88i Temperature Gap for Surfactant Drag Reduction

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The addition of binding counterions to quaternary ammonium cationic surfactants can induce threadlike micelle (TLM) formation in dilute solution. Generally, surfactant solutions with TLM microstructures are effective turbulent flow drag reducing (DR) agents over a certain temperature range. Near the upper temperature limit, counterions disassociate from TLMs which shrink in size and form spherical micelles. At the lower temperature limit, phase separation occurs due to the poor solubility of the surfactant. The effective temperature range for DR is affected by the molecular structure and concentration of surfactant and counterions, co-solvent and pH. In this study, the DR properties of the mixtures of a cationic surfactant, cetyltrimethylammonium tosylate (CTAT), and an anionic surfactant, sodium dodecyl sulfate (SDS) were investigated along with their micelle microstructures. With excess sodium tosylate (NaTos), the solution of 10mM CTAT/SDS (at a weight ratio of 85/15) was drag reducing at 30°C and 50°C but it showed a temperature gap for DR around 40°C, in which it lost significant DR effectiveness. At 25°C, the solution contains both TLMs and densely packed large aggregates observed by cryogenic transmission electron microscopy (cryo-TEM) and by digital light microscopy (DLM), respectively. At 40°C, coinciding with reduced DR, cryo-TEM images showed vesicles coexisting with very few TLMs. At 50°C, cryo-TEM images showed well-developed TLMs which formed networks. Temperature gaps for DR have been reported only twice in the literature, both for cationic surfactant systems containing two counterions with significant differences in their abilities to bind with the cationic surfactant. Here also, the negatively charged tosylate and SDS have different affinities for binding to the cationic surfactant suggesting that this is a requirement for the temperature “gap” in DR.