International Journal of Pharmaceutics, 75 (1991) 155–159
Elsevier Science Publishers B.V.
ADONIS 037851739100312B

IJP 02499

Effect of surfactants on the rheological and electrical properties of carboxymethylcellulose aqueous solution

Milica Jovanović, Radmila Rakić, Zorica Djurić and Ljiljana Živanović

Faculty of Pharmacy, Belgrade and Medical Centre, Kruševac (Yugoslavia)

(Received 21 March 1991)
(Accepted 29 April 1991)

Key words: Carboxymethylcellulose (Blanose 7D); Surfactant; Viscosity; Zeta potential

Summary

This report details the effect of addition of 0.5–3% of different ionic types of surfactants on the rheological and electrical properties of 5% carboxymethylcellulose aqueous solution. The nonionic surfactants caused significant change in neither viscosity nor zeta potential of 5% carboxymethylcellulose solution. The only exception was with Aminoxid WS 35. The amphoteric surfactant Tego-Betain L7 did not markedly affect the viscosity of 5% Blanose solution, but an unexpected increase in its viscosity was observed in the case of 2% concentration of Abil B 9950. Tego-Betain L7 and Abil 9950 increased the electronegativity of Blanose particles. The most significant change in zeta potential was observed with the Blanose sample in the presence of sodium lauryl sulphate.

Introduction

Dispersions of carboxymethylcellulose have been investigated from the viewpoint of both rheology and surface charge (Salama, 1981; Djurić and Jovanović 1983, 1984, 1985; Primorac et al., 1986).

Few authors have considered the relation between the viscosity and zeta potential (Rambhau et al., 1977; Dawes and Groves, 1978; Rakić et al., 1987). The effect of the addition of surfactants on the rheological properties of polyacrylate hydrogels has been reported (Eros and Ditigen, 1988).

Correspondence: M. Jovanović, Faculty of Pharmacy, Belgrade and Medical Centre, Kruševac, Yugoslavia.

The aim of the present study was to investigate the possible effect of surfactants on the rheological properties and surface charge of carboxymethylcellulose aqueous solution. The surfactants selected for this study are widely used in pharmaceutical and cosmetic preparations. These formulations frequently include viscosity increasing agents such as carboxymethylcellulose.

Materials and Methods

Blanose 7 MD (carboxymethylcellulose) was kindly supplied by Hercules. The following surfactants were used: (a) nonionic type: Abil B 8842, Abil B 8843, Abil B 8851 (polysiloxane-polyether copolymers), Tagat 02 (polyoxyethylene glycerol monooleate), Tagat L2 (polyoxyethylene

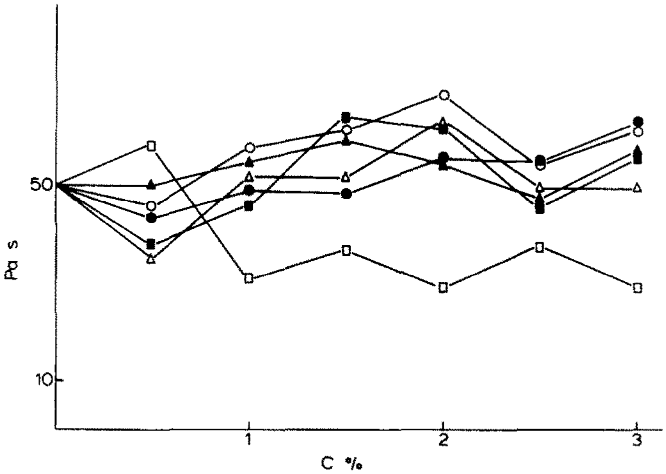

Fig. 1. Effect of nonionic surfactants on the viscosity of 5% Blanose solution at low frequency ($f = 0.158$ rad/s): (○) Abil B 8842, (●) Tagat 02, (△) Tagat L2, (▲) Abil B 8843, (□) Aminoxid WS 35, (■) Abil B 8851.

glycerol monolaurate) and Aminoxid WS 35 (fatty acid amido alkyl dimethylaminoxide); (b) amphoteric type: Abil B 9950 (polysiloxane polyorganobetaine copolymer) and Tego-Betain L7 (fatty acid amido alkylbetaine); (c) anionic type: sodium lauryl sulphate.

Surfactants of the first two were kindly donated by Goldschmidt. Sodium lauryl sulphate was Ph. Jug. IV grade.

A Rheometrics RMS 605 Mechanical Spectrometer (Rheometrics Inc. U.S.A.) equipped with parallel plates was used for viscosity measurements. A Zeta-Meter (Zeta Meter Inc., New York) was employed for measuring electrophoretic mobility.

