Superlow Fouling Poly(Sulfobetaine) Surfaces

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Statement of Purpose: Poly(sulfobetaine methacrylate) [poly(SBMA)] is of excellent stability as compared to poly(ethylene glycol) (PEG) or phosphorylcholine (PC). There are only a few studies on poly(SBMA). [1,2] It was shown before that poly(SBMA)-based materials were not as effective as those of 2-methacryloyloxyethyl phosphorylcholine (MPC) to resist protein adsorption and cell adhesion.[1] Recently, we grafted poly(SBMA) from a surface via polymer brushes or onto a surface via copolymers. Results show that they are highly resistant to protein adsorption and cell adhesion if their surface densities are well controlled. With their good stability and superlow fouling properties, poly(SBMA)-based materials have many advantages over existing nonfouling materials for biomedical applications that require long-term stability.

Methods: Two approaches were used to prepare superlow fouling surfaces covered with poly(SBMA). One is to graft polymer brushes from the gold surface while another is to graft copolymers onto the gold surface. For the preparation of polymer brushes, SBMA monomers were grafted from the gold surface coated with bromine-terminated self-assembled monolayers (SAMs) using the surface-initiated atom transfer radical polymerization (ATRP) method. For the copolymer approach, three well-defined diblock copolymers of poly(SBMA) and poly(propylene oxide) (PPO) were synthesized by the sequential addition of SBMA monomer using a ATRP method with fixed PPO and varying poly(SBMA) lengths. A wavelength-dependent surface plasmon resonance (SPR) spectroscopy was used to measure the adsorption of fibrinogen.

Results / Discussion: For the poly(SBMA) brushes, the adsorption of fibrinogen was decreased to less than 0.3 ng/cm^2 (or wavelength shift less than 0.02 nm) as shown in Figure 1. It was found that the thickness of poly(SBMA) could affect protein adsorption. The thickness of polymer layers could be controlled by reaction time and monomer concentration, and was measured by ellipsometry. These substrates grafted with poly(SBMA) were left in air or immersed in water at room temperature for more than one month without losing their superlow fouling properties. For the PPO-*b*-poly(SBMA) copolymers, three different copolymers A, B, and C were synthesized. While copolymer A has similar poly(SBMA) and PPO segments, copolymers B and C have larger poly(SBMA) than PPO segments. Figure 1 showed SPR sensorgrams that fibrinogen adsorption is very low on copolymers A and B surfaces and higher on copolymer C due to more surface packing defects formed from the large molecular size of copolymer C. When the surface covered with copolymer C was back-filled with copolymer A with smaller molecular weight (illustrated in Figure 2), very lower protein adsorption was also achieved. This result indicates that higher fibrinogen adsorption is due to higher surface cavities caused by the adsorption of the copolymer with higher molecular weight and these cavities can be back-filled with copolymers with smaller molecular weight. Results further show that the surface packing density of PPO-*b*-poly(SBMA) plays a significant role in surface resistance to protein adsorption.

Conclusions: This work demonstrates that the surfaces covered with poly(SBMA) via polymer brushes and copolymers are superlow fouling if surface SBMA densities are well controlled. Results indicate that phosohorycholine is not a unique group to highly resist protein adsorption. All the analogues of phosphorcholine materials, i.e. zwitterionic molecules and polymers, should share the same superlow fouling properties of phosphorycholine-based materials. Thus, superlow fouling materials can be developed from a large spectrum of zwitterionic materials.

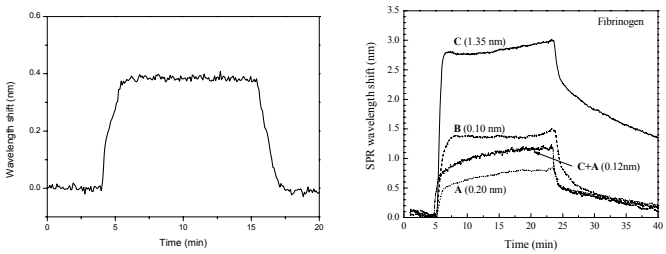

Figure 1 Adsorption of 1mg/mL fibrinogen in PBS buffer (0.15 M, pH 7.4) on a surface grafted with poly(SBMA) via ATRP (left) and on a copolymer-coated surface from SPR measurements.

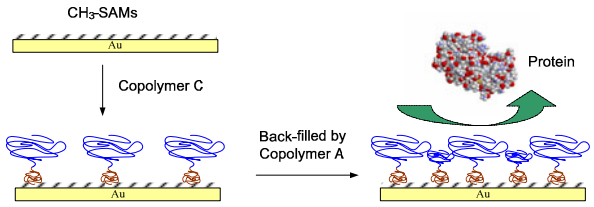

Figure 2 Illustration showing the back-filled process to achieve higher SBMA surface densities for effective resistance to protein adsorption.

References:

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2. Kitano, H.; Mori, T.; Takeuchi, Y.; Tada, S.; Gemmei-Ide, M.; Yokoyama, Y.; Tanaka M. Macromol. Biosci. 2005, 5, 314.