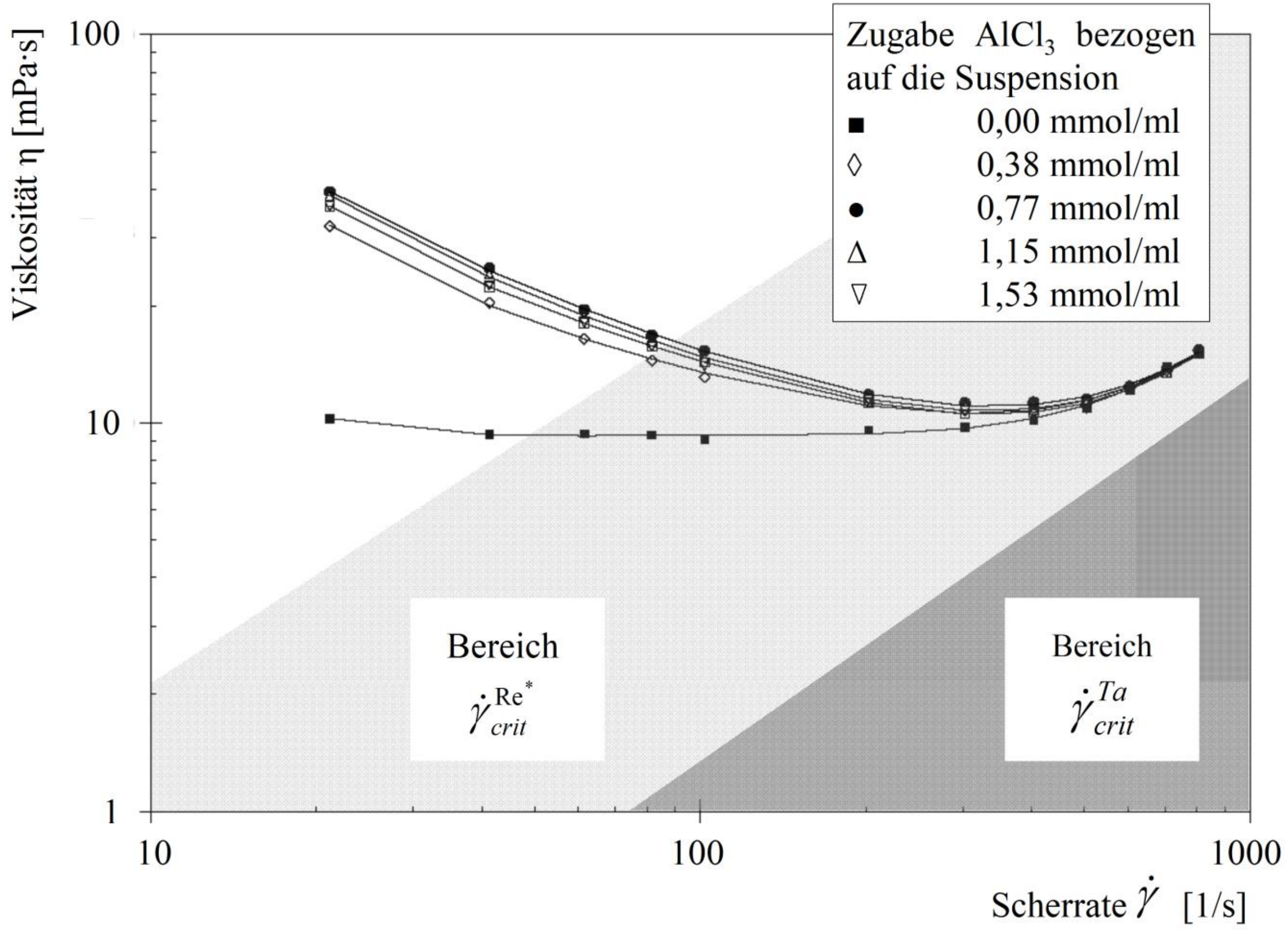

suspension viscosity of silica powder depending on concentration of Al^{3+} (ϕ_{FS} = 0.335)

$$D(x) = 1 - \exp\left[-\left(\frac{x}{x'}\right)^n\right]$$

RRSB	(**R**osin, **R**ammler, **S**perling, **B**ennet)
x‘	location parameter (grain size)
n	slope (amount of different particles sizes per distribution)

