Structural and Mechanical Characterization of HPMC/SDS Aggregation through Rheological and Neutron Scattering Measurements

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Surface Active Agents & Micellization

Hydrophobic Hydrophilic

H₃C

Na⁺

Hydrophilic

H₃C

Hydrophobic

Concentration

Total Surfactant Concentration

CMC

Monomeric

Micellar

Concentration

Total Surfactant Concentration

CMC

Monomeric

Micellar
Polymer-Surfactant Interactions

Hydroxypropylmethyl cellulose (HPMC)  
Sodium dodecyl sulfate (SDS)

Aggregation at Lower Surfactant Concentrations

Practical Rheological Properties


Disclaimer: Certain commercial equipment, instruments, or materials are identified in this presentation to foster understanding. Such identification does not imply recommendation or endorsement by the National Institute of Standards and Technology, nor does it imply that the materials or equipment identified are necessarily the best available for the purpose.
Conductivity Measurements

**CMC** = Critical Micelle Concentration

**CAC** = Critical Aggregation Concentration

**PSP** = Polymer Saturation Point
Proposed Aggregate Structures

\[ [SDS]_{\text{tot}} < CAC \]

\[ CAC < [SDS]_{\text{tot}} < PSP \]

\[ [SDS]_{\text{tot}} > PSP \]

Increasing SDS Concentration

\textbf{CMC} = Critical Micelle Concentration
\textbf{CAC} = Critical Aggregation Concentration
\textbf{PSP} = Polymer Saturation Point
Rheology 101

\[ \dot{\gamma} \]

\( \tau = \eta \dot{\gamma} \)

Stationary Boundary

Image from: materialssolutions.com.au
Shear Profiles: 3% HPMC Solutions with SDS

Increasing Viscosity
Shear Thinning

% SDS
- 0%
- 0.25%
- 1%
- 2%
Shear Profiles: 3% HPMC Solutions with SDS

Decreasing Viscosity
Shear Thinning

% SDS
- 2%
- 3%
- 4%
Shear Profiles: 3% HPMC Solutions with SDS

Decreasing Viscosity
Shear Thickening?
Viscosity Dependence on Concentration

- Viscosity (mPa s) vs. SDS Concentration (% w/v)
- Viscosity values range from 100 to 10,000,000 mPa s
- SDS Concentration range from 0 to 12 % w/v
- Shear rate values: 0.01, 0.1, 1, 10, 100, 1000 s^-1

Graph shows how viscosity changes with SDS concentration at different shear rates.
Small Angle Neutron Scattering (SANS) 101

\[ I(Q) = \frac{d\Sigma(Q)}{d\Omega} = \left( \frac{N_A}{V} \right) \left( \rho_A - \rho_B \right)^2 V_A^2 P(Q) S_I(Q) \]

\[ Q = \frac{4\pi}{\lambda} \sin \theta \]
Static SANS: HPMC/SDS Mixtures

![Graph showing scattering intensity (I(q)) versus wavevector (q) for different SDS and 3% HPMC concentrations. The graph includes data points for 0%, 0.25%, 1%, 2%, 4%, 6%, 12%, and 20% SDS concentrations.]
Static SANS: More than the sum of its parts…
RheoSANS

\[ \dot{\gamma} = 0.01 \text{ s}^{-1} \]

\[ \dot{\gamma} = 100 \text{ s}^{-1} \]

\[ \dot{\gamma} = 3000 \text{ s}^{-1} \]
Shear Thickening or Foaming?

*Videos courtesy of Daniel Seeman*
Looking Forward

Contrast Matching

Deuterate SDS

Enclosed Rheology

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Thank you for listening!

Questions?