Objective

The aim of this project is study of the properties of the following systems: starch pastes, solutions of non-starch hydrocolloids and mixtures of pasted starch and hydrocolloids during extensional flow. To realize the extensional flow it is planned to build elongational rheometer implementing stagnation flow, enabling to measure elongation Trouton viscosity. For comparative purposes it is planned to perform shear flow measurements and the resulting the first difference of normal stress using a rotational rheometer. The comparison of values of the elongation viscosity vs apparent viscosity, determined for shear stress, allows to determine basic relationships between these values. A mathematical modeling based on own relationships will be carried out to analyze time constants distributions for the investigated systems, both during extensional and shear flow. The obtained results will be interpreted in the aspect of the molecular structure of the studied polysaccharides and interactions occurring in solutions among solvent, starch, and non-starch hydrocolloid.

Basic research

As a part of this project it is planned to carry out the extensional viscosity measurements of the abovementioned systems based on the prototype elongation rheometer realize stagnant flow. The measurement idea is based on the simultaneous sucking of the investigated liquid, at the same flow rate by two identical nozzles located opposite of each other. These nozzles are immersed in the tested liquid. One nozzle is stationary, whereas the other is connected to the torque sensor. By measuring the flow rate of the sucked liquid and the torque which is generated on the arm connected to nozzle it is possible to determine the elongation viscosity and stretching rate.

In parallel with the elongation viscosity studies, within the project it will also be carried out a measurement using rotational rheometer. It will be determined the apparent viscosity curves and the first difference of normal stress. Mathematical models described in the previous paragraph will be fitted to both values. The rheological properties of the study systems will be described using mathematical models in the form of power series type equation.

Dynamic light scattering measurements on biopolymers coils will be performed using a goniometer coupled with autocorelator. The results will be used to determine the autocorrelation function,which will be used to determine a dependence of hydrodynamic radius on the temperature [5,6]. SLS techniques studies will involve in measurement of light scattered by the analyzed biopolymers solutions. Further data processing will be based on the creation of Zimm graphs, and they will be used to determine the following parameters: the radius of gyration, the second virial coefficient, average molecular weight. Further investigation will contain the analysis of shape of the macromolecules present in investigated solution. An appropriate shape functions (particle scattering factors) P(qRg) or P(q), will be fitted, enabling to determine shape (conformation) of macromolecules in solution at rest.

Linking of these results with the detailed analysis of the first normal stress difference will create an complete view of the properties of starch pastes, hydrocolloids solutions, and mixtures thereof during the effective flow.

Reasons for choosing the research topic

In the case of extensional viscosity measurements research are mainly concerned with synthetic polymers, and works on bioplymers soltions focused on xanthan gum, cellulose and its derivatives solutions. There is a lack of publications about „other" properties of large group of polysaccharides solutions during extensional flow.

The result of the project will be understanding of the unique properties of starch pastes, solutions of selected non-starch hydrocolloids and mixtures of starch pastes and hydrocolloids. These results will fill a severe gap in the knowledge related to mentioned systems behavior during elongation flow. The implementation of the tasks planned in this project will allow to determine the impact of hydrodynamic radius and shape of the particles on the extensional and apparent viscosity - stated during shear flow, and hence on the Trouton ratio. This aspect has not been considered by investigators. Construction of the instrument in with wide range of nozzle diameters and changeable, different-lenght arms will allow to the analysis of studied systems' behavior at different measurement conditions. Research materials were selected to significat differences in molecular weight and a possible dimensional conformation in solution exist. It will allow to the widest possible illustration of the previously mentioned relationships.