Microscopic study of zinc oxide molecular biointerface

Bohuslav Rezek[1], Jaroslav Jíra[1], David Rutherford[1], Hadi Hematian[1], Egor Ukraintsev[2], and Zdeněk Remeš[2]

[1]*Faculty of Electrical Engineering, Czech Technical University in Prague, Technicka 2, 16627 Prague 6, Czech Republic*
[2]*Institute of Physics of the Czech Academy of Sciences, Cukrovarnicka 10, 16200 Prague 6, Czech Republic*

Zinc oxide is a semiconductor material well known as transparent conductive electrode as well for its photocatalytic and bactericidal properties. It has been prepared in various forms and sizes and it also available commercially. Properties and functions of various ZnO nanoparticles and nanomaterials are thus intensively investigated also in biological systems for diagnostics, therapy, health risks assessment as well as decontamination purposes. Yet understanding actual processes behind the observed effect is still debated. One of the reason is complexity in terms of ZnO fabrication properties, resulting structural, chemical and electronic properties as well as the effect of biological environment, where the nanomaterials can significantly change the size, shape and zeta potential (even reverse it). The mutual interaction of ZnO nanomaterials and biological environment can manifest itself in various ways and can be very specific for particular nanomaterial and its surface modification.

In this work, we focus on the actual interface between ZnO and biological environment. At first, by using atomic force microscopy (AFM) we have studied adsorption of fetal bovine serum and bovine serum albumin (typical supplement in cell culture medium) on ZnO plates. Droplets of biomolecular solution (20 uL, 30 mg/mL) were deposited on clean ZnO substrates for 10 minutes, rindsed with demi water, dried with nitrogen. We employed CF_4 treated AFM tips to minimize tip contamination by biomolecules during morphology analysis. The RMS surface roughness was below 1 nm in all cases. Globular features were resolved for both FBS and BSA. We also employed so-called nanoshaving method to determine thicknes of the biomolecules adsorbed on ZnO. Thickness of FBS 1.9 $\pm$ 0.2 nm, BSA was 2.0 $\pm$ 0.3 nm, thus very comparable. However, BSA layer was more strongly attached to ZnO compared to FBS layer. Force of 10 $\pm$ 5 nN was sufficient to remove FBS layer from ZnO, however, 25 $\pm$ 5 nN were needed to remove BSA layer. Compared to our reference, oxidized diamond surfaces, the morphology of molecular layer is similar, however, the binding forces are much stronger on ZnO. We performed atomic scale computing of the ZnO bionterface by force field method to support understanding the above effects and differences. We discuss implications for protein corona on ZnO nanostructures.

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