EFFECT OF IONIC LIQUIDS ON AGGREGATION OF LATEX COLLOIDS

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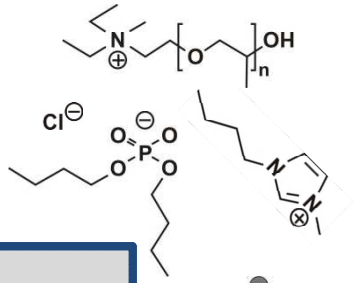
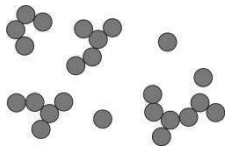
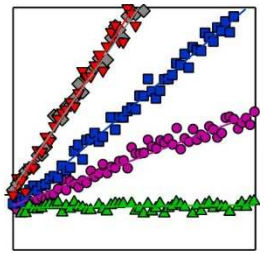
MOTIVATION

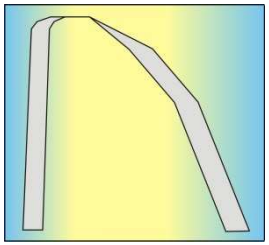


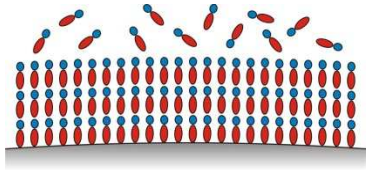
SYSTEMS

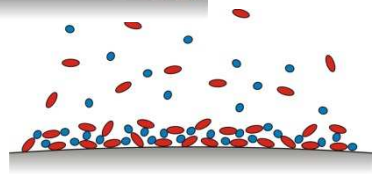




AGGREGATION

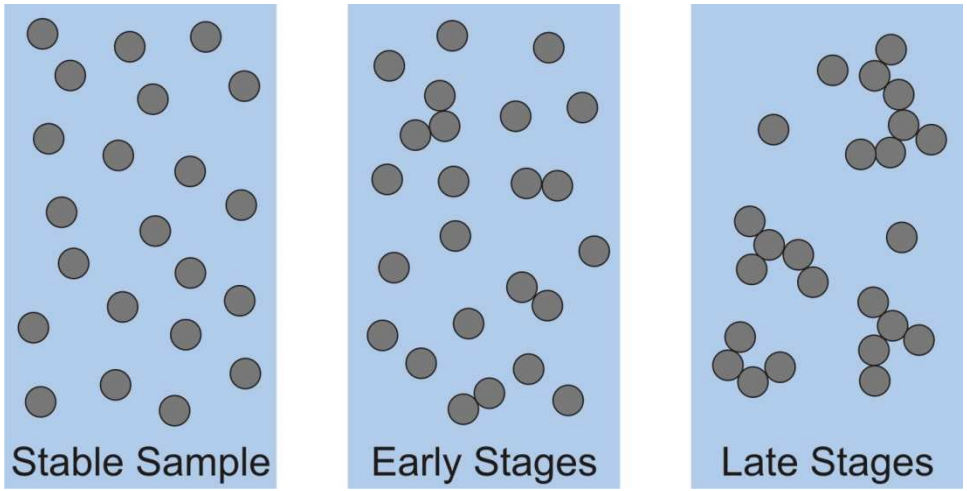






CONCLUSIONS

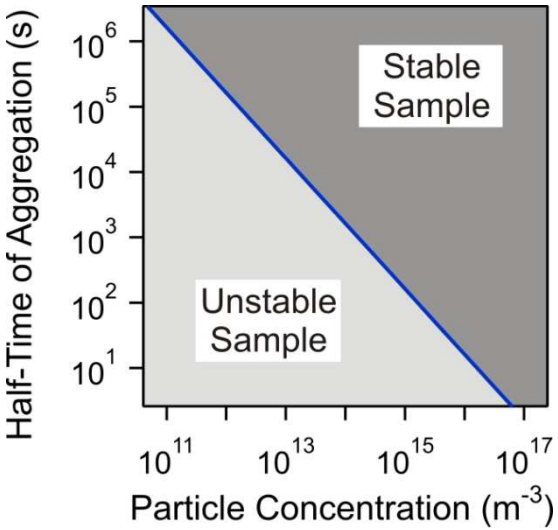
PARTICLE AGGREGATION IN WATER



stabilization of colloids
foods, cosmetics, paints…

destabilization of colloids
wastewater treatment, papermaking…

particles as catalysts
