Novel Sodium Alginate – Poly(N-isopropylacrylamide) Thermoreversible Injectable Hydrogels with Semi-Interpenetrating Network Structure

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INTRODUCTION Thermoresponsive polymers displaying lower critical solubility temperature (LCST) in water have been intensively researched within the last years due to their potential uses in many fields, including tissue engineering, controlled release of therapeutics, cell growth, rheology modifiers, chemical valves and sensors, catalysts, smart textiles. Amongst the LCST-displaying thermosensitive polymers, poly(N-isopropylacrylamide) (PNIPAM) is the most well-known. It was very much studied, especially for biomedical purposes, due to the LCST close to body temperature (about 32°C), abrupt thermal response and low sensitivity to slight modifications of pH, concentration or chemical environment.

AIM Our goals are the preparation and the presentation of thermogelation properties of novel thermoreversible hydrogel formulations based on SA–PNIPAM physical mixtures. We will show for the first time that the addition of hydrophilic SA polymer to the PNIPAM aqueous solution strongly improves the stability against syneresis of the hydrogels.

RESULTS AND DISCUSSION

Temperature-sweep rheological measurements upon PN-C aqueous of 5-20wt.% concentration displaying demixing phenomenon. Temperature-sweep rheological measurements upon PN-C aqueous solutions of 10-20 wt.% concentration showed first a sharp increase of dynamic viscosity at about 33°C due to the polymer chain association at the phase-separation temperature, followed by a sharp decrease of these parameters when demixing occurs.

The effect of SA addition upon viscosity (A), elastic modulus G’ (B) and hydrogel stability after 60 min at 37°C (C1, C2 – 0 wt.% SA; D1, D2 – 2 wt.% PN-C aqueous solutions.

Dependence of G’ and G” on temperature and SA concentration for the 15 wt.% PN-C aqueous solutions of: A) PN-C 15%-SA 0%; B) PN-C 15%-SA 2%; C) PN-C 15%-SA 4%. At temperature higher than the temperature at which viscosity increases, all PN-C 15% - SA x% solutions displayed a preponderently elastic character on the temperature interval investigated because G’ became larger than G” immediately after viscosity started to increase.

Dependence of the temperature corresponding to the minimum of the endothermic peak on the DSC curve on SA concentration for 15 wt.% PNIPAM aqueous solutions. The phase-separation temperature of the PNIPAM aqueous solutions decreased with alginate concentration, while the dynamic viscosity and the elastic modulus of the hydrogels increased due to the more numerous PNIPAM – alginate physical interactions.

The properties of the PNIPAM – alginate hydrogels depend also on PNIPAM molecular weight and molecular weight distribution.

CONCLUSIONS:

- Novel injectable thermoreversible hydrogel compositions with SIPP structure were prepared by adding SA to PNIPAM aqueous solutions. The addition of the hydrophilic biopolymer improved the stability against syneresis of the 15 wt.% PNIPAM hydrogels formed at 37°C from less than 15 minutes in the absence of alginate to more than 7 days in the presence of 4 wt.% SA.
- The phase-separation temperature of the PNIPAM aqueous solutions decreased with alginate concentration, while the dynamic viscosity and the elastic modulus of the hydrogels increased due to the more numerous PNIPAM – alginate physical interactions.
- The properties of the PNIPAM – alginate hydrogels depend also on PNIPAM molecular weight and molecular weight distribution.

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FTIR spectra of PN-C, SA and 15/4 wt/wt PN-C/SA mixture.

Dependence of the temperature corresponding to the minimum of the endothermic peak on the DSC curve on SA concentration for 15 wt.% PN-C aqueous solutions. The phase-separation temperature decreased with alginate concentration, as indicated by the evolution of both the temperature at which viscosity increases and the temperature corresponding to the minimum of the endothermic peak on the DSC curve.