

Influence of preparation method on viscosity of different poloxamer solutions

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Key words

Aqueous polymer solutions, Cold water preparation, Hot water preparation, Sol/gel transition

Introduction

In literature, two different methods of how to prepare an aqueous solution containing poloxamers are described (1). To keep viscosity low, either cold or hot water can be used as solvent.

For lab scale preparation, “cold water” preparation is commonly used for convenience. Whereas, in production scale “hot water” preparation is the only feasible procedure, as most reactors cannot be cooled down to 5 °C. At ambient temperatures, most poloxamer formulations tend to form gels, making both a homogeneous distribution and fast preparation difficult (2, 3, 4).

Purpose of this study was to investigate whether the preparation method has an influence on the rheological properties of the polymer solution.

Experimental methods

Materials

For this investigation, poloxamer 188 (Lutrol® F68) and poloxamer 407 (Lutrol® F127), both BASF SE, Ludwigshafen, Germany were used.

Methods

For the investigation, solutions containing 10 and 20 % (w/w) poloxamer 188 and 10 % (w/w) poloxamer 407 in water were prepared.

“Cold water” preparation

Pre-cooled water of 5 °C was weighed into a beaker. The required quantity of poloxamer was added within 2 minutes into the water.

The mixture was stirred with a magnetic stirrer for 5 minutes. Afterwards it was stored at approx. 5 °C for 24 hours.

“Hot water” preparation

Pre-heated water of 70 °C was weighed into a beaker. The required quantity of poloxamer was added within 2 minutes into the water. To get a homogeneous solution, the mixture was stirred for 60 minutes, using a magnetic stirrer.

Equipment

To perform the rheological investigations on dynamic viscosity, a Thermo Scientific™ HAAKE™ Rheometer, from Thermo Fisher Scientific, Karlsruhe, Germany was used.

As the viscosity to be measured is low, a DG43Ti double gap concentric cylinder measuring geometry was used.

Prior to viscosity measurements, the solutions were homogenized for 1 minute at 200 rpm. To ensure reproducible results, a relaxation time of 1 hour was applied. All measurements were performed at 25.0 °C ± 0.2 K. For temperature equilibration, a shear rate of 100 s⁻¹ was used.

The measurement was performed using a shear rate ramp starting at 100 s⁻¹, ending at 3000 s⁻¹ within 180 s. This shear rate was kept constant for 30 s. Finally, the shear rate ramp was reversed to the starting point of 100 s⁻¹.

Results and discussion

All examined poloxamer solutions showed Newtonian flow behaviour which means that the viscosity is independent of the applied shear rate.

Comparing the rheological data (Figure 1) of both preparation methods, no differences in the flow properties of all tested poloxamer solutions could be observed.

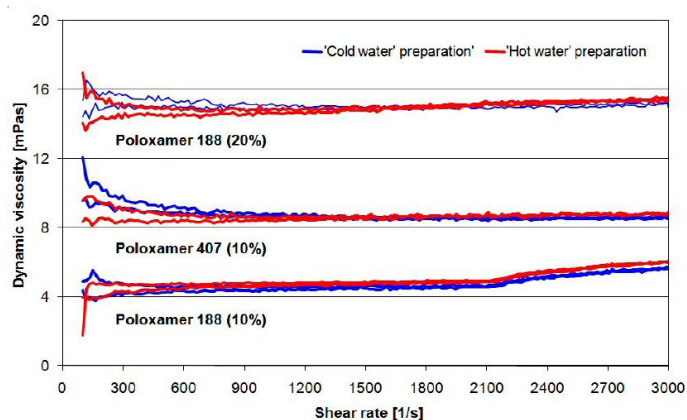


Figure 1: Dynamic viscosity of different poloxamer solutions prepared at different temperatures as function of shear rate.

Even the slight shear heating with poloxamer 188 (10 %) above 2100 s⁻¹ was present for both preparation methods, as well as for both storage times (Figure 2).

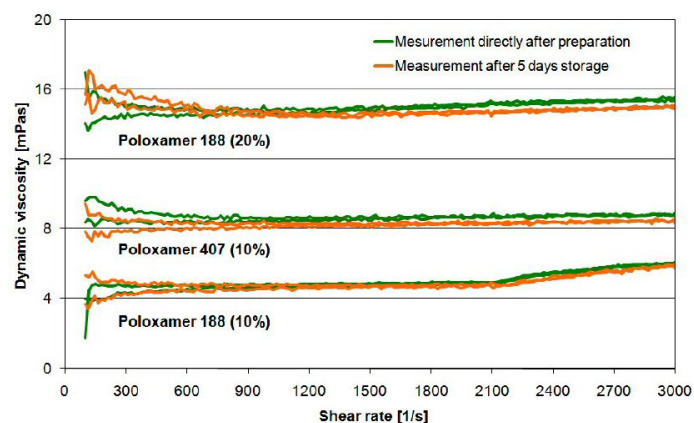


Figure 2: Dynamic viscosity of different poloxamer solutions as function of shear rate, measured at different times after preparation.

Therefore, the method of preparation has no influence on the rheological properties of the aqueous poloxamer formulation. Examining storage time, no influence in the rheological characteristics could be found (Figure 2).

The poloxamer formulations can therefore be regarded as stable viscosity enhancers. Even at high concentrations (e.g. 20 %), no change over storage time could be observed.

Conclusion

Below the gel point, poloxamers form an ideal viscous solution. Their properties can be regarded as Newtonian flow behaviour.

These rheological characteristics were found to be independent of both the method of preparation and storage time of the aqueous formulation.

The method of preparation can be freely chosen according to side parameters such as temperature dependant solubility of the active, because no differences in the rheological properties of the polymer solution have to be expected.

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