stability during the run & removal by aggregation



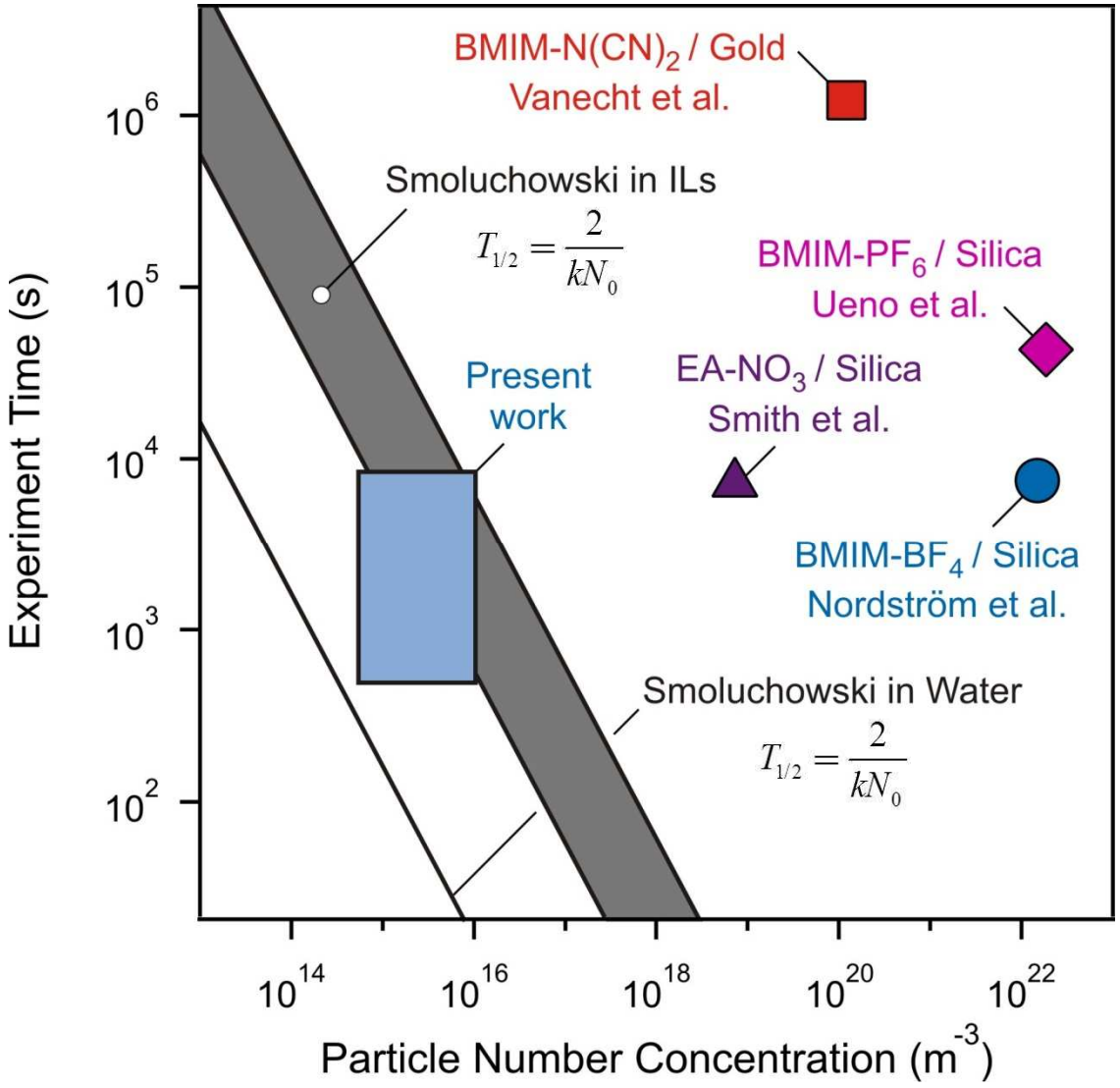
von Smoluchowski

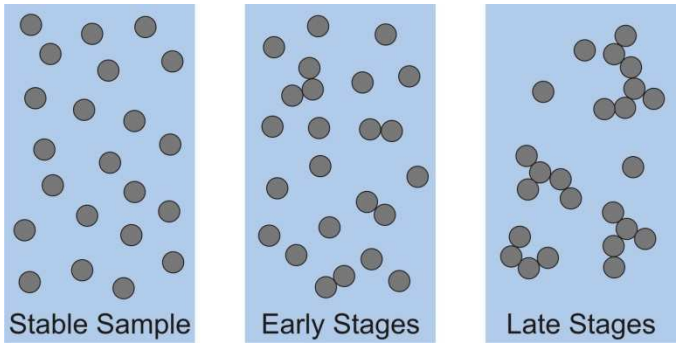
$$T_{1/2} = \frac{2}{kN_0} \qquad k = \frac{8k_B T}{3\eta} \approx 1.23 \times 10^{-17}\ \mathrm{m^3/s}$$

Derjaguin, Landau, Verwey and Overbeek (DLVO)

$$F = F_{vdW} + F_{dl} \qquad F_{vdW} \sim H \quad F_{dl} \sim \Psi^2$$

PARTICLE AGGREGATION IN ILS





$$N = \frac{N_0}{1 + t / T_{1/2}}$$

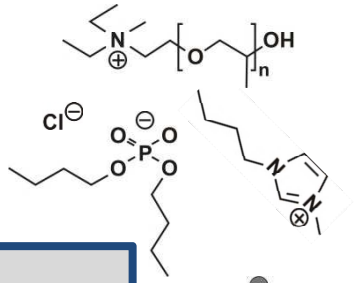
$$N = N_1 + N_2 + N_3 + \ldots \quad N_0 = N_1 + 2N_2 + 3N_3 + \ldots$$

$$T_{1/2} = \frac{2}{kN_0}$$

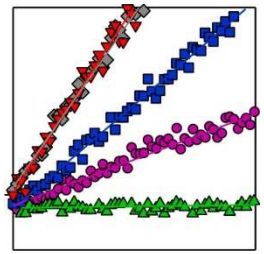
$$k = \frac{8k_B T}{3\eta} \approx 1.23 \times 10^{-17}\ \mathrm{m^3/s}$$

