Hydration of ultra-thin surface films and its role in enhancement of biocompatibility of medical devices

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Interaction of substrates with protein and cellular components of biological fluids has constituted an extremely difficult problem with respect to many medical devices. One extremely important example is the extracorporeal circulation of blood associated with renal hemodialysis and coronary bypass surgery. It is widely recognized that the blood-bypass circuitry interaction can lead to stimulation of the immune system and to thrombosis. The latter, in turn, can lead to organ dysfunction, such as cognitive disability. Over many years a variety of strategies have been employed to attempt reduction of this type of surface interaction, with some emphasis on control of surface free energy and imposition of a plethora if surface coatings. In our work, we have developed a surface modification protocol that involves a covalently-bound silane containing a PEG backbone. This structure has been shown to reduce thrombi formation by over 97% on polymer surfaces.

The mechanism of this effect appears to be strongly connected to the structure of water intercalated into the surface -5 Angstrom thin film. The sub-monolayer can be better described as an "adlayer" since it is not close-packed such as in a conventional self-assembled monolayer (SAM). This observation flies in the face of an existing literature mantra that indicates enhanced biocompatibility is linked to SAM chemistry. We have studied the nature water of associated with the adlayer by neutron reflectometry and molecular dynamic calculation. The former shows that the pronounced antifouling properties of the silane stem from a special intra-film zone of hydration that involves the key participation of the internal atoms of oxygen and from which a diffuse inter-phase of water originates.

The presentation will also include an appraisal and comparison of the chemistry evident in the afore-mentioned adlayer with that observed for hydration of the biological membrane head-group region. Although minimally recognized to the present time, such hydration may paly an important role in the nature receptor-agonist interaction.