TEMPERATURE DEPENDENCE OF THE RHEOLOGICAL PROPERTIES OF POLY (ETHYLENE OXIDE)

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The study of the rheological behavior of polymeric fluids continues to draw the attention of many researchers because of their complexity and the great number of their industrial applications. Since the rheological properties of polymer solutions are strongly related to the chemical formulation, the molecular weight and the concentration of the polymer, the solvent properties and external variables such as the temperature and the pressure, understanding the relationship between the microstructure of the polymer solutions and their macroscopic properties is of fundamental importance.

The polymer studied here is a high molecular weight Poly (ethylene oxide), PEO, where M_w= 10^6 g mol^{-1}. This polymer is used in many applications that depend on their solubility, rheology and thermoplastic character. Indeed, high molecular weight PEO have the remarkable property of friction (or drag) reduction of water in turbulent pipe flow, known as the Toms effect. It is also used as dispersant for cementitious materials, as flocculent for finely dispersed solids in water, and in miscellaneous applications, to cite just a few.

In a previous study, we investigated the rheological properties of aqueous solutions of PEO at different molecular weights (1×10^5, 4×10^5, 1×10^6 and 4×10^6 g mol^{-1}) and concentrations [1]. In this work, the rheological properties of aqueous solutions of PEO (M_w= 10^6 g mol^{-1}) was studied, using shear viscosity, creep and dynamic rheological measurements, at different concentrations (0.5 to 10%) and different temperatures (5, 15, 20, 40, 60°C). It was found that the PEO solutions do not exhibit a yield stress and that, above a critical shear rate, all PEO solutions exhibit shear-thinning behavior, well described by the Cross model. Below a critical temperature, between 50 and 60°C, the temperature-dependent behavior of the POE solutions is satisfactorily described by the Arrhenius law. Beyond this critical temperature, the viscosity increases for all the PEO concentrations.

Furthermore, the parameters of the Cross model, namely the zero-shear rate viscosity and reciprocal of the time constant, were determined and discussed. These parameters allowed the determination of the critical concentrations c* and c** (respectively, the transition to semi-dilute network solution and concentrated solution) at different temperatures. These results, found by the use of shear viscosity measurements, were discussed and confirmed by dynamic measurements.

References:

[1] Ebagninin K. W., Benchabane A., Bekkour K., Rheological characterization of poly(ethylene oxide) solutions of different molecular weights. *Journal of Colloid and Interface Science* 336, 360-367 (2009).