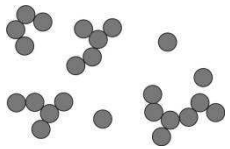
in aqueous electrolyte

MOTIVATION

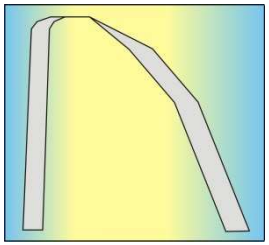


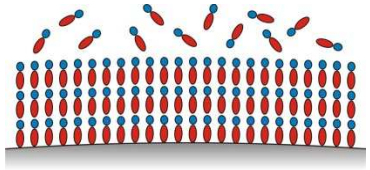
SYSTEMS

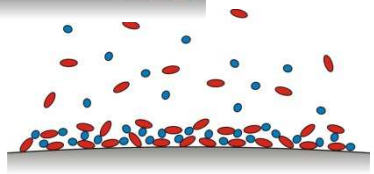




AGGREGATION



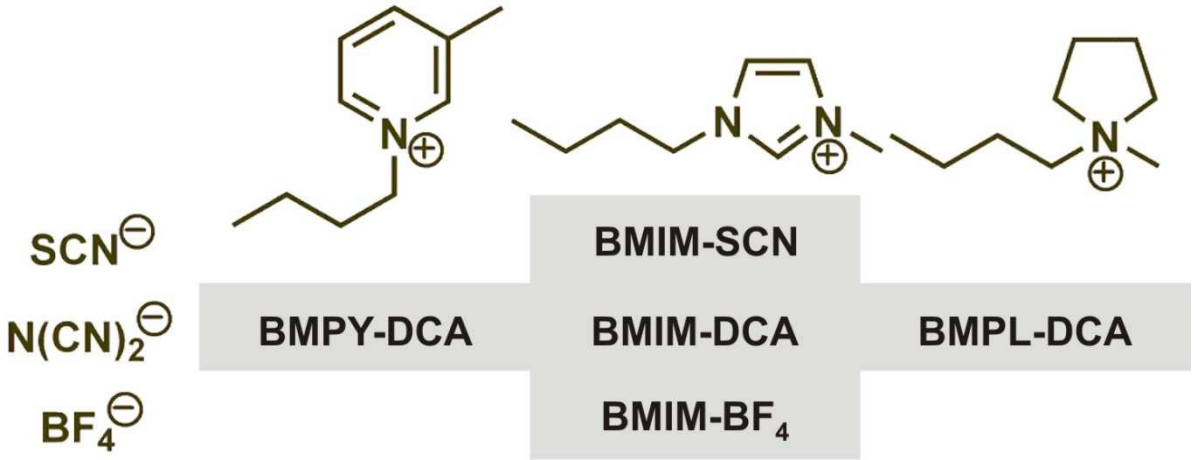




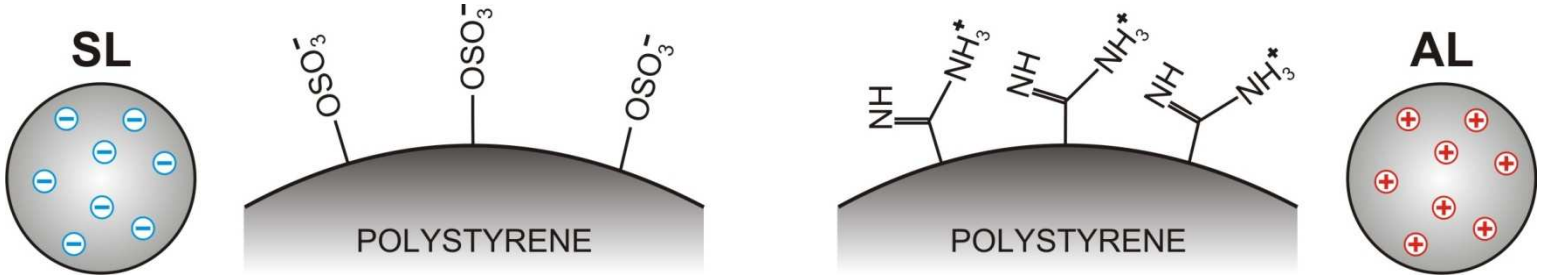
CONCLUSIONS

PARTICLES SUSPENDED IN ILS

ILs – room-temperature, water miscible ILs & their aqueous solutions