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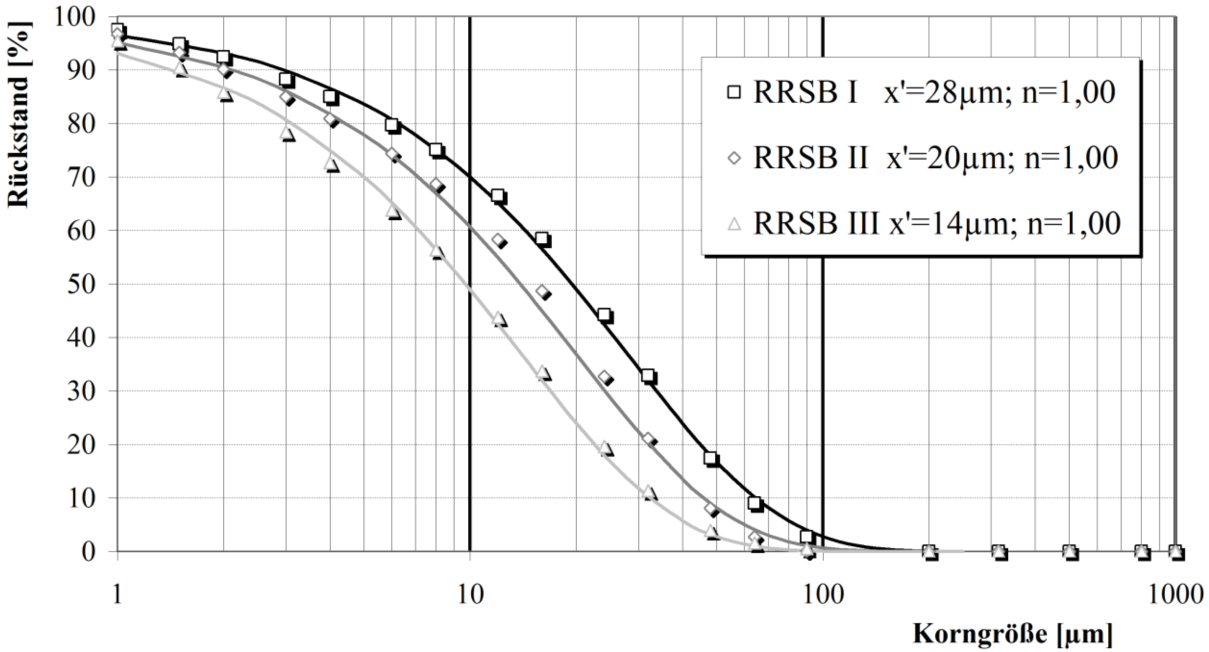
