Nano-Structure and Dynamics of Branched, Worm-Like Micelles

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Abstract:
Surfactants are amphiphilic molecules that can self-assemble into complex structures. The assembly of structures, such as micelles and vesicles, is governed by the chemical structure and shape of the surfactant molecules, the solvent conditions such as organic content and salt content and can be controlled through the addition of low molecular weight organic additives. For example, the addition of salt to an anionic surfactant like sodium dodecyl sulfate system first destabilizes spherical micelles due to favorable energetics for larger curvature. Increasing salt content increases the penalty for the end cap termination leading to longer and longer cylindrical micelles. At some point these cylindrical micelles gain bending curvature due to a balance between thermal motion and the increasing lever-arm provided by longer cylindrical micelles. The structure has similarities to persistent chain synthetic polymers and a persistence length can be identified as well as a scaling regime for the coiled micelles. In addition to tortuosity of path these worm-like micelles can display branching. The energetics of branching is not well understood but it occurs at a discrete salt composition and can be manipulated by other solvent conditions and by temperature. Changes in micellar structure can have dramatic effects on the viscosity and this is important to many applications of micellar solutions. For example, it is the presence of WLM's in shampoo that leads to polymer like viscoelastic properties. Since the structure of WLM's is important to predicting the properties many researchers have attempted to quantify the characteristics of these materials. Freeze fracture TEM, NMR, structural interpretation of rheology data, light scattering and dynamic light scattering have been applied to these systems. We have used small-angle neutron scattering to quantify the branch content, persistence length and diameter of these micelles as a function of salt content, concentration and other parameters. The results agree with theory, simulation and rheology and shows some agreement with freeze fracture TEM.
Bio:
Karsten Vogtt studied Biochemistry at the University of Bochum in Germany. For his diploma thesis he employed Fourier-Transform Infrared Spectroscopy to examine the mechanism of proton pumping in membrane bound proteins. He acquired the Phd degree at the University of Dortmund in the group of Prof. Dr. Winter, using NMR-spectroscopy to study protein unfolding under various conditions. For his thesis he likewise applied small angle x-ray scattering to characterize the structure of proteins in solution. Fascinated by this method, he continued with a postdoctoral position at the Helmholtz-Zentrum Berlin, Germany. Here he worked at the set-up of a new small angle neutron scattering instrument. Since July he is employed as a postdoc in the group of Prof. Beaucage at the University of Cincinnati, where he continues working with small angle neutron scattering as a tool for structure determination as applied to worm-like micelles.