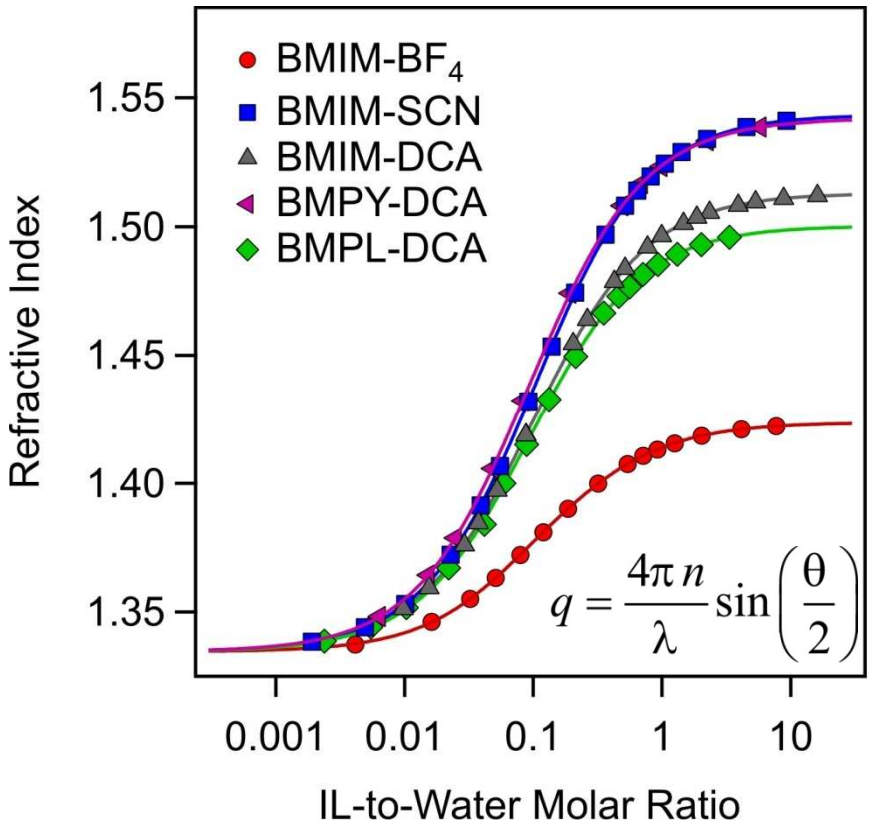


Particles – polystyrene latexes of 265 (SL) & 110 nm (AL) in radius

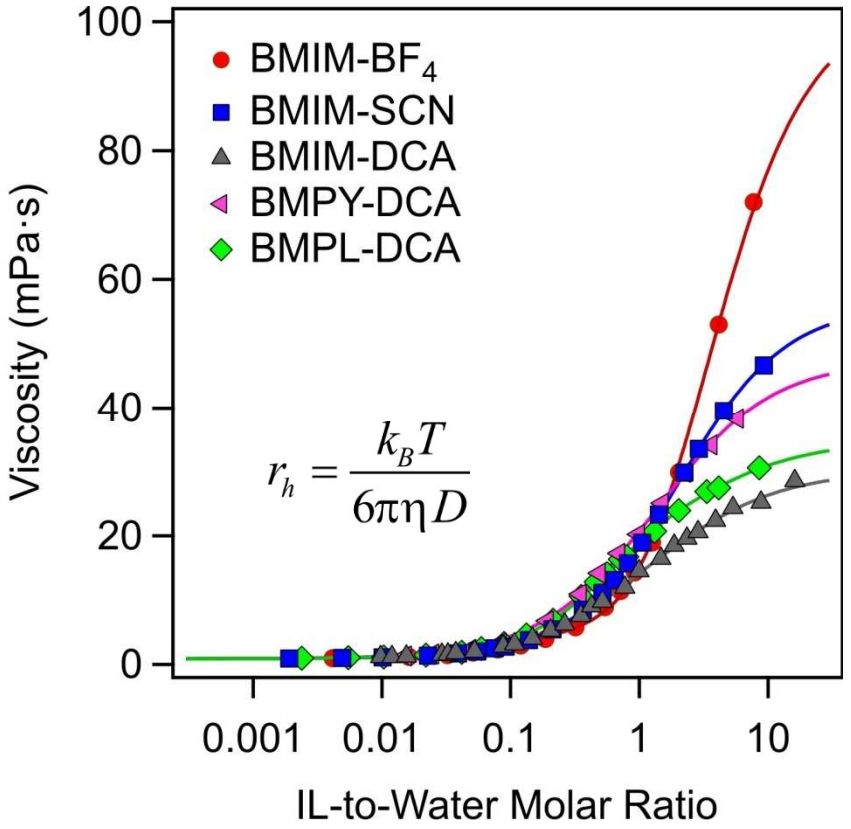


PHYSICO-CHEMICAL DATA

REFRACTIVE INDEX



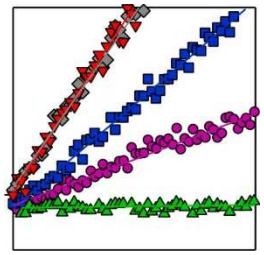
DYNAMIC VISCOSITY

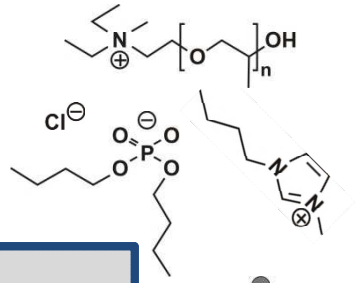


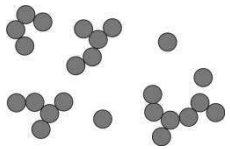
refractive index & viscosity – scattering vector & hydrodynamic radius in LS

