Surface Grafting of Biocompatible Phospholipid Polymers for Obtaining Excellent Lubrication

Kazuhiko Kitano[1], Tomohiro Konno[2, 3], Madoka Takai[2, 3], and Kazuhiko Ishihara[1, 2, 3]
[1]Department of Bioengineering, School of Engineering, The University of Tokyo
[2]Department of Materials Engineering, School of Engineering, The University of Tokyo
[3]Center for NanoBio Integration, The University of Tokyo

Statement of Purpose: The purpose of this study is giving both biocompatibility and lubricity to biomaterial surfaces. For this purpose, we investigated the effects of a graft polymerization of 2-methacryloyloxyethyl phosphorylcholine (MPC) onto polypropylene (PP) surface. We also aimed for making clear the lubrication mechanism of the polymer-grafted surface.

Methods: The poly(MPC)-grafted surface (PMPC surface) was prepared using a photo-induced graft polymerization with benzophenone as a surface-initiator.

The PMPC surface was characterized by X-ray photoelectron spectroscopy (XPS), attenuated total reflection Fourier transform infrared spectroscopy (ATR-FTIR), and static water contact angle measurements. Friction test was conducted in air and in water. After the friction test in water, the surface was observed with scanning electron microscopy (SEM). Friction test was also performed under biological conditions; in phosphate buffered saline (PBS), PBS solution containing a bovine serum albumin (albumin-PBS), and containing fetal bovine serum (FBS).

Results/Discussion: The stable grafting of PMPC on the PP was confirmed using XPS and ATR-FTIR, and high hydrophilicity of the PMPC surface was confirmed by static contact angle measurement.

Figure 1 shows the results of friction test. In air, the kinetic friction coefficient (μ_k) of the PMPC surface was the same degree as that of non-grafted PP. However, the PMPC grafting greatly increased lubricity in water. The average of the friction coefficient of the PMPC surface in water was 0.019, which is similar to that of the human joints. These results indicated that the presence of water is a necessary condition for lubricating the PP surface by PMPC grafting.

From SEM observation after the friction test in water, no flaw was observed on the PMPC surface. It was considered that the hydrated PMPC layer completely kept the surfaces apart during the friction test. The PMPC surface showed the behavior of hydrodynamic lubrication in water.

Our solution of the lubricity mechanism is as follows. On the condition of hydrodynamic lubrication, surface friction is dependent on the mobility of liquid layer between the friction surfaces. Kitano found that the PMPC had a very small effect on the structure of the hydrogen-bonding network of water molecules[1]. The structure of hydrated layer in the vicinity of the PMPC graft chains are similar to that of bulk water which has high mobility. In short, the reason why the PMPC surface clearly reduces surface friction in water is that the PMPC graft chains have high mobile hydrated layer between the friction surfaces.

Friction test was also performed under biological conditions. The μ_k of the non-grafted PP in albumin-PBS and in FBS were clearly higher than that in water and in PBS (Figure 1 (c)). This high friction was caused by the protein adsorption on the non-grafted PP surface. On the other hand, the μ_k of the PMPC surface under all biological conditions were equal to that in water. The PMPC grafting onto the surface of medical devices has already been shown to suppress biological reactions when they are in contact with living organisms [2,3].

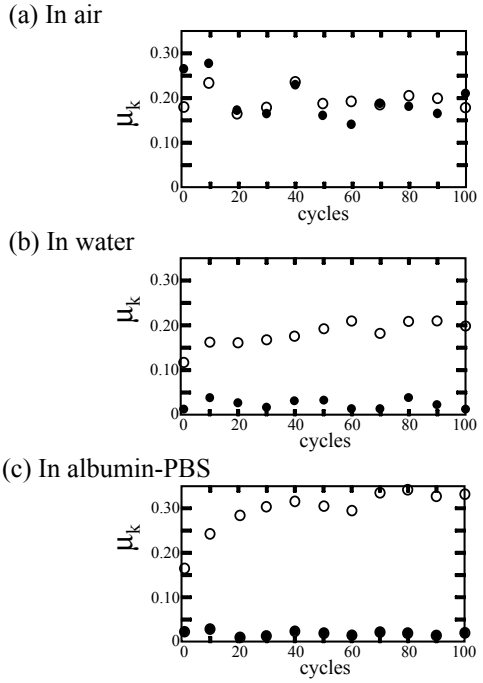

Figure 1. The results of friction test in air, in water, and in albumin-PBS (μ_k: kinetic friction coefficient).
(○: non-grafted PP, ●: PMPC-grafted PP)

Conclusions: We reported the preparation of the PMPC surface in order to enhance its surface biocompatibility and lubricity. The biocompatible PMPC grafting clearly reduced the friction coefficient in water and under the biological conditions because the PMPC surface had hydrated layer, which had high mobility like bulk water, and showed the behavior of hydrodynamic lubrication.

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