The 5% Blanose dispersions were prepared by mechanical stirring in distilled water or in 0.5–3% of aqueous solutions of surfactants. The viscosities were measured 24 h after preparation of the Blanose solutions. All measurements were made in the dynamic mode at 16 different frequencies at 25 °C. As the solutions were in the gel form, they required dilution before the determination of electrophoretic mobility; 1:10 dilutions were

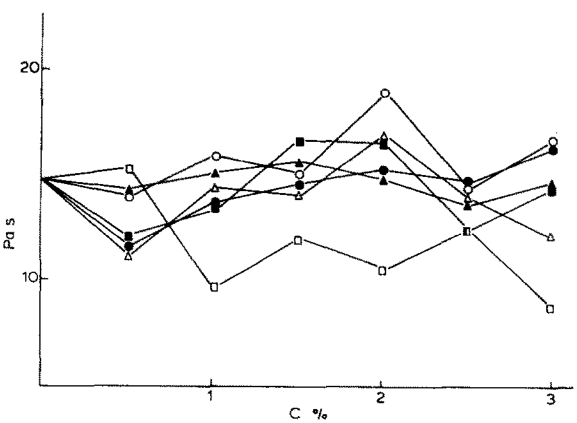

Fig. 2. Effect of nonionic surfactants on the viscosity of 5% Blanose solution at medium frequency ($f = 2.512$ rad/s): (○) Abil B 8842, (●) Tagat 02, (△) Tagat L2, (▲) Abil B 8843, (□) Aminoxid WS 35, (■) Abil B 8851.

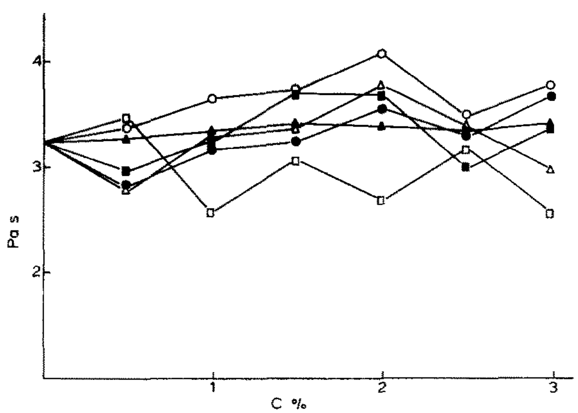

Fig. 3. Effect of nonionic surfactants on the viscosity of 5% Blanose solution at high frequency ($f = 63.1$ rad/s): (○) Abil B 8842, (●) Tagat 02, (△) Tagat L2, (▲) Abil B 8843, (□) Aminoxid WS 35, (■) Abil B 8851.

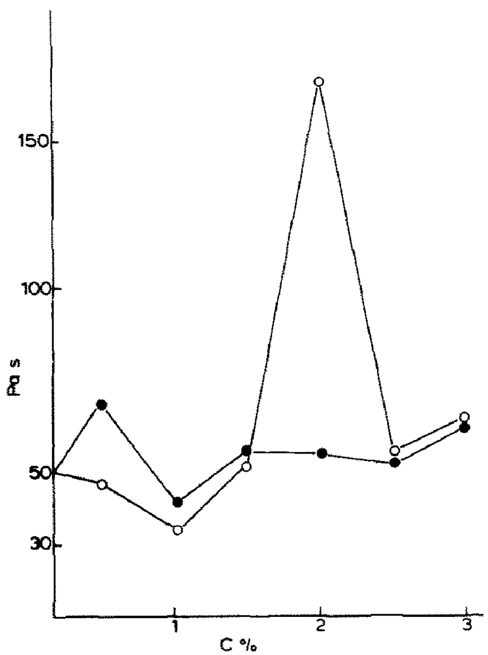

Fig. 4. Effect of amphoteric surfactants on the viscosity of 5% Blanose solution at low frequency ($f = 0.158$ rad/s): (○) Abil B 9950, (●) Tego-Betain L7.

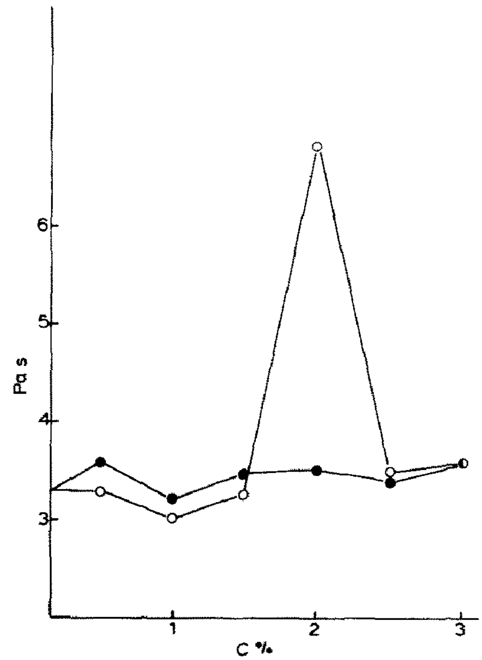

Fig. 6. Effect of amphoteric surfactants on the viscosity of 5% Blanose solution at high frequency ($f = 63.1$ rad/s): (○) Abil B 9950, (●) Tego-Betain L7.