MOTIVATION

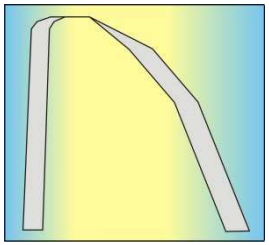
SYSTEMS

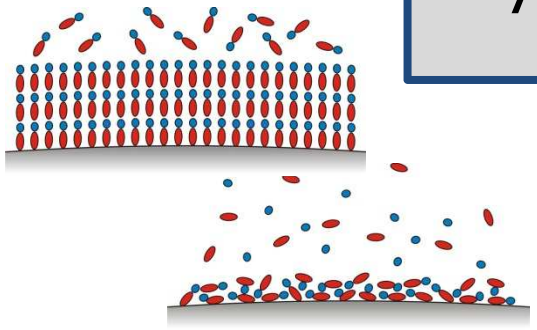






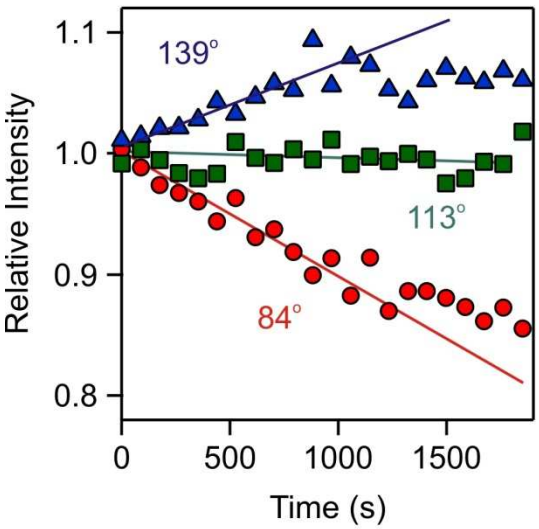
AGGREGATION

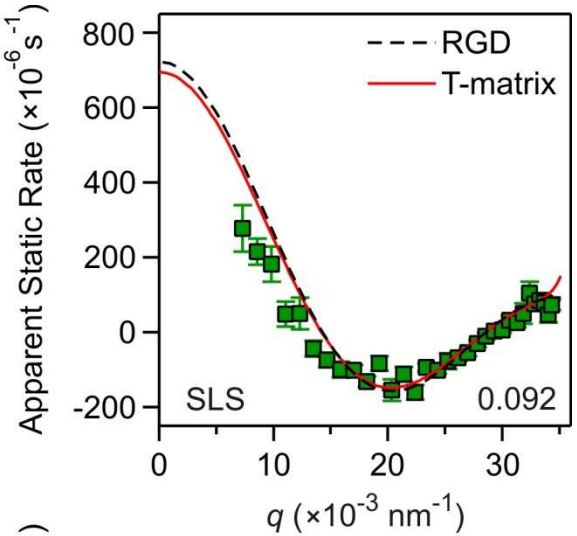


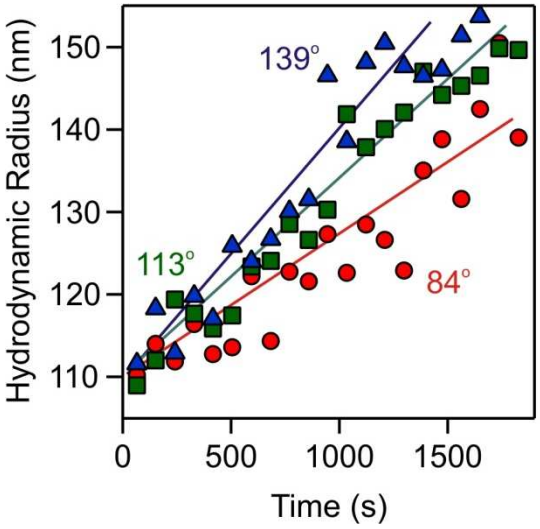


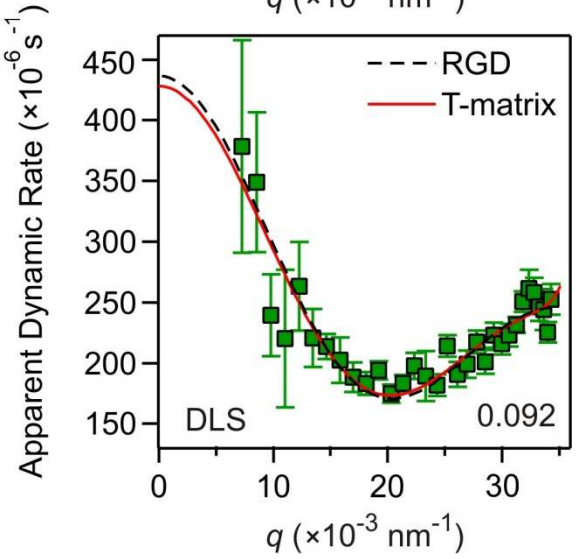
CONCLUSIONS

PARTICLE AGGREGATION RATES BY LS





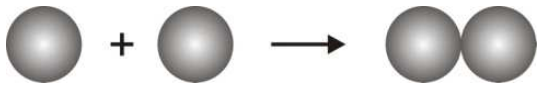




STATIC LIGHT SCATTERING

$$\frac{1}{I(q,0)} \cdot \left.\frac{dI(q,t)}{dt}\right|_{t\to 0} = kN_0\left(\frac{I_2(q)}{2I_1(q)} - 1\right)$$

optical factor: RGD or T-matrix
aggregation rate: least-squares fit



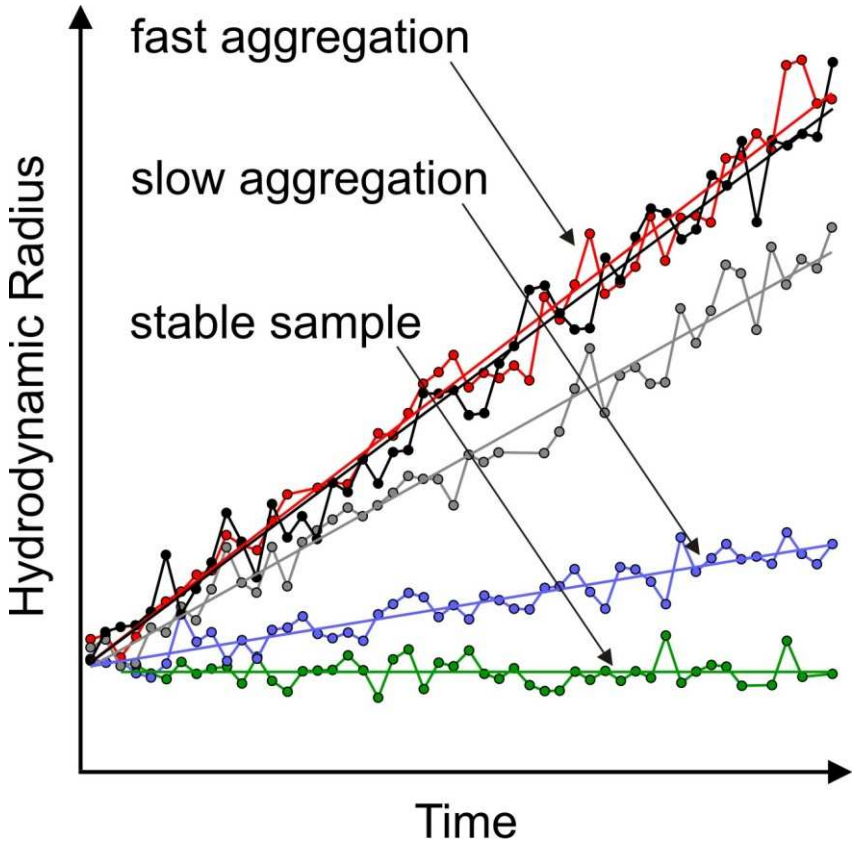
DYNAMIC LIGHT SCATTERING

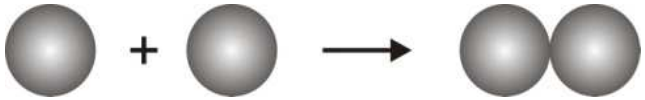
$$\frac{1}{r(q,0)} \cdot \left.\frac{dr(q,t)}{dt}\right|_{t\to 0} = kN_0\left(1 - \frac{r_1}{r_2}\right)\frac{I_2(q)}{2I_1(q)}$$

