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Characterization of polysulfone based hemodialysis membranes by afm

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Most of the hemodialysis membrane materials are hydrophobic in nature and allow protein adsorption on the surface easily due to hydrophobic interaction between membrane surface and protein molecules when in contact with blood. Adsorbed proteins can affect platelet and leukocyte adhesion, and modulate the response of plasmatic reactions followed by the activation of different defense systems in blood (Sun et al. 2003). In order to solve this problem, surface modification techniques such as; blending hydrophilic polymers into the membrane forming solution, grafting hydrophilic groups by UV-irradiation or low temperature plasma technique, graft copolymerization of monomers, coating with hydrophilic polymers or copolymers (Sun et al. 2003) and polyelectrolyte multilayer immobilization (Yu et al. 2007), are commonly used. Recently, the layer by layer self-assembly (LBL) technique has emerged as an efficient and easy surface modification technique in biomedical engineering. The method basically depends on the sequential deposition of polycations and polyanions on a polymeric surface upon immersing the membrane into an aqueous solution of oppositely charged polyelectrolyte solutions (Yu et al. 2007).

The amount and types of proteins adsorbed on membranes are evaluated by experimental techniques such as mass spectroscopy, X-ray photoelectron spectroscopy (XPS) and surface plasmon resonance (SPR). However, these techniques do not provide information about the physicochemical interactions occuring during the adsorption. On the other hand, the modification of surfaces at molecular level, as in LBL method, requires an experimental technique that provides detailed dynamic information on the forces which drives protein adhesion.

In this study, we attempted to quantify the magnitude of forces driving protein adhesion on biomaterials using Atomic Force Microscopy (AFM). Bovine serum albumin (BSA) modified silicon AFM tips or specially constructed colloid probes of desired material (silica, charged ploystyrene, etc) were employed to investigate the interactions between the BSA and subsequent polyethyleneimine/alginate layers deposited on PSF membranes.

Modification of the AFM tips or colloid probes (called probes hereafter) with model protein BSA have been carried out using the methodology described by Jens Schafer et. al. (2011). In this method, the probe surface is silanized through subsequent dipping and cleaning procedures to facilitate the BSA adsorption. Initial BSA concentration is varied to yield varying BSA thickness on the probe surface. The modified probes are evaluated using characterization techniques such as Scanning Electron Microscopy (SEM).

Substrates used were the PSF membranes consisting of subsequent polyethyleneimine/alginate layers and were prepared with layer by layer method (LBL). The number of layers was the chosen parameter for membrane surface modification and ranged between 1 and 9 layers. The prepared membranes were characterized in terms of protein adsorption capacity, hydrophilicity (contact angle measurements) and surface morphology (SEM micrographs).

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In order to develop quantitative information on the magnitude and nature of the forces driving BSA adsorption on LBL modified PSF surface, the pull-off forces between BSA modified and bare AFM tips and membrane surfaces were measured. The raw AFM data was in the form of a cantilever deflection versus piezo translation curves. It was converted to force versus separation distance curves using cantilever spring constans determined by the Sader's Method.

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