

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

Lubomira Broniarz-Press, Karolina Smuszkiewicz
Poznan University of Technology, Faculty of Chemical Technology,
Department of Chemical Engineering and Equipment, Poznan, Poland
E-mails: mirka@box43.pl , lubomira.broniarz-press@put.poznan.pl

Abstract

In the paper the results of rheological studies for mixtures of polymer/surfactant in an aqueous solutions 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). The rheological properties change observed in polymer/surfactant solutions can be connected with increase in the length of micelles added into polymer solutions.

Key words: polymer/surfactant solutions, shear-induced structure, viscoelastic fluid, threadlike micelles

INTRODUCTION

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

Rheological properties of solutions poly(ethylene) oxide (PEO) strongly depend on the type of micelles that are formed in a solution. The most concentrated solutions showed the viscoelastic behaviour and were the most stable systems. 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 as shear-induced phase SIP (Schmitt et al., 1995; Barentin and Liu, 2001).

RESULTS

The rheological properties of the solutions analyzed were determined using the rheometer Physica MCR 501 (Anton Paar). All measurements were performed in the temperature range 293-308 K. In the solutions tested the concentrations of PEO were equal to 0.6, 0.8 and 1.0% and the volume ratios of polymer to surfactant were 1:1, 1:1.4 and 1:1.8, respectively.

It has been shown (Figures 1 and 2) that an 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 behaviour from Newtonian through shear thinning, shear thickening, over again shear thinning to viscoelastic one. The most concentrated solutions showed the viscoelastic behaviour and were very stable systems. The effect observed is also dependent 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 $M_w = 2 \cdot 10^6$ (PEO_{2,000,000}) added to surfactant solution in the range of shear rate $\gamma = 1530 \div 2870 \text{ s}^{-1}$ caused the shear-thinning effect, when in the range of $\gamma = 2870 \div 7430 \text{ s}^{-1}$ the solutions show shear-thickening properties.

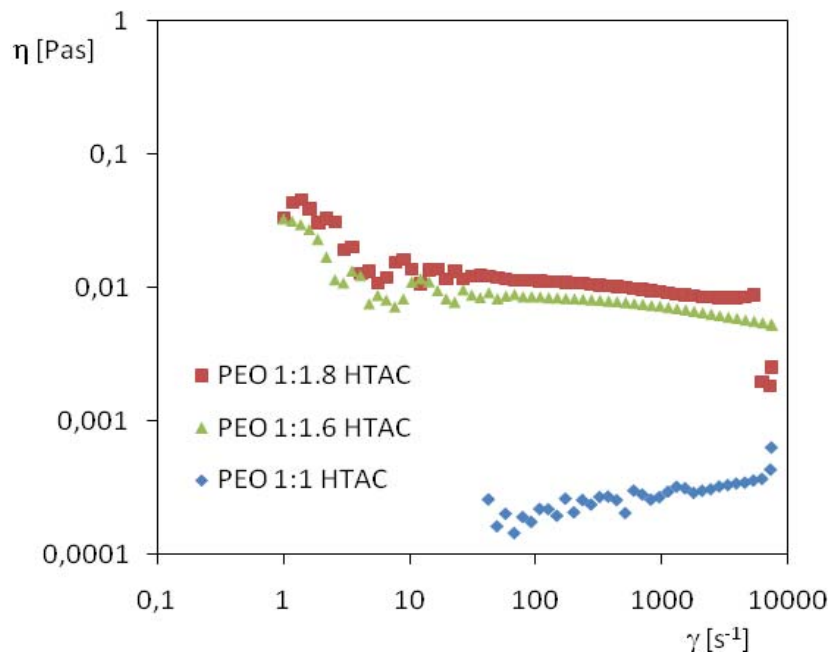
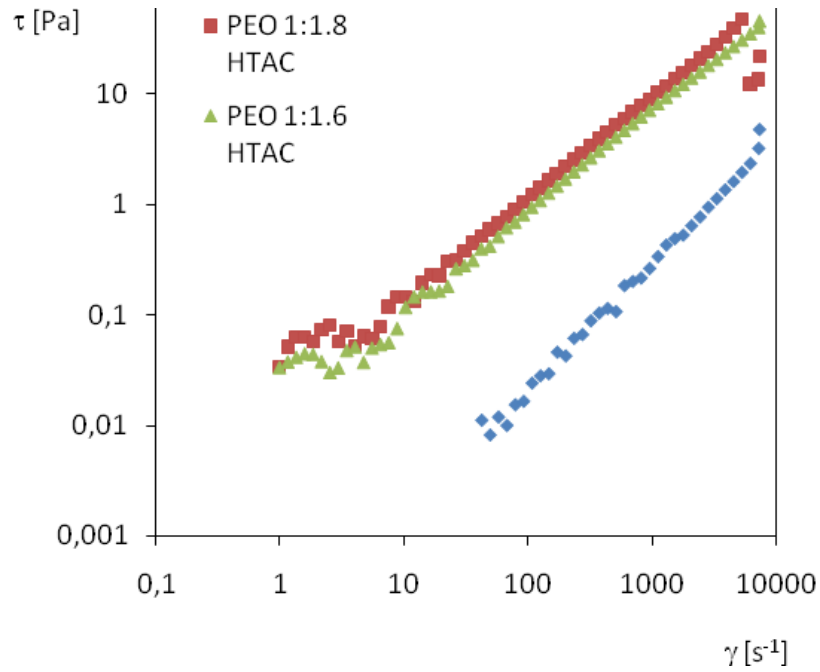


