Comparative Evaluation of Nanoscale Surface Coatings on Silicon Substrates for Implantable Device Applications

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Background:

Highly uniform silicon nanopore membranes (SNM) are under investigation for use in implantable devices for organ replacement functions. A robust, readily scalable, non-fouling surface coating is required to enhance SNM biocompatibility while preventing pore occlusion. We evaluated a number of thin-film surface coatings compatible with silicon processing techniques. Five candidate biocompatible coatings were optimized for sub-5 nm deposition and evaluated for protein resistance.

Methods:

Silicon surfaces were modified using 1) surface grafted self-assembled monolayer polyethylene glycol (PEG); 2) RF plasma polymerized PEG; 3) poly(sulfobetaine methacrylate) (pSBMA) grown on surface via atom-transfer radical polymerization (ATRP); 4) poly(2-methacryloyloxyethyl phosphorylcholine) (pMPC) coated via ATRP; and 5) titanium oxide (TiO_2) deposited via atomic layer deposition. Coating thickness was determined by ellipsometry. Protein adsorption was determined by enzyme-linked immunosorbent assays after 2-hour incubation in single protein solutions of human fibrinogen and albumin. All adsorption data was normalized to uncoated silicon substrates.

Results:

Average coating thickness for the coatings ranges between 0.7 nm to 4.7 nm (Figure 1). All coatings exhibited reduced protein adsorption compared to non-coated substrates (Figure 2). TiO_2-coated silicon had the highest overall fouling, while pSBMA exhibited least fouling with an 84% reduction in human albumin adsorption and 98% reduction in human fibrinogen adsorption compared to bare silicon. The results demonstrate that pSBMA-coated surface exhibit superior non-fouling characteristics that make it suitable for application to SNM-based devices.

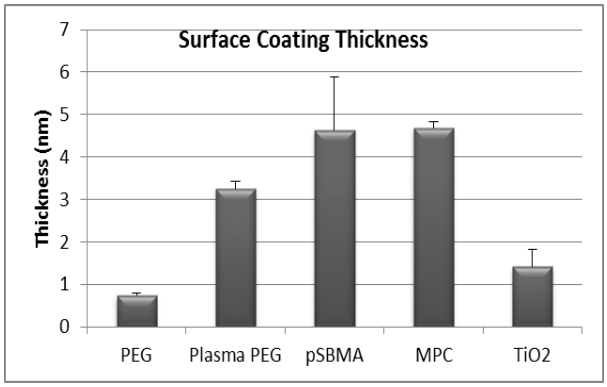

Figure 1: Surface modification coating thickness.

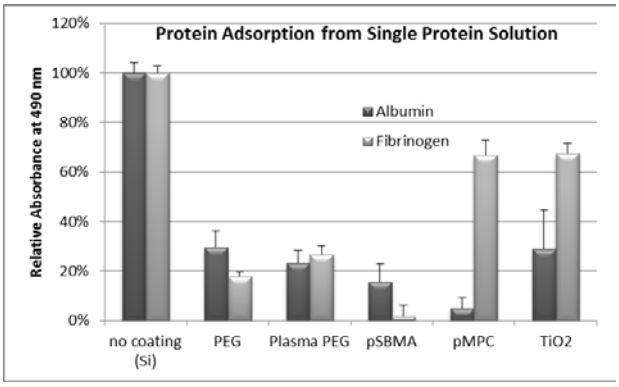

Figure 2: Normalized protein adsorption of human albumin and fibrinogen from single protein solutions.