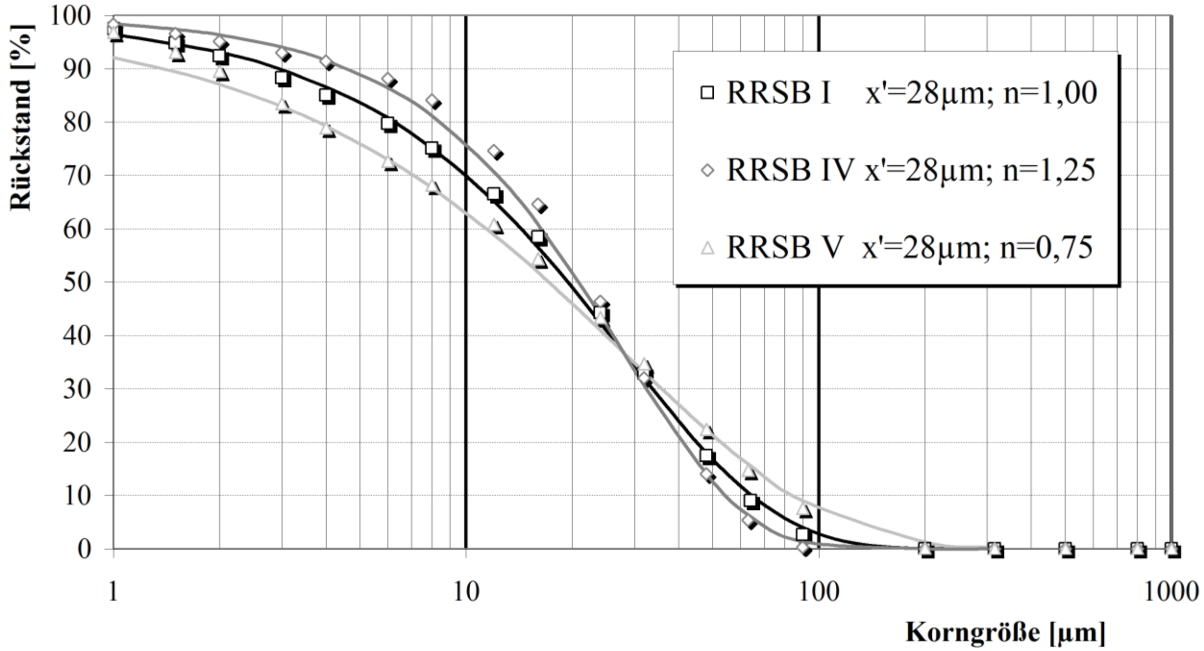
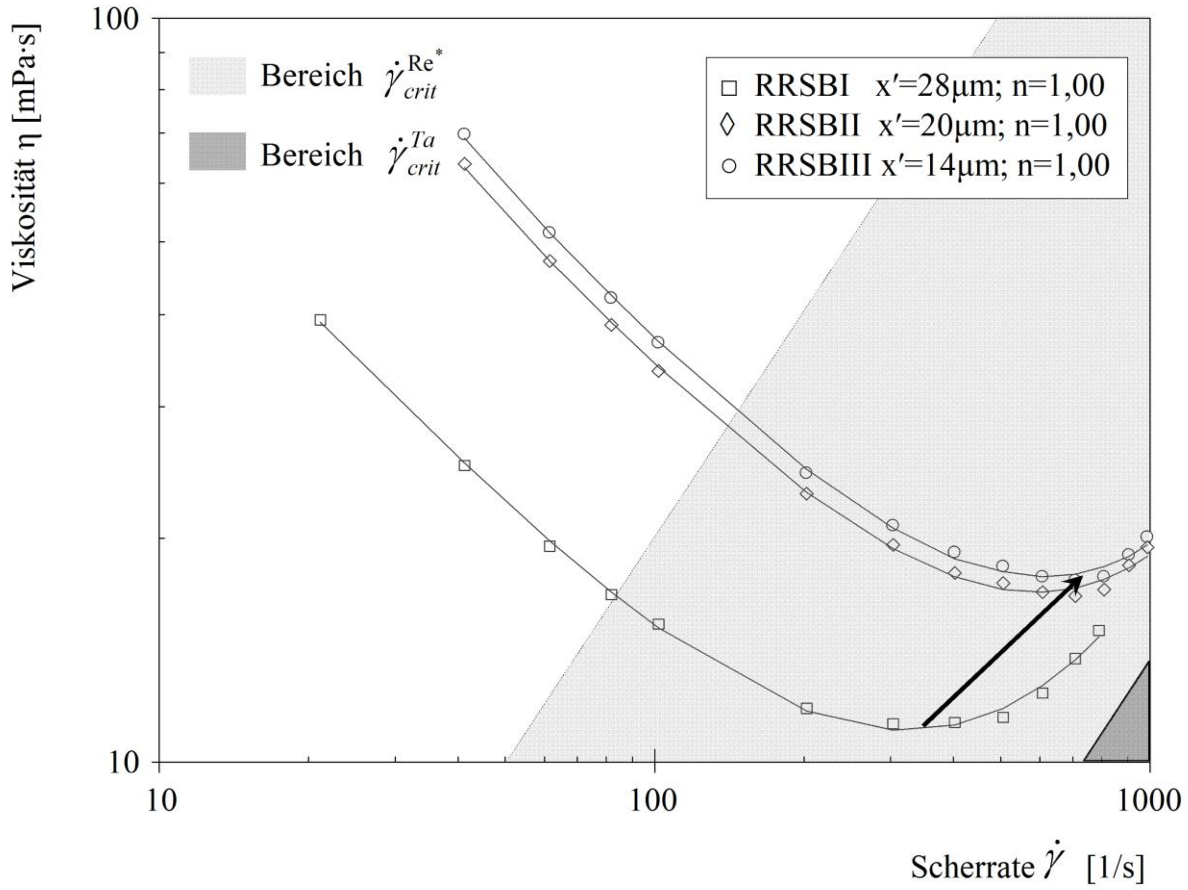