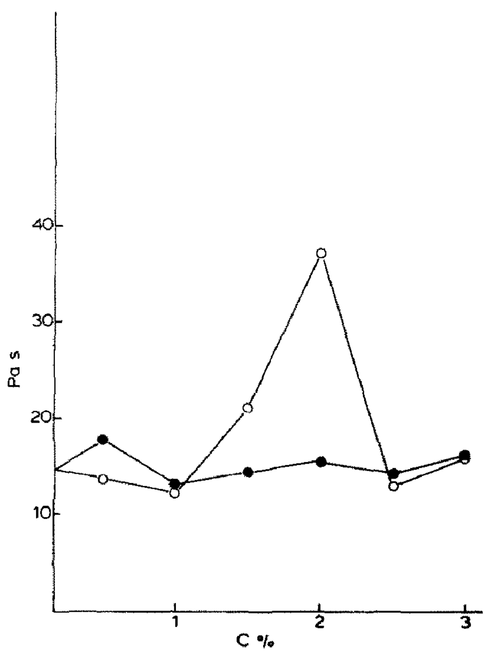

Fig. 5. Effect of amphoteric surfactants on the viscosity of 5% Blanose solution at medium frequency ($f = 2.512$ rad/s): (○) Abil B 9950, (●) Tego-Betain L7.

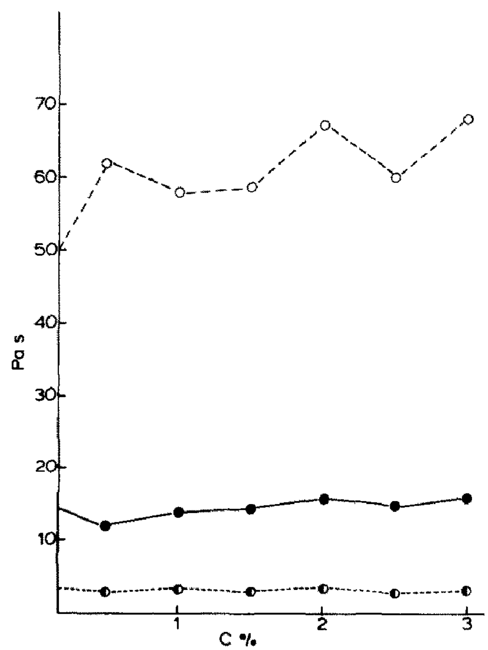

Fig. 7. Effect of sodium lauryl sulphate on the viscosity of 5% Blanose solution at different frequencies: (○) 0.158 rad/s, (●) 2.512 rad/s, (◐) 63.1 rad/s.

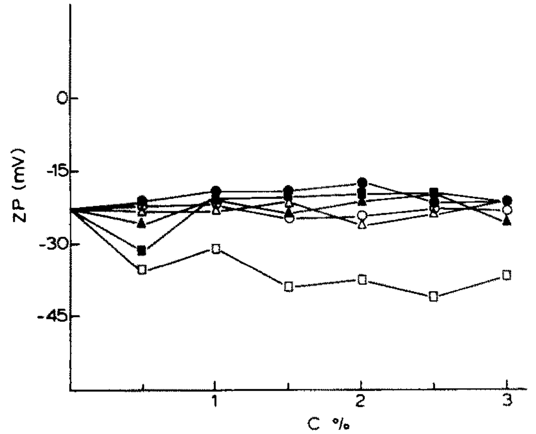

Fig. 8. Effect of nonionic surfactants on the zeta potential of Blanose particles: (●) Abil B 8842, (▲) Abil B 8843, (■) Abil B 8851, (○) Tagat 02, (△) Tagat L2, (□) Aminoxid WS 35.

found to be well suited to the Zeta-Meter with regard to particle observation and counting. All measurements and calculations of zeta potentials were carried out as described in the instrument manual.

Results

The effects of the concentration of the nonionic type surfactants and of different frequencies on the viscosity of Blanose solution are summarized in Figs 1–3. Of the 16 different frequencies employed, three were selected for graphical presentation: low (0.158 rad/s), medium 2.51 rad/s) and high (63.1 rad/s).

