MICRO- AND MACROSCOPIC PROPERTIES OF CHITOSAN COLLOIDAL SOLUTIONS INVESTIGATED BY RHEOLOGICAL METHODS COUPLED WITH THE SMALL ANGLE LIGHT SCATTERING

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Introduction

Chitosan is an amino-polysaccharide obtained by deacetylation of chitin. Chitosan, as a natural biopolymer, a substance with biocompatible and biodegradable properties [1], has found a wide application in medicine, food and cosmetics industries as well as in wastewater treatment processes [2].

In this work, we aimed to study the microstructural and macroscopic properties of chitosan colloidal systems. An analysis of properties of colloidal chitosan solutions using rheological methods combined with a simultaneous small angle light scattering (SALS) measurements was conducted.

Materials and Methods

The measurements were carried out using the Anton Paar Physica MCR 502 rheometer equipped with an integrated SALS optical analysis system. The study concerns chitosan colloidal system with addition of disodium β-glycerophosphate [3].

To determine viscous properties of the medium, the sample was subjected to rotational shear for 60 s at subsequent fixed shear rates of 1...500 s^{-1}, repeating the procedure toward decreasing shear rate values. The process of thermo-induced gelation was carried out under oscillatory shear at fixed strain amplitude γ = 1%, and angular frequency ω = 5 rad/s. The samples were heated from 5°C (storage temperature) to 80°C, maintaining constant heating rate of 1 K/min. The light source was 10 mW LED diode laser operating at a wavelength of 658 nm.

Results and Discussion

The investigated chitosan system reveal a shear thinning behaviour. Simultaneously with a viscosity decreases, a change in the shape of the scattering pattern from circular to elliptical was observed. This change represents orientations and deformations of the polymer domains. Based on the eigenvalues of the second-order tensor of the intensity distribution, the anisotropy was determined to quantify a deformation phenomenon.

The gelation temperature, radius of gyration, and conformation of chitosan molecules were determined based on the oscillatory shear and non-isothermal measurements combined with recording of SALS data. The rheological (crossover point of dynamic moduli and Fredrickson-Larson method) and light scattering (Zimm plot) approaches were used to determine values of phase transition temperatures. Quantification of the chitosan molecules size was achieved by applying the Debye function in order to determine the radius of gyration. Changes in the radius of gyration as a function of temperature for all tested concentrations of colloidal chitosan solutions are shown in FIG. 1.

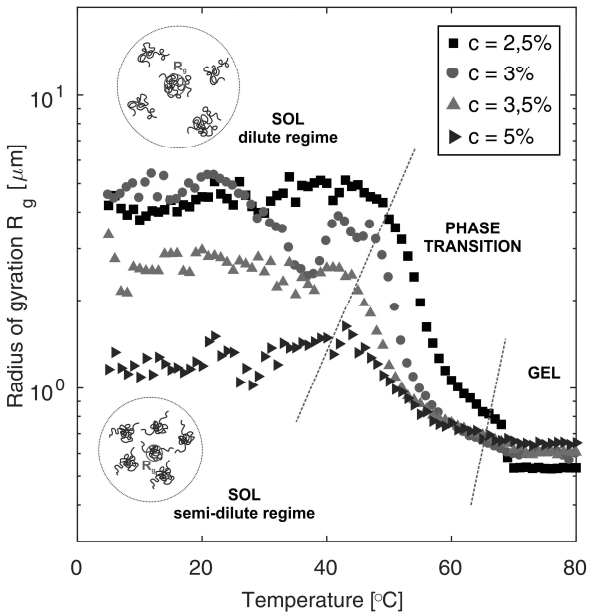

FIG. 1. Changes in the radius of gyration R_g as a function of temperature and the schematic presentation of chains conformations depending on concentration regime.

Conclusions

The conducted studies have shown that in colloidal chitosan solutions, the polymer domains occur in the form of Gaussian coils. Based on rotational shear measurements, it was found that chitosan solution reveals two different behaviours delimited by the critical value of the shear rate.

It was found that with an increase of chitosan concentration, the molecule size decreases. The above statement indicates that in more concentrated solutions, the chitosan coils are more tangled and smaller but occur in a larger number than in the diluted solutions.

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