The rheological behavior of weak gels made with a blocky CMC and salt

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ABSTRACT

The wide range of rheological properties of carboxymethyl cellulose (CMC) in the presence of salt is presented. Aqueous solutions of CMC and NaCl were prepared at concentrations up to 10% wt. Flow curves as well as the dynamic properties were measured. The rheological behavior was found to vary from Newtonian liquid to viscoelastic, with elastic properties dominating (G'>G") depending on salt concentration and the order of adding CMC and salt.

INTRODUCTION

Carboxymethylcellulose (CMC) is widely used in many application areas such as food, pharmaceutical, personal care, paper, paint and milling industry. Consequently, many types of commercial CMC varying in molecular weights, degree of substitution (DS) and uniformity of substitution are available on the market.

In CMC cellulose has been made water soluble trough substitution of carboxymethyl groups attached along the cellulose backbone. Hence, CMC is an anionic polyelectrolyte. It is stabile to a relatively wide range of pH and salt due to a high degree of substitution[1].

The presentation deals with a blocky CMC where the substitution is distributed in blocks instead of uniformly along the polymer chain, and its response to NaCl in aqueous glycerol.

EXPERIMENTAL

Aqueous glycerol (30%wt) solutions of CMC (1%wt) were mixed for 35 min, before NaCl (0-5%wt) was added and mixed another 10 min.

The solutions were stored 7 days before a flowcurve between 0.01 and 100 1/s was run on the Physica MCR 301 Anton Paar rheometer. The viscosity at 0.1 1/s was chosen to represent the rheological properties in the figures. Frequency sweeps were run in the linear viscoelastic region the strain 0.01. The concentric cylinder geometry C25 was used.

RESULTS & DISCUSSION

Generally, the hydrodynamic volume of charged polymers depends on ionic strength, pH and salts present. For example at increasing concentration of NaCl, and depending on the degree of substitution CMC will shrink and precipitate to avoid contact with water. This is shown for CEKOL 500T in Figure 1. Already above 2% NaCl the viscosity is reduced when CMC is added to the aqueous salt solution. On the other hand, the viscosity is increasing with salt concentration when CMC is allowed to dissolve before salt is added (Figure 1).

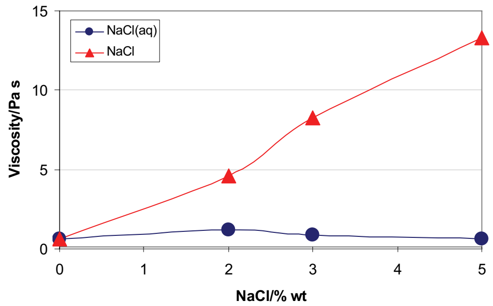

Figure 1. The effect of NaCl concentration on viscosity of aqueous solutions (no glycerol) of CEKOL 500T. NaCl added to the CMC solution (top), or NaCl dissolved in water before CMC is added.

In Figure 2 the viscosity of CEKOL 500T (DS 0.7), with blocky substitution is compared with two CMCs of higher and uniform degree of substitution, CEKOL 2000 (DS 0.9) and 2000S (DS 1.2) (Table 1). We can see that the viscosity of CEKOL 2000S is not influenced by storage time at 3% NaCl, where as CEKOL 500T increases almost 100 times during the first days.

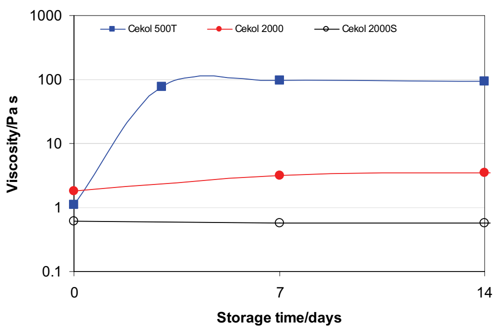

Figure 2. The effect of storage time on viscosity for CEKOL 500T, CEKOL 2000 and CEKOL 2000S (aqueous glycerol with 3% NaCl added after CMC is dissolved.

The increase in viscosity with increasing NaCl concentration is shown in Figure 3. We can see that the viscosity is much higher and reaches a plateau when glycerol is present in the solution (compare with Figure 1). A stabile viscosity is reached within a few days (Figure 2).

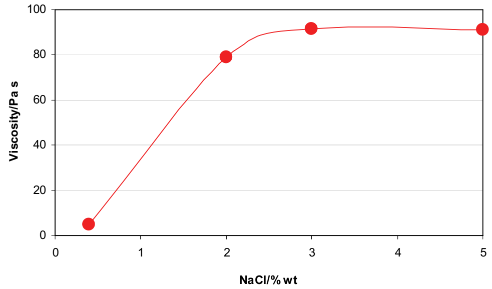

Figure 3. The effect of NaCl concentration on viscosity of the aqueous glycerol solution of CMC.

In Figure 4 the frequency sweeps for CEKOL 500T at 0.4, 5 and 10% NaCl are compared. At 0.4% NaCl the viscous properties still dominated. However, already when 2% NaCl was included a gel with similar dynamic properties to the one shown in figure 4 for 5 and 10% NaCl resulted. A higher value of G' and a lower phase angle (delta) were found at 5 and 10% NaCl. It is worth pointing out that CEKOL 500T can sustain high NaCl concentrations such as 10% when the salt is added after CMC is dissolved.

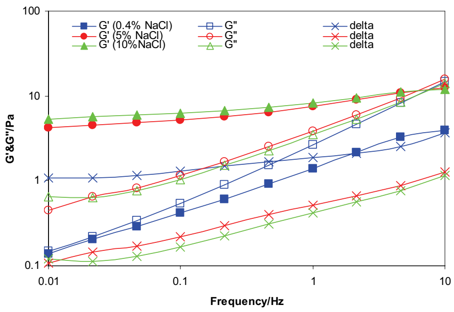

Figure 4. The effect of NaCl (0.4, 5 & 10%) on the frequency sweep of CEKOL 500T dissolved in aqueous glycerol.

ACKNOWLEDGMENTS

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REFERENCES

1. Nomura, Koda, Hattori, S. (1990), J. Appl Polym Sci, **41,** 2959.