

The influence of counterions on the formation and functionality of polyelectrolyte membranes

Polyelectrolyte multilayers (PEM) are among the most promising systems in the field of material science, intensively developed and broadly examined with constantly increasing interest, being a simple, inexpensive, flexible and versatile surface modification tool. The mechanism of how various counterions affect the formation of polyelectrolyte multilayers is not entirely clear and thus, in the case of polyelectrolyte multilayers it is a scientific novelty with many fundamental problems to be solved.

Specific interactions of counterions with macromolecules have already been observed more than 100 years ago and the phenomenon has been named the Hofmeister effect. It refers to an ordered sequence of ions, the Hofmeister series, also called the lyotropic series. Originally it was found in the studies on the precipitation of egg white proteins in the presence of different salts. The Hofmeister effect is known to play an important role in several biological phenomena, but it is rarely mentioned in connection with synthetic polyelectrolytes.

Systematical research on the surface properties of selected polyelectrolyte systems in the presence of counterions of various valences from lyotropic series is needed to propose a suitable mechanism. The scientific goal of the project is to develop the model of the formation of polyelectrolyte and nanocomposite films in the presence of the selected counterions of various valences from the lyotropic series, thus to incorporate the Hofmeister ion effects into the properties of polyelectrolyte multilayers. Undeniable scientific innovation of the project is the use of series of multivalent ions as counterions in polyelectrolyte solutions. Although the number of studies on various aspects of polyelectrolyte/nanocomposite multilayers is tremendous, there are almost no attempts to combine films properties with the type of electrolyte (valence of its ions and lyotropic effect).

Multilayer films will be deposited using layer-by-layer technique of sequential adsorption of polyions from their solutions. Optimization of the formation of such structures in the presence of selected electrolytes will include the studies on the kinetics and efficiency of the deposition process by Quartz Crystal Microbalance with Dissipation. Thickness and roughness of multilayers adsorbed on the selected surfaces, as a function of parameters specific to the selected deposition will be controlled and the structure of the obtained materials will be examined with imaging spectroscopic ellipsometry as well as by using atomic force microscopy. Characteristics of wettability and surface energy of the obtained polyelectrolyte (nanocomposite) films in relation to the electrolyte used during the deposition will be done by direct image profile analysis of the sessile drop. Broad, comprehensive characterization of the properties of obtained systems will include also permeability and active release of model functional substances from obtained multilayers by means of cyclic voltammetry.

The main and measurable effect of the project will be to develop the model of the formation of polyelectrolyte and nanocomposite films in the presence of the selected counterions of various valences from the lyotropic series. Basic knowledge and experience collected will help to understand the mechanisms responsible for the structure formation and thus, it will enable the design of materials of strictly defined properties and to relate the counterion conditions with PEM functionality. It will be useful in follow-up studies leading to the implementation of obtained results into the area of selective membranes, biomaterials and nanocontainers, making a significant contribution to them. This is extremely important from a practical point of view, because it will increase the possibility of designing biomaterials or membranes taking into account the desired physicochemical properties and their specific applications. This is why the decent understanding of these, so far – overlooked factors affecting multilayers' structure and permeability is particularly important.