National Conference with International Participation
ENGINEERING MECHANICS 2001
Svratka, Czech Republic, May 14 - 17, 2001

SUBSTANCES FOR THE COMPLEX MODUS LUBRICATION IN ARTIFICIAL JOINTS

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Summary: *We have been studying some possibilities to fulfil the lubrication demands in artificial joints. The interactions of gamma-globulin (GG) or polyvinylpyrrolidone (PVP) with sodium salt of carboxymethyl cellulose (NaCMC) were followed by the rheological measurements. The results indicated that GG might slightly interact with NaCMC, thus forming some super-molecular arrangement, while PVP did not correspond adequately.*

1. INTRODUCTION

The lubrication in synovial joints under physiological conditions is very complex one. It comprises at least two different mechanisms of lubricating action, i.e. the fluid film lubrication and the boundary lubrication. In artificial joints, where pathologically changed joint´s structures have been replaced by some kind of the prosthetic material (e.g. titanium, stainless-steel, ceramics, UHMWPE), lubrication is being performed by the spontaneously occurring blood plasma exsudate. It is composed mainly of plasma albumin (11 mg/ml) and gamma-globulin fraction (7 mg/ml), supplemented with variable amount of hyaluronic acid, functioning here as a fluid film lubricant [1,2,3].

Recently**,** sodium salt of carboxymethyl cellulose derivative (NaCMC) has been chosen as a suitable replacement for the hyaluronic acid. However, some substances coming from the plasma exsudate (especially gamma-globulin fraction), might be interacting with NaCMC to form a super-molecular structure arrangement. Therefore, we studied interactions of bovine gamma-globulin with NaCMC in aqueous solutions by rheological methods. Moreover, we used here also polyvinylpyrrolidone (PVP) as a model substance for the gamma-globulin fraction.

2. MATERIALS AND METHODS

Materials:

Bovine gamma-globulin, carboxymethyl cellulose/high and low viscosity/ and polyvinylpyrrolidone (K15: Mw=1x10^4 and K30: Mw=4x10^4) were purchased in Germany, from Fluka Chemie AG - RdH Laborchemikalien GmbH&Co. KG.

Hydrochloric acid GR – NORMANAL (c_{HCl}=0.1 mol/l) was obtained from Lachema, a.s., Brno. Distilled water was used in preparation of the following aqueous solutions:

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a) 1% (w/v) NaCMC/High viscosity, pH=7.4;
b) 1% (w/v) NaCMC/Low viscosity, pH=7.2;
c) 2% (w/v) NaCMC/High viscosity, pH=7.4;
d) 2% (w/v) NaCMC/Low viscosity, pH=7.2;
e) 0.7 g bovine gamma-globulin and 0.02 g sodium azide in 100 ml of the a solution;
f) 0.7 g bovine gamma-globulin and 0.02 g sodium azide in 100 ml of the b solution;
g) 0.7 g bovine gamma-globulin and 0.02 g sodium azide in 100 ml of the c solution;
h) 0.7 g bovine gamma-globulin and 0.02 g sodium azide in 100 ml of the d solution;
i) 1% (w/v) PVP (K15), pH=4.5 (original value) and pH=0.9 (after addition of HCl);
j) 1% (w/v) PVP (K30), pH=3.5 (original value) and pH=1.3 (after addition of HCl);

Remark: Sodium azide was used there as a preservative - to protecting growth of bacteria.

Rheological procedures:

The measurements were performed at 25°C and 37°C on the rotary viscometer Rheotest™; some viscosity data were obtained with help of classical Höppler´s viscometer (at 25°C).

3. RESULTS AND DISCUSSION

The rheological data, i.e. viscosity (Pa.s) vs. velocity gradient (1/s), revealed only a slight increase for the viscosity values of the NaCMC solutions, that had been supplemented with bovine gamma-globulin fraction. While, in the case of PVP: viscosity of all samples is being lowered markedly by increasing concentration of PVP in NaCMC solutions. However, this effect is more pronounced with PVP (K15) sample; having lower Mw (10 000) and, therefore, a higher number of macromolecules in the solution. Similar decrease of viscosity can be achieved also by the addition of the pure 0.1 N-HCl. The marked interference of PVP/HCl mixture within NaCMC macromolecules in aqueous solution has lead in some cases to the controversial actions: an increased or decreased velocity of the viscosity droping. These effects were not observed with the pure PVP substances in aqueous solutions, albeit the original pH values have been considerably low (3.5 and 4.5, respectively). It must be stressed that positive charges on the PVP molecules being formed by protonization of the nitrogen atoms, i.e. in an acidic environment only.

4. CONCLUSIONS

From the experimental data following statements have been drawn: First, the GG and NaCMC molecules in aqueous solution might interacting each other and thus forming some supermolecular structures. From the practical point of view, however, these seem not important at the physiological concentrations. On the other hand, the PVP has not been found as an adequate model compound for GG because of precipitation NaCMC molecules in solution, which action caused drop of its viscosity.

5. REFERENCES

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