Amino Acid - Based Antifouling Poly(serine methacrylate)

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Statement of Purpose:

Surfaces with antifouling materials are critical to many applications, such as biocompatible and functional biomedical implants biosensors, drug delivery, and ship hulls. Due to unique zwitterionic and biomimetic nature of amino acids, we have designed new zwitterionic antifouling polymer poly(serine methacrylate) (pSerMA) incorporating serine, a natural amino acid. In this study, pSerMA brushes were grated on gold surfaces using a living surface-initiated photoiniferter-mediated polymerization (SI-PIMP) method. The antifouling properties of the surface-grafted pSerMA to resist protein adsorption and cell adhesion were explored.

Methods:

Synthesis of the monomer and photoiniferter

The monomer, serine methacrylate (SerMA), was synthesized through the reaction of L-serine and methacryloyl chloride. The photoiniferter 11-mercaptorundecane-1-[4({[(diethylamino)-carbonothioyl] thioethyl}phenyl) carbamate] (DTCA) was synthesized following a procedure reported previously.

Grafting pSerMA on gold by surface initiated-PIMP

The photoiniferter SAM was prepared by soaking the cleaned chip in 1mM photoiniferter DTCA in THF overnight at room temperature. The chip was rinsed then with THF and dried with a stream of filtered air and was put into a quartz tube under N_2 protection. The SerMA monomer solution in phosphate buffered saline (PBS) was then purged with N_2 and transferred to the quartz reaction tube using a syringe and samples were irradiated with a 302 nm UV lamp coupled with a 280 nm cut-off filter for the desired reaction time. After reaction the chip was washed with water and PBS and kept in PBS before use.

Protein adsorption

Protein adsorption on the pSerMA-coated or bare gold surfaces was measured with a custom-built four channel surface plasmon resonance (SPR) sensor based on wavelength interrogation at a fixed light incident angle. The bovine serum albumin (BSA, 1mg/mL), 100% human blood serum, 100% human blood plasma were allowed to run through independent channels of SPR for 10 min. Protein adsorption was finally quantified by measuring the wavelength shift in the buffer baselines before and after protein adsorption and converting the wavelength shift to the adsorbed mass in ng/cm^2.

Cell adhesion

Bovine aortic endothelial cells (BAECs) were maintained in continuous growth in Dulbecco's modified Eagle medium supplemented with 10% fetal bovine serum 1% sodium pyruvate, 1% nonessential amino acids, and 2% penicillin streptomycin. The pSerMA-grafted or bare gold-coated glass substrates were transferred to individual wells of a 24-well plate and rinsed by PBS. Two milliliters of cell suspension, at 10^5 cells/mL was added to each well. The cells were then incubated with the samples in a humidified incubator with 5% CO_2 at 37 °C.

Results:

With the SI-PIMP method, thickness of the grafted pSerMA film can be easily controlled by varying UV-irradiation time. It was found from the study that at a UV-irradiation time of 120 min (with a 37.2 nm-thick polymer film), the pSerMA-grafted samples exhibited minimum protein adsorption.

BSA	100% Serum	100% Plasma
1.8	9.2	12.9

Table 1: Protein adsorption (ng/cm^2) on pSerMA surfaces

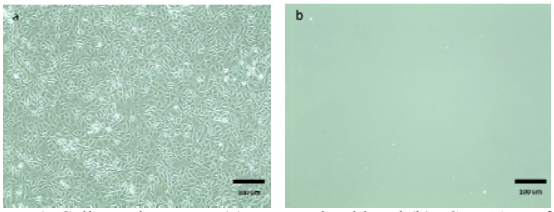

Figure 1. Cell attachment on (a) uncoated gold and (b) pSerMA-grafted gold surfaces after culturing for 7 days.

Table 1 shows that pSerMA brushes exhibited strong protein resistance not only for single-protein solutions, but also for complex media including 100% human blood serum and plasma. Notice that on bare gold surfaces, adsorption from full serum or plasma was greater than 150 ng/cm^2. Cell culture results show that BAECs developed into nearly a confluent layer on the bare gold surface (Figure 1a), while no cells were observed on the surfaces grafted with pSerMA (Figure 1b).

Conclusions:

In this study we found that zwitterionic serine-based pSerMA brushes with uniform and well-controlled thickness were achieved on gold surfaces via surface-initiated PIMP. With optimal polymer film thickness pSerMA-grafted surfaces can highly resist not only single protein adsorption but also adsorptions from full human blood serum and plasma. The grafted surfaces also highly resist mammalian cell attachment. It is concluded that PSerMA is an effective antifouling material.

References:

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