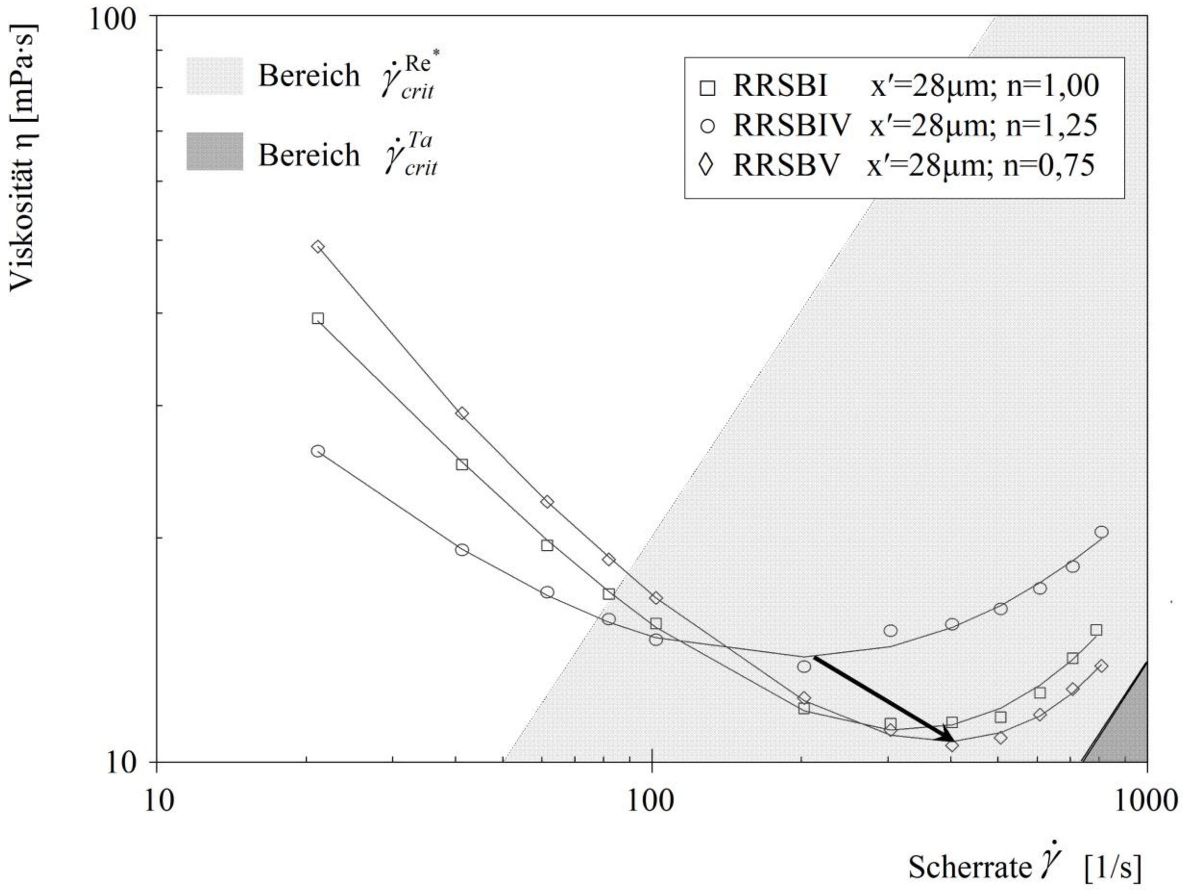
created particle size curves accordingly the RRSB theory
(left: variation of particle size, right: variation of distribution slope)