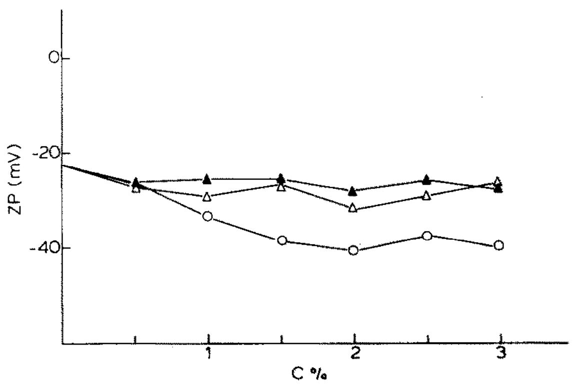

Fig. 9. Effect of amphoteric [(△) Abil B 9950, (▲) Tego-Betain L7] and anionic [(○) sodium lauryl sulphate] surfactants on the zeta potential of Blanose particles.

The influence of the amphoteric surfactants on the viscosity of 5% Blanose solution is presented in Figs 4–6.

The effect of the anionic surfactant, sodium lauryl sulphate, on the viscosity of 5% Blanose solution at different frequencies is presented in Fig. 7.

Figs 8 and 9 show the effect of the surfactants on the zeta potential of Blanose particles.

Discussion

In general, nonionic surfactants caused no significant change in the viscosity of 5% Blanose solution. The only exception was the sample made with Aminoxid WS 35, for which a decrease in viscosity was observed. The Abil surfactants resulted in a very slight increase in viscosity up to a concentration of 2%, which was followed by a decrease. With Tagat 02 and L2 a similar trend was evident but is even less significant. From Figs 1–3 it is obvious that the applied frequencies did not affect the results obtained.

Comparable effects of surfactants on the viscosity were observed for all three frequencies.

From Figs 4–6, it is clear that Tego-Betain L7 did not influence significantly the viscosity of Blanose solution, particularly at higher frequency. At low frequency there occurs a very small increase in viscosity. The results obtained with Abil B 9950 are very interesting; at all frequencies applied, the viscosity of Blanose solution displayed a sudden and considerable increase at 2% concentration of Abil B 9950.

From Fig. 7 it is seen that the values of the viscosity of 5% Blanose solution remain very similar for different concentrations of surfactant and at different frequencies of measurement.

Figs 8 and 9 show that the nonionic surfactants generally lack a significant effect on the values of the zeta potential of Blanose particles. The only exception is Aminoxid WS 35, which gave rise to a significant increase in the electronegative value of the zeta potential. It could be concluded that with increase in the viscosity, the zeta potential decreased. This is probably related to the fact that the presence of an electrical double layer exerts a profound influence on the flow behaviour, this phenomenon being well known as the electroviscous effect. Abil B 9950 and Tego-Betain L7 increased the electronegativity of Blanose particles. The most significant change was observed with the Blanose sample containing added sodium lauryl sulphate. In conclusion, it is obvious that, in most of the samples investigated, changes in viscosity were insignificant, as were the electrical properties. Only in the presence of 2% of Aminoxid WS 35 did the Blanose solution exhibit a marked change in viscosity and zeta potential.

Acknowledgement

This work is part of an investigation financially supported by the Science Fund of Serbia, Yugoslavia.

References

Dawes, W.H. and Groves, M.J., The effect of electrolytes on phospholipid stabilized Soybean oil emulsions. *Int. J. Pharm.*, 1 (1978) 141–150.

Djurić R.Z. and Jovanović D.M., The electrophoretic mobility of sodium carboxymethylcellulose particles. *Arh. Farm.*, 4 (1983) 185–191.

Djurić R.Z. and Jovanović D.M., The effect of carboxymethylcellulose on the electrophoretic mobility of sulfadiazine particles. *Arh. Farm.*, 6 (1984) 287–292.

Djurić R.Z. and Jovanović D.M., The effect of carboxymethylcellulose on the electrophoretic mobility of hydrocortisone acetone particles. *Arh. Farm.*, 3 (1985) 71–77.

Eros I. and Ditigen M., Effect of the addition of surfactants on the rheological properties of polyacrylate hydrogels. *Pharmazie*, 43 (1988) 797–798.

Primorac M.M., Tufegdžić J.N. and Sekulović V.D., Determination of the viscosity of vehicles for vaginal contraceptives with sodium carboxymethylcellulose and Veegum HV. *Pharmazie*, 41 (1986), 292.

Rakić M.R., Jovanović D.M. and Djurić R.Z., Relation between viscosity of carboxymethylcellulose aqueous solutions and charge of its particles in the presence of preservatives. *Int. J. Pharm.*, 39 (1987) 47–50.

Rambhau D., Phadke D.S. and Dorle A.K., Evaluation of O/W emulsion stability through zeta potential I. *J. Soc. Cosm. Chem.*, 28 (1977) 183–196.

Salama H.A., Effect of sodium carboxymethylcellulose on the rheological characteristics of Macaloid dispersions. *Pharmazie*, 36 (1981) 621–624.