Light-sensitive Fluoropolymer Coated Surface for Control of Cell Adhesion Behavior

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Statement of Purpose: In recent years, stimuli-sensitive material surfaces have attracted great interest in efforts to regulate the interaction with biomolecules and cells in biomedical field. Most of stimuli-sensitive surfaces generally use hydrophilic/hydrophobic property change to modulate the interaction with bio-related analytes [1]. On the other hand, moderately hydrophobic surface properties show high interaction with proteins and adhesive cells, while the strongly hydrophobic surfaces (i.e., water-repellent surface) significantly reduce interactions with them [2]. Therefore, we hypothesized that the use of weak/strong hydrophobic switchable property is one of the promising modes to control bio-related surface interaction. In this study, we designed a smart fluoropolymer-coated surface with showing the reversible alternation of surface hydrophobicity derived from the photoisomerization of surface-introduced spirobenzopyran units by light irradiation. In addition, cell adhesion behavior on light-sensitive hydrophobic surface was further investigated to discuss the possibility of light-switchable cell adhesion/detachment control.

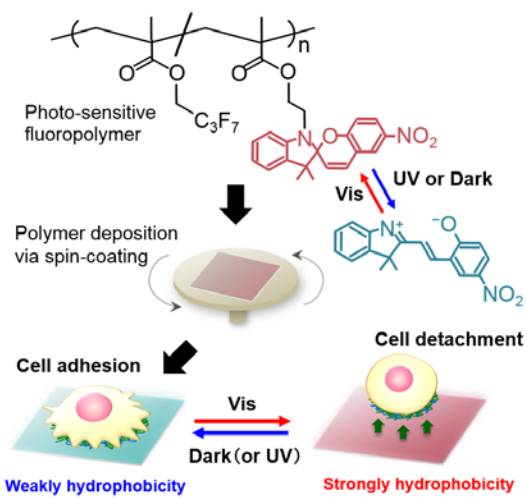

Figure 1. Schematic illustration of light-sensitive fluoropolymer coated surface for light-induced cell adhesion control.

Methods: Poly(heptafluorobutyl methacrylate-*co*-spirobenzopyran methacrylate) [poly(F7MA-*co*-SpMA), monomer ratio of F7MA/SpMA: 87/13, molecular weight: 44000) was prepared by random radical copolymerization. Polymer solution (1wt/v%) was dropped and spin-coated on hydrophobically treated glass coverslip (Figure 1). The surface was characterized by ATR/FT-IR and ellipsometric measurements. We determined surface wettability changes after irradiating either ultraviolet (UV) (352 nm) or visible (530 nm) light by static contact angle measurement. Additionally, bovine endothelial cells (BECs) were seeded and cultured on the UV light-treated surface, and then the difference of cell adhesion behavior was investigated between before and after visible light irradiation for 30 min.

Results: The amount of immobilized polymer and polymer layer thickness on glass surfaces were 6.08 μg/cm^2 and 36.3 nm, respectively. In static contact angle study, the spirobenzopyran-introduced polymer coated surface demonstrated a reversible surface wettability change by light-switchable irradiation. Namely, polymer coated surface showed a static contact angle of 78^o after irradiating UV light. Upon irradiation with visible light, surface hydrophobicity increased (contact angle: 88^o) (Figure 2A). This light-induced surface wettability change was due to the photoisomerization of surface-introduced spirobenzopyran between hydrophobic spiropyran (SP) and hydrophilic merocyanine (ME) forms. On the other hand, BECs significantly adhered on the weaker hydrophobic surface with ME-forms after UV light irradiation, compared to the stronger hydrophobic surface with SP-forms after visible light irradiation. Moreover, adhering BECs on the weaker hydrophobic surface spontaneously detached after visible light treatment probably due to the decrease in surface-cell affinity (Figure 2B). In addition, confluently cultured cells were able to be harvested as a single cell monolayer (cell sheet) via visible light irradiation. These results indicate that the light-switched weak/strong hydrophobic alternation can be used as the trigger signal to control cell adhesion/detachment.

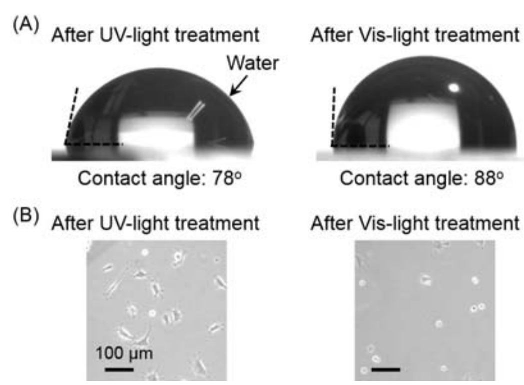

Figure 2. Pictures of (A) static contact angles and (B) incubated cells on polymer coated surfaces after either ultraviolet (UV) or visible (Vis) light irradiation.

Conclusions: Light-sensitive surface with light-switchable weak/strong hydrophobic surface property was constructed by nanoscale physical coating of spiropyran-installed fluoropolymer. Non-cytotoxic visible light-induced hydrophobicity enhancement successfully achieved the detachment of adhering cells from the surfaces. This concept of light-sensitive bioseparation would be promising strategy for cell manipulation in various applications of cell biology and cell therapy.

References:

1. Nagase K., Kobayashi J., Okano T. J R Soc Interface, 2009; 6; S293–S309.
2. Tamada Y., Ikada Y. J Biomed Mater Res, 1994; 28; 785-789.