		RRSB I	RRSB II	RRSB III	RRSB IV	RRSB V
Streuungsparameter		1,00	1,00	1,00	1,25	0,75
Lageparameter		28	20	14	28	28
S_V^{RRSB}	[m^2/g]	0,623	0,872	1,245	0,323	2,558
Blaine	[cm^2/g]	3.470	5.920	6.270	2.120	4.720
d_{10}	[µm]	2,6	2,0	1,5	4,9	1,9
d_{50}	[µm]	20,6	15,4	9,9	22,3	19,0
d_{90}	[µm]	61,4	44,6	33,8	53,9	78,7

created particle size curves accordingly the RRSB theory
parameter overview



intrinsic suspension viscosity in respect to particle size



intrinsic suspension viscosity in respect to slope of psd

Pointner & Rothschädl Ges.m.b.H.
Urstein Süd 17
5412 Puch/Salzburg – Österreich
T +43 662 43 15 41-126
F +43 662 43 15 41-20
E salzburg@poro.eu
www.poro.eu

discussion of results

there is one additional effect, which is dependend by the different waterdemand of psd themselves – the rheological active water content

		RRSB I	RRSB II	RRSB III	RRSB IV	RRSB V
Streuungsparameter		1,00	1,00	1,00	1,25	0,75
Lageparameter		28	20	14	28	28
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5412 Puch/Salzburg – Österreich

T +43 662 43 15 41-126
F +43 662 43 15 41-20
E salzburg@poro.eu

discussion of results

adjustment of intrinsic suspension viscosity by using QUEMADA equation

$$\eta\left(\tilde{\Phi}\right) = \eta\left(\dot{\gamma}\right)\left(1 - \frac{\tilde{\Phi}}{\Phi_{max}}\right)^{-\varepsilon}$$

$\eta\left(\tilde{\Phi}\right)$	determined intrinsic viscosity
$\eta\left(\dot{\gamma}\right)$	shear dependent base viscosity
$\left(1 - \frac{\tilde{\Phi}}{\Phi_{max}}\right)$	solid wetted area
ε	colloidal parameter → for coarse particles tends to 2

discussion of results

adjustment of intrinsic suspension viscosity by using QUEMADA equation

$$\left(1-\frac{\tilde{\Phi}}{\Phi_{\max}}\right)$$

$\Phi_{\max}^{Puntke}$ compactness of material, used PUNTKE theory

$\Theta_{FL}^{rheol.}$ compactness of material, determined by evaporation

discussion of results

adjustment of intrinsic suspension viscosity by using QUEMADA equation

		RRSB I	RRSB II	RRSB III	RRSB IV	RRSB V
Streuungsparameter n		1,00	1,00	1,00	1,25	0,75
Lageparameter x′		28	20	14	28	28
$\tilde{\Phi}_{FS}$	[-]	0,335	0,335	0,335	0,335	0,335
Φ_{max}^{Puntke}	[-]	0,61	0,58	0,58	0,56	0,66
$\Theta_{FL}^{rheol.}$	[-]	0,75	0,62	0,60	0,78	0,72