aggregation rate: from SLS
hydrodynamic factor: fit

COMBINATION OF SLS & DLS

PARTICLE AGGREGATION RATES BY DLS





aggregation rate constant

$$\frac{1}{r(q,0)} \cdot \left. \frac{dr(q,t)}{dt} \right|_{t \to 0} = kN_0 \left(1 - \frac{r_1}{r_2}\right) \frac{I_2(q)}{2I_1(q)}$$

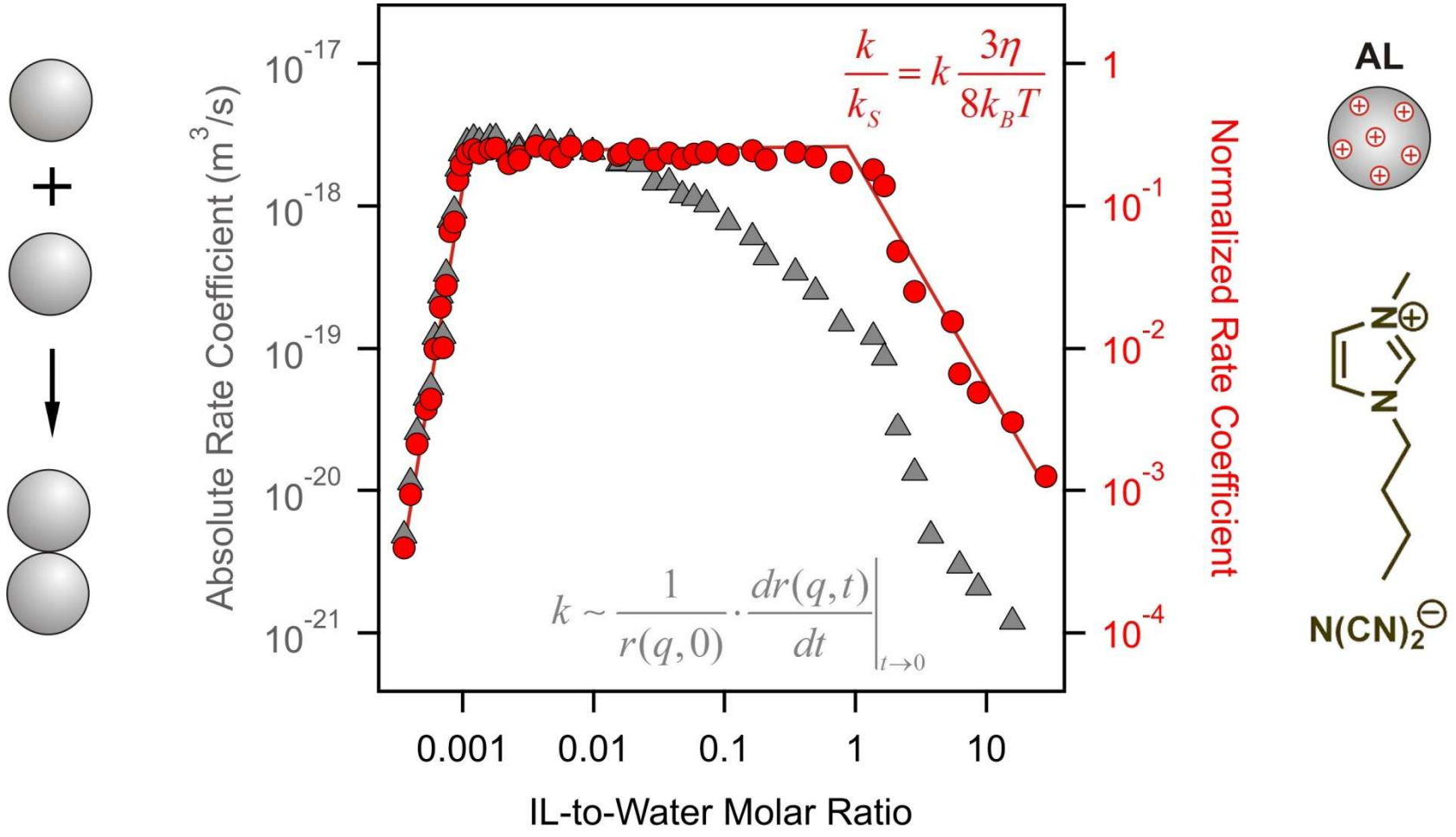
Smoluchowski's constant

