

RHEOLOGICAL ANALYSIS OF AN EFFECT OF ADDITION OF SURFACTANT TO AQUEOUS SOLUTIONS OF POLYMERS

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In the last years the special attention was directed to elaborate the similarities and differences of drag reduction in high-molecular polymers and surfactants solutions, which relate to the flow phenomena. It has been shown that presence of surfactant or polymer in drag reducing polymer systems causes an increase of the system stability and of the temperature range in which the additives are most effective (Nakamura et al., 2007).

In the study the results of experimental analysis directed on the rheological properties of aqueous solutions of polymer/surfactant mixtures are presented. The polymer used was poly(ethylene) oxide (PEO) of two molecular weights ($M_w = 1,000,000, 2,000,000$). The cationic surfactant added was hexadecyltrimethylammonium chloride (HTAC).

It has been shown (Figures 1 and 2) that addition of surfactant to aqueous polymer solution causes significant changes in the rheological properties of complex fluids. It was observed that the solutions tested changed their rheological behaviours from Newtonian through shear thinning, shear thickening, again shear thinning to viscoelastic one. The most concentrated solutions showed the viscoelastic behaviour and were more stable systems. The effect is dependent also on polymer mass weight, shear rate as well as the volume ratio of polymer to surfactant. The courses of flow and viscosity curves suggest that polyethylene oxide PEO of molecular weight $M_w = 2 \cdot 10^6$ added to surfactant solution in the range of shear rate $\dot{\gamma} = 1530 \div 2870 \text{ s}^{-1}$ caused the shear-thinning effect, when in the range of $\dot{\gamma} = 2870 \div 7430 \text{ s}^{-1}$ the complex aqueous solutions were shear-thickening ones.

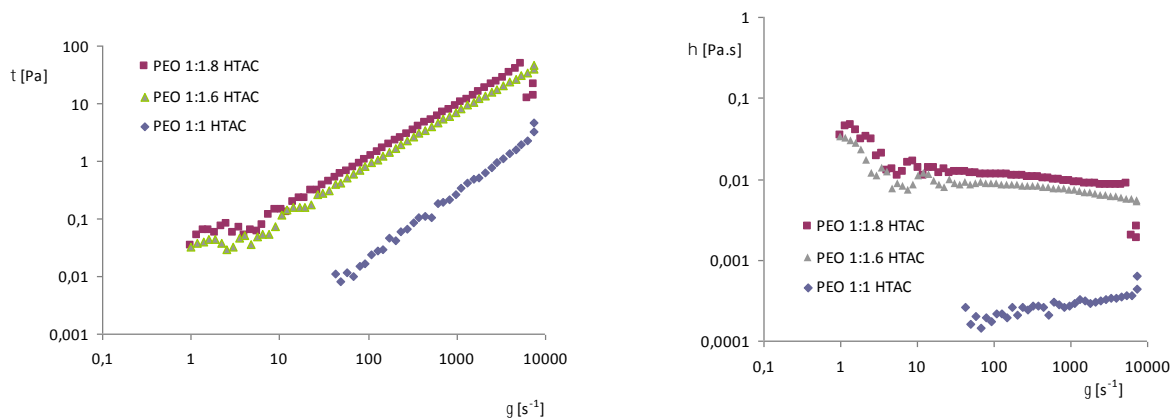


Fig. 1. Flow and viscosity curves for aqueous solutions of the mixtures of PEO₁₀₀₀₀₀₀ and HTAC of various volume ratios

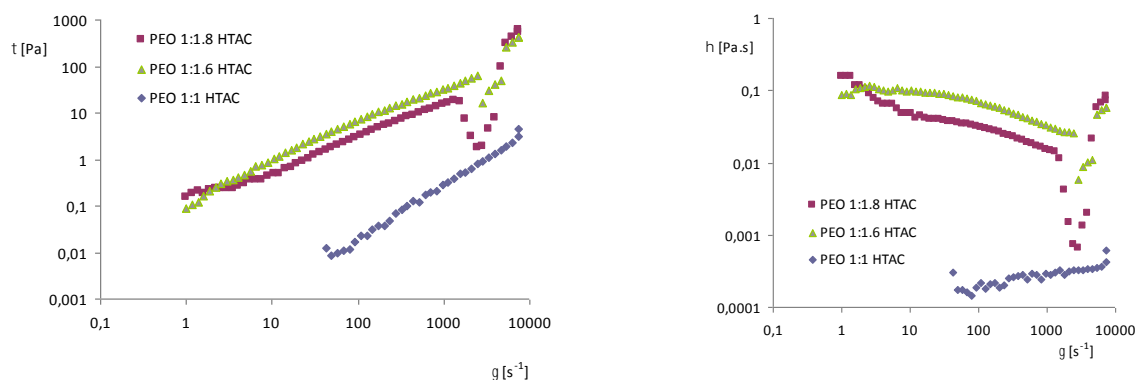


Fig. 2. Flow and viscosity curves for aqueous solutions of the mixtures of PEO₂₀₀₀₀₀₀ and HTAC of various volume ratios

The rheological properties change in polymer/surfactant solutions can be connected with increase in the length of micelles added into polymer solutions. The occurrence of shear thickening scope is obviously related to the change of internal structure of the solution under the influence of shear stress. Such a phenomenon is known in the literature as shear-induced state (SIS) or shear-induced phase (SIP) (Schmitt et al., 1995; Barentin and Liu, 2001). In opinion of Nakamura and Shikata (2007) surfactant and polymer molecules instead of the low-molecular weight additive salt construct in a solution the hybrid threadlike micelles. The polymer molecules may be crowded into the micellar interior, placing their changes and/or hydrophilic groups on the micelle surface exposed the bulk of aqueous phase, while hydrophobic parts of the polymer molecules occupy positions slightly closer to the micellar core. In our opinion the complex polymer/surfactant systems tested not only construct in a solution the hybrid threadlike micelles but the network of them too. The viscoelastic properties of the threadlike micellar solutions become more pronounced, giving them great potential for new applications as strong rheology modifiers or excellent viscoelastic materials in aqueous media.

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