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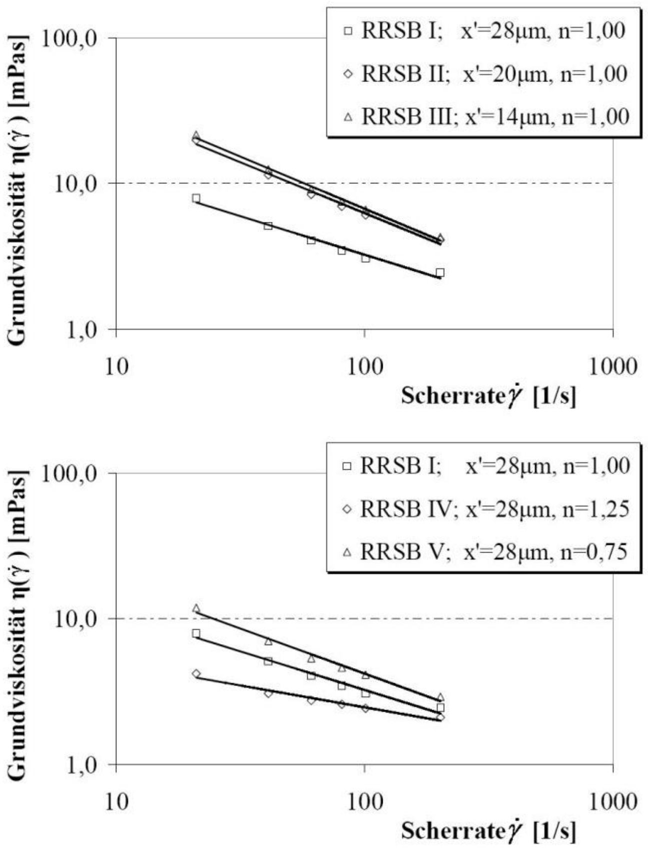
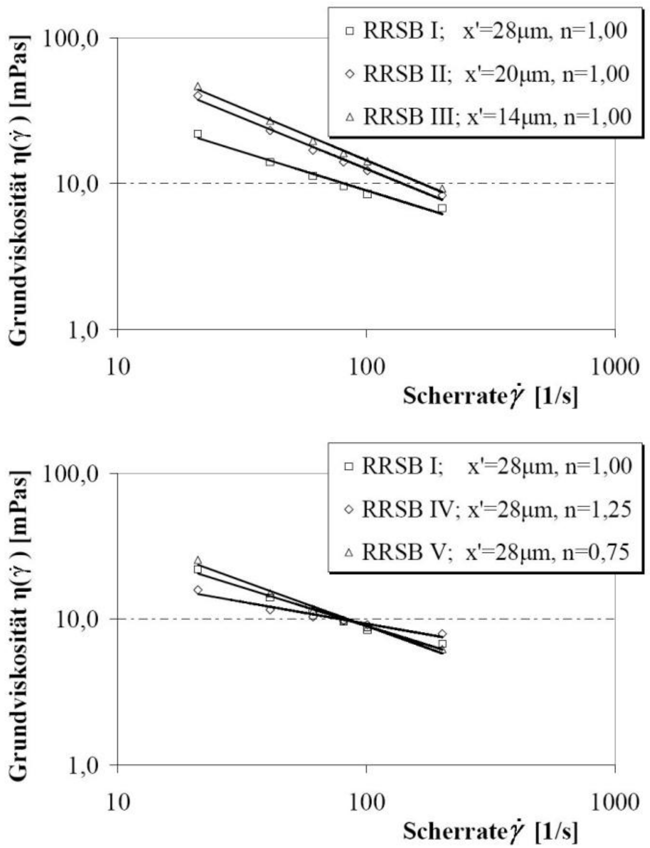
calculated base viscosity by using PUNTKE



calculated base viscosity, determined by evaporation



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T +43 662 43 15 41-126
F +43 662 43 15 41-20
E salzburg@poro.eu

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Conclusion

Low shear area of suspension viscosity is dominated by interparticle forces. Increasing the shear force will decreasing this effect.

With lowering the particle size of a distribution with constant slope, suspension viscosity is shifted nearly parallel about the whole shear range. This effect is not dominated by increased particle surface.

Changing the slope of a particle size distribution from narrow to a wide one, the basic flow behaviour of suspension change in more shear thinning. Also, a suspension with a narrow particle size distribution tends more to dilatancy flow at higher shear rates.

Thanks for your attention!

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Urstein Süd 17
5412 Puch/Salzburg – Österreich

T +43 662 43 15 41-126
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