$$k_s = \frac{8k_B T}{3\eta}$$

normalized rate constant

$$k_{normalized} = \frac{k}{k_s}$$

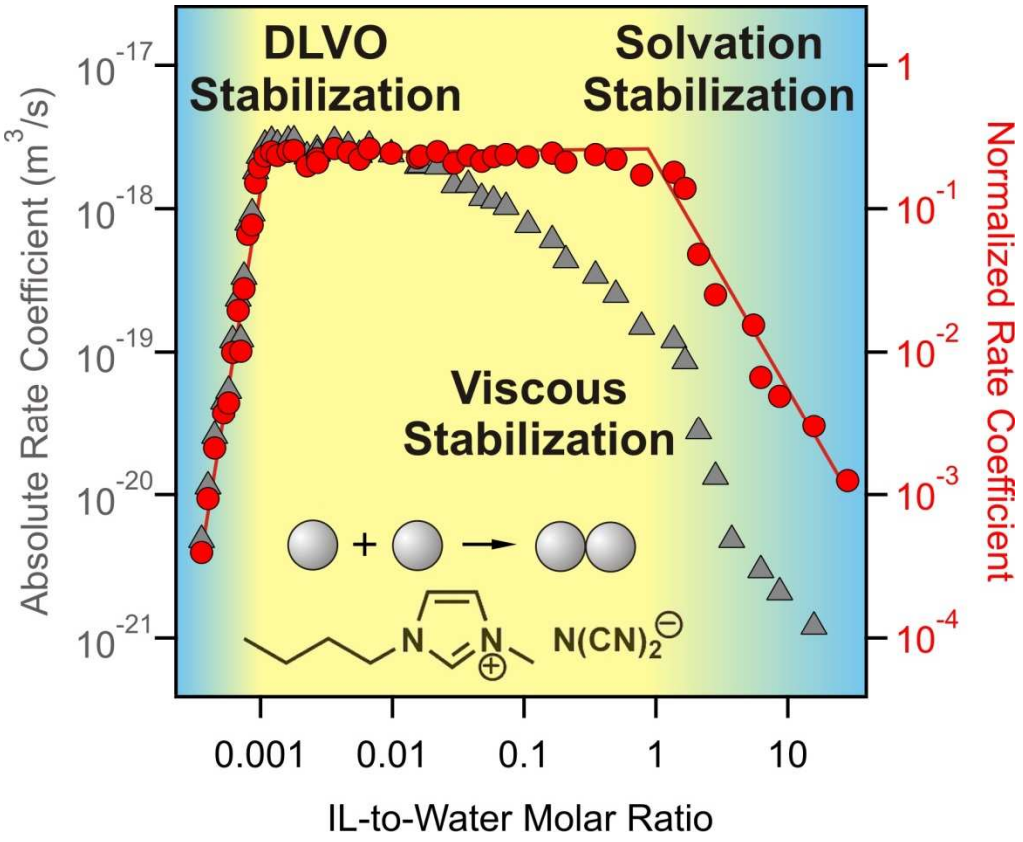
NORMALIZED AGGREGATION RATES



STABILIZATION MECHANISMS

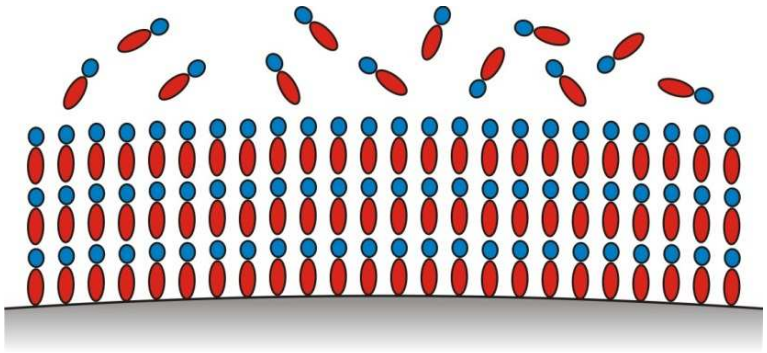
Stabilization Effects

Low IL Dose – Electrical Double Layers
Intermediate IL Dose – Viscosity Effect
High IL Dose – Interfacial Assembly



