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Plasma processes that create one-step multi-functionalisable surfaces and nanoparticles: Fundamentals and applications

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Bio-functionalized surfaces are of great interest for a wide range of applications, particularly in biomedical diagnostics and implantable medical devices. We have shown that radicals embedded in polymeric surfaces facilitate simple, one-step surface-functionalisation [1]. The radicals are created by energetic ion bombardment of the surfaces. Covalent immobilisation of functional molecules is achieved by immersion or spotting / painting of the biomolecule-containing solutions onto the activated surfaces. This strategy simplifies covalent functionalisation of surfaces enormously, eliminating the need for wet-chemistry and the associated solvent disposal and yield problems. This approach has been used to immobilise bioactive peptides, antibodies, enzymes, single stranded DNA, and extra-cellular matrix proteins [2] onto many materials, including polymers, metals and ceramics.

This presentation will expound the fundamental science underpinning these new approaches. Process adaptions that extend the application of these techniques to functionalisation of the internal surfaces of complex, porous materials and structures will be explored. New applications enabling biological studies of the response of individual cells to proteins on a sub-cellular scale [3], and the preparation of multi-functionalisable nanoparticles for theranostics [4] will be elucidated.

Finally, we describe recent work which shows that spontaneous covalent immobilisation enabled by surface embedded radicals allows control of the density and orientation of surface-immobilised bioactive peptides [5]. This is achieved by tuning electric fields in the double layer at the surface during the immobilisation through pH variations and/or the application of external electric fields as delivered by a simple battery.

References:
[1] Bilek et al, PNAS 108:14405-14410 (2011);
[2] Bilek et al, Appl. Surf Sci 310:3-10 (2014);
[3] Kosobrodova et al, ACS Appl. Mater. and Interfaces (2018);
[4] Santos et al, ACS Appl. Nano Materials (2018);
[5] Martin et al, Nat. Comm. 9:357 (2018)

Primary author(s) : Prof. BILEK, Marcela (School of Aerospace, Mechanical and Mechatronic Engineering & School of Physics, University of Sydney, NSW 2006, Australia); Dr KOSOBRODOVA, Elena (School of Aerospace, Mechanical and Mechatronic Engineering & School of Physics, University of Sydney, NSW 2006, Australia); Mr LEWIS, Martin (School of Physics, University of Sydney, NSW 2006, Australia); Dr AKHAVAN, Behnam (School of Aerospace, Mechanical and Mechatronic Engineering & School of Physics, University of Sydney, NSW 2006, Australia)

Presenter(s) : Prof. BILEK, Marcela (School of Aerospace, Mechanical and Mechatronic Engineering & School of Physics, University of Sydney, NSW 2006, Australia)

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