

## Effect of Cationic Surfactant on the Gelation of HPAM by Cr(III)

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**Abstract:** The effect of cationic surfactant cetyltrimethylammonium bromide (CTAB) on the gelation of partially hydrolyzed polyacrylamide (HPAM) by Cr (III) was investigated by using rheological measurements. The results indicated that the CTAB concentration has a pronounced effect on the viscoelastic properties of the gelling system.

**Keywords:** Rheological study, cationic surfactant, gelation.

Aqueous gels formed by the crosslinkage of Cr(III) with partially hydrolyzed polyacrylamide (HPAM), have been commonly applied in the field of petroleum production<sup>1</sup>. Polymer and surfactants are used in enhancement of oil recovery<sup>2</sup>. Some studies<sup>3</sup> indicate that a strong interaction is existent between polyelectrolytes and oppositely charged surfactants. So it is very important to study the effect of cationic surfactants on the gelation process of crosslinkage of Cr(III) with HPAM. To our knowledge, there are only few studies on this subject.

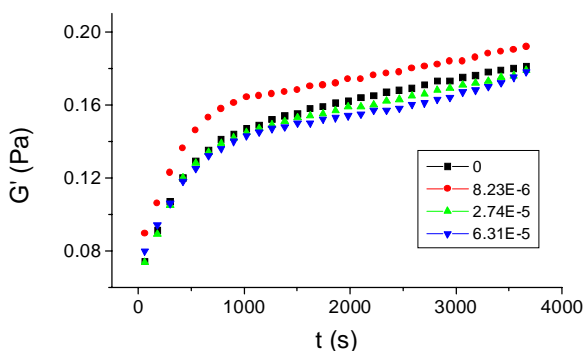
HPAM was purchased from Mitsubishi Chemical Co., the average molecular weight was  $2.4 \times 10^7$ , the hydrolysis degree was 27.4%. Cetyltrimethylammonium bromide (CTAB) of analytical reagent grade was purchased from Jining Chemical Institute. Cr(III) solution was prepared from  $\text{CrCl}_3 \cdot 6\text{H}_2\text{O}$ . A small quantity of concentrated CTAB solution, together with Cr(III) solution was gradually added to the HPAM solution under stirring, the pH value of the mixture was carefully adjusted to 5.86 with NaOH and HCl solution. The oscillatory experiments were performed with a HAAKE RS75 controlled-stress rheometer equipped with Z41 cylinder sensor system. The shear storage,  $G'$ , and the shear loss,  $G''$ , moduli were recorded in the linear viscoelasticity range.

**Figure 1** shows the effect of surfactant concentration on the storage modulus of the HPAM/Cr(III) gelling system. The concentrations of polymer and NaCl are kept constant at 0.4% and 0.6% by weight, respectively, the concentration of Cr(III) is kept constant at 0.4 mmol/L, the temperature is 30°C and the pH is 5.86. The initial slopes of  $G'$  versus time plots can be used directly to compare relative gelation rates for HPAM/Cr(III) gelling system<sup>4</sup>. The gelation rate and the storage modulus of the gelling system with low CTAB concentration ( $8.23 \times 10^{-6}$  mol/L) are larger than those of the gelling

system without CTAB. The concentration of CTAB is lower than the critical aggregate concentration (CAC) of CTAB<sup>5</sup>, so the molecules of CTAB exist freely in the gelling system. As a result, the molecules of CTAB can bind to the carboxylic groups of HPAM that have not been linked with Cr(III). In the result low CTAB concentration caused higher gelation rate and storage modulus of the gelling system.

From **Figure 1** we can observe that the higher concentrations of CTAB are, the lower gelation rates and storage moduli of the gelling systems are. This is because when concentrations of CTAB are close and/or higher than the CAC of CTAB<sup>5</sup>, the CTAB molecules may aggregate along the HPAM molecules, C<sub>16</sub>N(Me<sub>3</sub>)<sup>+</sup>, replacing the sites of Cr(III) and the network of the system was weakened due to the electrostatic attraction and hydrophobic interaction between the surfactant and the HPAM molecules.

**Figure 1** Effect of CTAB concentration on the storage modulus of the gelling system



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