Fig. 1. Flow ($\tau = f(\gamma)$) and viscosity ($\eta = f(\gamma)$) curves for aqueous solutions of the mixtures of PEO_{1,000,000} and HTAC of various volume ratios

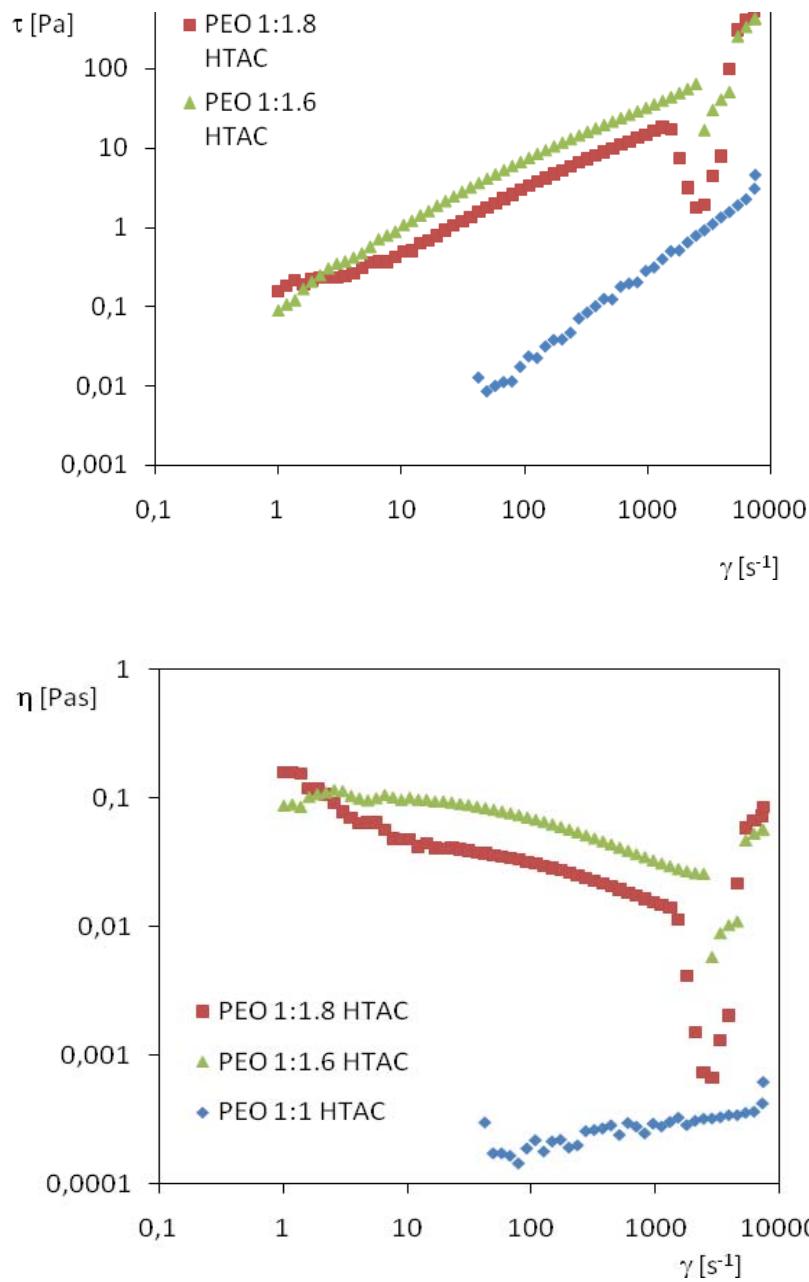


Fig. 2. Flow and viscosity curves for aqueous solutions of the mixtures of PEO_{2,000,000} and HTAC of various volume ratios

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 (Schmitt et al., 1995) or shear-induced phase SIP (Barentin and Liu, 2001). In opinion of Nakamura and Shikata (2007) surfactant and polymer molecules in contrast to the low-molecular weight additive salt construct the hybrid threadlike micelles in a solution. The constituent polymer molecules may be crowded into the micellar interior, placing their charges and/or hydrophilic groups between surfactant head groups on the micellar surface exposed towards the bulk 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 the hybrid threadlike micelles in a solution but the network of them too.

CONCLUSIONS

The polymers involved in the threadlike micelles partially overlap with one another to form threadlike micelles that are long enough to entangle with each other. The complex polymer/surfactant systems tested not only construct the hybrid threadlike micelles in a solution 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.

ACKNOWLEDGEMENTS

The financial support of Ministry of Science and High Education (Poland) is gratefully acknowledged (Grant PUT No. DS ICT-32/113).

REFERENCES

- Nakamura K., Shikata T., (2007): *Formation and Physicochemical Features of Hybrid Threadlike Micelles in Aqueous Solution*, European Journal of Chemical Physics and Physical Chemistry, Vol. 8, pp. 2568-2574
- Schmitt V., Marques C.M., Lequeux F., (1995): *Shear Induced Phase Separation of Complex Fluids – The Role of Flow Concentration Coupling*, Physical Review E, Vol. 52, pp. 4009-4015
- Barentin C., Liu A.J., (2001): *Shear Thickening in Dilute Solutions of Wormlike Micelles*, Europhysics Letters, Vol. 55, pp. 432-438