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Bioactivation of surfaces using embedded radicals: A platform technology for harnessing nature's nanomachines

Marcela Bilek[1], Alexey Kondyurin[1], Stacey L Hirsh[1], Elena Kosobrodova[1], Daniel V Bax[2], Anna Waterhouse[2], Yongbai Yin[1], Neil J Nosworthy[3], David R McKenzie[1], Anthony S Weiss[2]

[1]School of Physics, A28, University of Sydney, Australia [2]School of Molecular Biosciences, G08, University of Sydney, Australia [3]School of Medical Sciences, F13, University of Sydney, Australia

m.bilek@physics.usyd.edu.au

The ability to strongly attach biomolecules to surfaces whilst retaining their biological activity underpins a host of biotechnologies, such as biosensors and diagnostic microarrays for early disease detection. Recent work has revealed that radicals embedded in carbon rich surface layers by energetic ion bombardment can covalently immobilize bioactive proteins [*Proc. Nat. Acad. Sci* 108(35) pp.14405-14410 (2011)]. This new approach delivers the strength and stability of covalent coupling without the need for multi-step wet chemistry. Immobilization occurs in a single step directly from solution and the hydrophilic nature of the surface ensures that the bioactive 3D shapes of the protein molecules are not disturbed.
Energetic ion treatments conferring protein immobilization capability can be applied to any underlying material making it possible to achieve covalent biomolecule immobilization whilst maintaining the physical properties (including mechanical and electrical) of an underlying material. This opens up the possibility of new applications such as integrated microelectronic or photonic biosensing devices, continuous flow reactors for enzymatic chemical, textile or biofuels processing and implantable biomaterials that interact with their host via an interfacial layer of active biomolecules to direct a desired cellular response to the implant.
This presentation will describe a number of plasma-based approaches for creating suitable buried radicals through energetic ion impacts. The crucial roles of surface chemistry and microstructure in simultaneously preventing radical annihilation whilst allowing sufficient radical mobility are elaborated and a kinetic theory model of the immobilization process is presented. Preliminary applications of this technology to direct cell growth, to create biosensors and protein microarrays, and to engineer the surfaces of implantable biodevices will be reviewed.

Keywords
biologically functionalized surfaces
energetic ion bombardment