Measurement of Trapped Electric Charge in Dielectric Biomaterials Charged in Scanning Electron Microscope

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Abstract. Charging of dielectrics in a Scanning Electron Microscope (SEM) is a common effect that complicates the imaging of dielectric samples. However, it can be intentionally used to electrically modify surfaces of biomaterials to increase their bioactivity and enhance protein and cell adsorption. The adsorption processes are carried out in three main ways: electrostatic interactions, hydrophobic/hydrophilic interactions and acido-basic interactions, while the first two can be significantly influenced by electrical modification. In this study, we investigate the changes in the wettability of bulk hydroxylapatite samples after electron beam irradiation. Thanks to the dielectric character of hydroxylapatite, some electrons that irradiate the sample get trapped in the surface layer and modify surface properties of the biomaterial. According to X-ray photoelectron spectroscopy and X-ray diffraction, the used samples are made of pure polycrystalline hexagonal hydroxylapatite. Samples were repeatedly irradiated with electrons accelerated by 30 kV in SEM combined with an electron lithograph, which allowed to define the area to be irradiated and to set the exact electron dosage that varied from 0.01 $\mu C/cm^2$ to 10 $\mu C/cm^2$. With increasing dosage, we observed an increase in the average value of the contact angle, thus a decrease in the wettability, which opposes the expectations based on the electrowetting theory. The real value of the trapped electric charge was measured by a coulombmeter. The average value of the trapped charge was of the order of 10^{-10} - 10^{-9} C and increased with increasing dosage, however, in some cases differed by 1-2 orders of magnitude from the total value that had been radiated. The standard deviation increased with increasing dosage as well, which indicated either instabilities of the charging process or unsuitability of the measurement method. Moreover, the electron-mirror effect was observed when high dosages were irradiated.