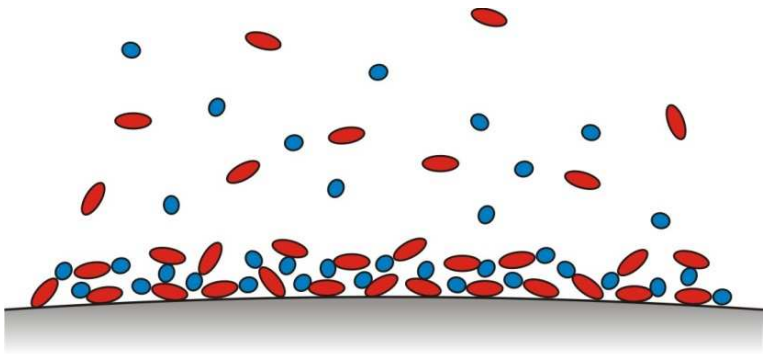
Interfacial IL Layers

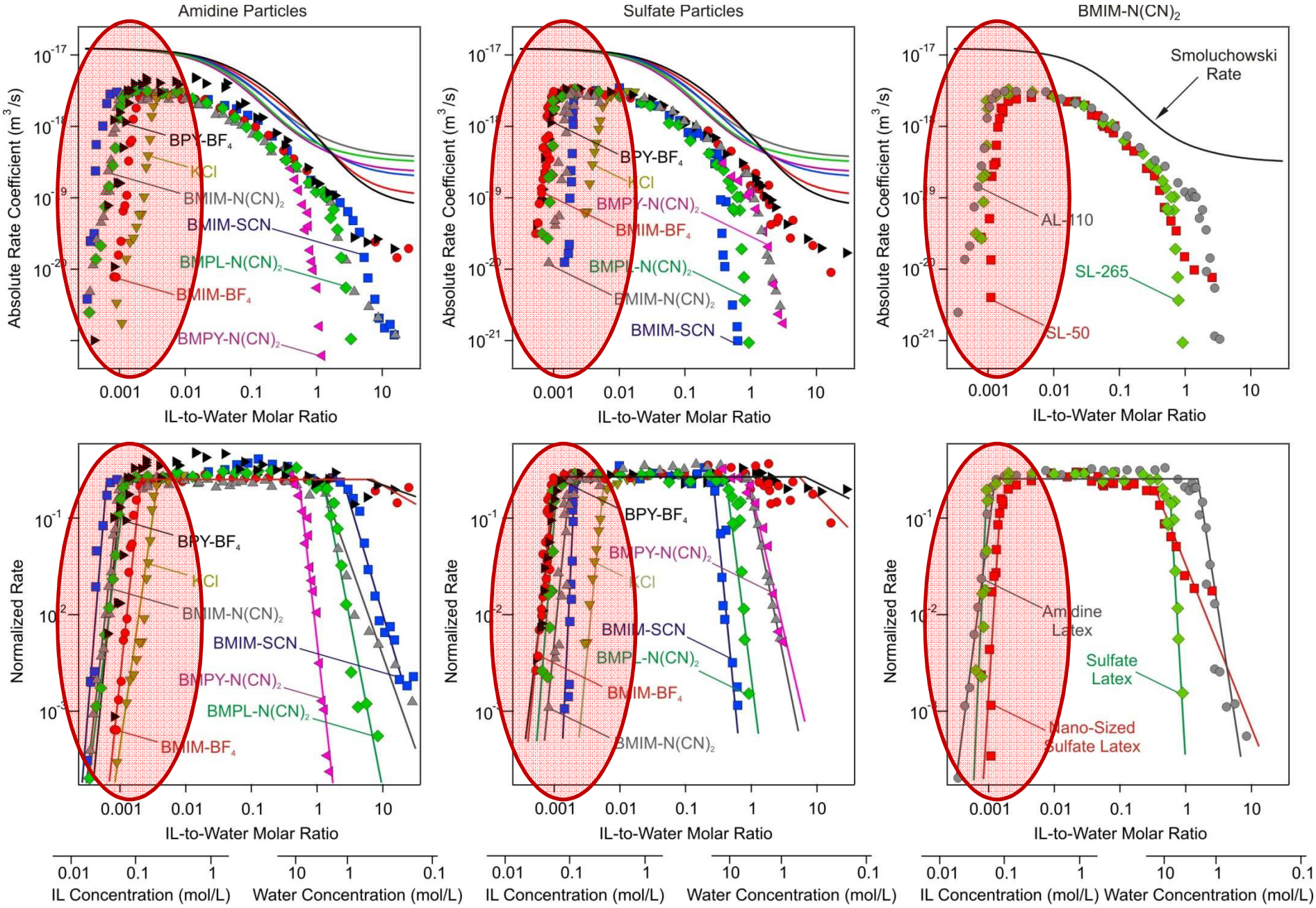
Science 322 (2008) 424 & JPCC 111 (2007) 5162



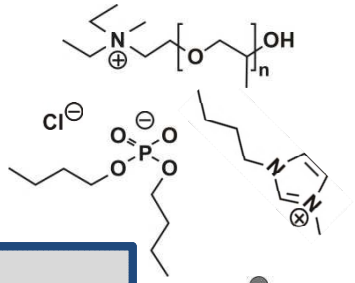
Electrical Double Layer

PNAS 110 (2013) 9674 & JPCC 113 (2009) 16445

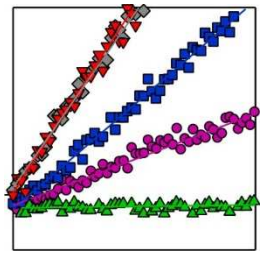


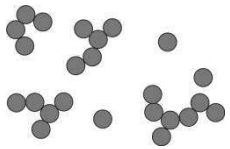

Amidine Particles
Sulfate Particles
BMIM-N(CN)2
Absolute Rate Coefficient (m3/s)
Smoluchowski Rate
BPY-BF4
KCl
BMIM-N(CN)2
BMIM-SCN
BMPL-N(CN)2
BMIM-BF4
BMPY-N(CN)2
AL-110
SL-265
SL-50
IL-to-Water Molar Ratio
Normalized Rate
Amidine Latex
Sulfate Latex
Nano-Sized Sulfate Latex
IL Concentration (mol/L)
Water Concentration (mol/L)

MOTIVATION



SYSTEMS





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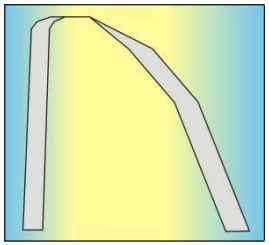

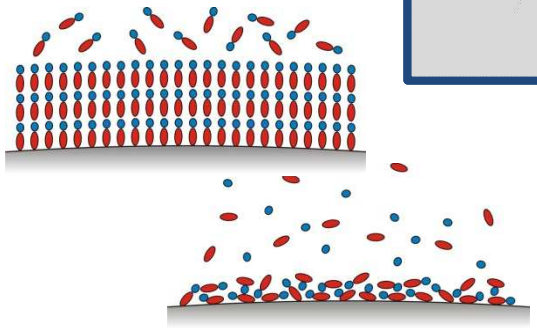

CONCLUSIONS

Conclusions

Absolute aggregation rates can be determined

by light scattering in IL-water mixtures

Colloidal stability is influenced by the IL dose

diluted – DLVO-type forces

intermediate – viscous stabilization

pure – solvation stabilization

Increasing IL hydrophobicity led to lower CCCs

extended Hofmeister series

$OMIM^+ < HMIM^+ < BMIM^+ < BMPL^+ < EMIM^+ < MIM^+ < N(CH_3)_4^+ < NH_4^+ < Cs^+ < K^+ < Na^+ < Li^+$