Biomembrane Mimetic Polymer Layer Constructed on Polydimethylsiloxane: Antibiofouling Characteristics

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Statement of Purpose: Surface modification of polydimethylsiloxane (PDMS) is important for biomedical and biochemical applications. We have graft-polymerized a biomimetic phospholipid polymer, poly(2-methacryloyloxyethyl phosphorylcholine (MPC)), from the PDMS substrate using photoinduced technique to obtain hydrophilic, nonbiofouling, and biocompatible characteristics without affecting the bulk properties of PDMS[1]. In this study, the graft layer thickness which was controlled by UV irradiation time affected the surface wettability. The protein adsorption and cell attachment behaviors for the wettability were examined.

Methods: PDMS (Silpot 184®, Dow corning Asia) was immersed in acetone solution containing 1wt% benzophenone (BP) for 1 min and dried in dark-vacuum condition for 1 h. The BP coated PDMS was placed in the degassed MPC aqueous solution (0.25 mol/L) and sandwiched in glass plates. The photoinduced graft polymerization was conducted using a 500 W of ultra-high pressure mercury lamp with 10 cm distance for 2 h at 35 ºC without a filter. After that, the membrane was rinsed in water and ethanol, and dried in vacuo for 24 h. Characterization was performed using XPS, ATR-FTIR, ellipsometry, AFM, and contact angle measurements. In the evaluation of bovine serum albumin adsorption, the sample was immersed in 4.5 mg/mL albumin-PBS solution for 2 h at 37 ºC. The amount of albumin adsorption was determined using micro BCA™ technique (Pierece, Rockford, IL)[1]. The L929 mouse fibroblast cell attachment was observed using a phase microscope.

Results/Discussion: ATR-FTIR and XPS measurements respectively confirmed the entity of ester bonding and the elements of nitrogen and phosphorus on the poly(MPC)-grafted surface. This photoinduced reaction is a living polymerization so that it can control the graft layer thickness by UV irradiation time[2,3]. However, an excessive UV irradiation causes termination reaction and cross-linking between the graft chains as well as polymerization of the monomer solution. According to AFM measurements, high roughness and gel-like structures were observed on the modified surface with a UV exposure of 120 min (data not shown). Figure 1 shows relations between the UV irradiation time and water contact angle, and graft layer thickness. The static and advancing angles were decreased with an increase of UV irradiation time and graft layer thickness, while the receding angles were constant. The poly(MPC) graft chains are so hydrophilic and water retentive that they, being buried in PDMS under dry, were swollen to show a good hydrophilicity under wet. The static and advancing angles were dependent on the graft layer thickness. Figure 2 shows the amount of adsorbed albumin and kinetic friction coefficient under dry and wet for the UV irradiation time. The results indicate albumin adsorption behavior and lubrication property on the modified surface is independent of the UV irradiation time, i.e., the graft layer thickness. These characteristics are similar to those of receding angles. Figure 3 shows the cell adhesion behaviors on the modified PDMS with 20 min's UV irradiation at the incubation day 3. The modified surface clearly resisted the cell adhesions though naked PDMS surface reached confluent.

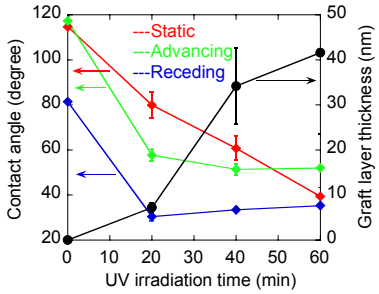

Figure 1. Relations between UV irradiation time and contact angle, and graft layer thickness by ellipsometry.

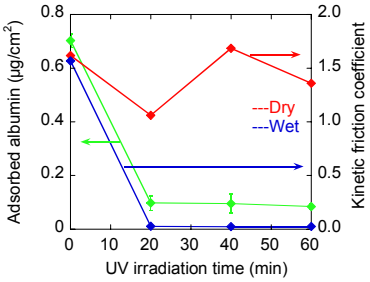

Figure 2. Relations between UV irradiation time and amount of albumin adsorption, and friction coefficient

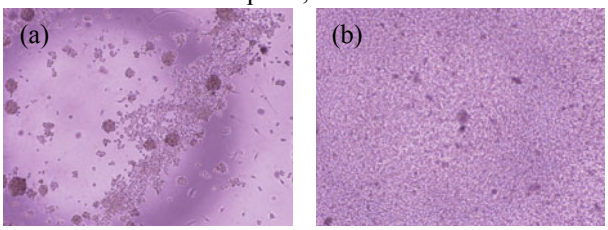

Figure 3. Phase microscope images (x4) of the fibroblast cell attachments on the modified PDMS (a) and naked PDMS (b).

Conclusions: The surface modification of PDMS was conducted by photoinduced poly(MPC) grafting from the surface. The surface characteristics are independent of the graft layer thickness. Receding contact angle on the poly(MPC)-grafted PDMS is important for the lubrication and antibiofouling characteristics.

References:

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2. Yang W. Macromolecules. 1996;29:3308-3310.
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