Abstract

The aim of this work is to develop a simple, non-invasive method for measuring the excess electric charge trapped in dielectric materials. Here proposed solution is based on the optical pendant drop method that is commonly used to measure the surface free tension of liquids. Therefore, the developed solution will be easily implementable into existing tensiometers by simple software modification. The pendant drop method uses axisymmetric drop shape analysis of the droplet hanging from a needle in a given atmosphere in gravitational field. When the electric field is added to the system, we observe that the shape of the studied droplet changes. The change increases with increasing electric intensity and eventually, when the critical value of the electric intensity is reached, the droplet detaches from the needle. In this thesis we develop a microscopic theoretical model that aims to interpret these phenomena as well as to quantify them as a function of the acting electric field. The theoretical model is confronted with experiment and with conventional method for charge measurement using coulombmeter. In the experiment the electric field is generated by the excess electric charge in the dielectric sample. The studied dielectric is biocompatible hydroxyapatite that was irradiated by the electron beam in Scanning Electron Microscope. The electrically modified hydroxyapatite demonstrably accelerates the adsorption of cells, proteins, or bone-like layers onto its surface, thereby potentially aiding the healing process. Since the electric field generated by the charged sample of finite dimensions is non-homogenous, the value of the electric intensity can be increased by decreasing the distance between the droplet and charged sample. We document the evolution of the surface free tension as a function of the distance between the droplet and charged dielectric sample as well as the critical distance at which the droplet detaches. The experimental curves are in good agreement with theoretical predictions. Moreover, by fitting the experimental data with here-developed theory, we can calculate the value of the excess electric charge trapped in the hydroxyapatite sample. Results from the fitting of the surface free tension, calculation from the critical distance and coulombmetric measurements are all very similar. At the end of the thesis we apply the newly developed method to three scientifically relevant problems. Namely, to demonstrate the stability of the trapped charge in samples, to measure small values of trapped charge in thin films, and to compare various hydroxyapatite samples prepared by different methods.
Keywords: pendant drop, electric charge, hydroxyapatite, electrohydrostatics, electron beam