Biocompatible Surface Generation on Poly(ether ether ketone) by Self -initiated Photoinduced Graft Polymerization

Takaharu TATEISHI,[1] Masayuki KYOMOTO,[1] Tetsuji YAMAOKA,[2,3] and Kazuhiko ISHIHARA[1,3]
[1]Department of Materials Engineering, The University of To kyo, Tokyo 113-8656, Japan, [2]National Cerebral and Cardiovascular Center Research Institute, Osaka 565-8565, Japan, and [3]Core Research of Evolutional Science and Technology (CREST), J apan Science and Technology Agency, Tokyo 102-0075, Japan
E-mail: tateishi@mpc.t.u-tokyo.ac.jp

Statement of Purpose: Poly(ether ether ketone) (PEEK) is a kind of superengineering plastic. PEEK exhibits high mechanical propertys and heat -, chemical - and radiation - resistances. Therefore, PEEK has also employed as a biomaterials for trauma, orthopedic and spinal implants. We thought to use PEEK in the cardiovascular devices, such as an artificial heart valve. The artificial heart valve requires high mechanical properties, antithrombogenicity and anti -infection. However, PEEK can not satisfy those requirements. How to modify materials is changing bulk property and surface modification. In this study, we modified PEEK surface by "self -initiated photoinduced graft polymerization" for obtaining a super -functional PEEK [1]. The self -initiated photoinduced graft polymerization uses semi -benzopinacol radicals from benzophenone units in PEEK molecule structure under UV-irradiation. Advantages of this method are easy handling, well suited for application and graft polymer coating strongly b inding the substrate.

Methods: 2-Methacryloyloxyethyl phosphorylcholine (MPC) polymers exhibit excellent biocompatibility, that is, antithrombogenicity, anti -infection due to reduced protein adsorption. We controlled monomer concentration, polymerization t emperature, UV intensity and solvent during the polymerization. Additionally, we evaluated the amount of absorbed protein to predict antithrombogenicity. The surface of PEEK was ultrasonically cleaned in ethanol. The MPC was dissolved in degassed water or ethanol and then adjusted to monomer concentration (0.25 –1.0 mol/L) and temperature (25–60°C). PEEK was immersed in these solutions. Polymerization was carried out for 90 min on PEEK surface under UV (36 0 ± 50 nm) irradiation with intensity (2.5–9.0 mW/c m^2). After polymerization, poly(MPC) (PMPC)-grafted PEEK surface was washed with clean solvent to remove monomers and free polymers. PMPC -grafted PEEK was analyzed by XPS, FT -IR/ATR, water contact angle measurement and protein adsorption by micro BCA method. IR intensity ratio was calculated by area ratio of carbonyl peak (1730 cm^{-1}) and aromatic ring peak (1600 cm^{-1}).

Results: Photoinduced graft polymerization of MPC on the PEEK proceeded well. In the XPS and FT -IR/ATR spectra and water contact angle measure ment showed that the hydro philic PMPC layer formed on the PEEK substrate. With increasing the monomer concentration, IR intensity ratio increased (Fig. 1). IR intensity ratio corresponds to the number of MPC units on PMPC -grafted PEEK. So the number of MPC units in the PMPC layer increa sed with increasing the monomer concentration. Generally, in the radical polymerization, the molecular weight increases with incre asing the monomer concentration. It seemed that the PMPC layer thickness increased with increas ing MPC concentration. The IR intensity of PMPC -grafted PEEK with 5.0 mW/cm^2 UV intensity showed a maximum value when the polymerization was carried out in ethanol. The number of MPC units in the PMPC layer increased with increasing UV intensity. It seemed that the amount of radicals generated on PEEK surface increased with increasing UV intensity. Therefore, it seemed that the density of the PMPC layer increased with increasing UV intensity. The amount of adsorbed protein decreased with increasing MPC conc entration and UV intensity (Fig. 2). This is corresponding to the increase hydrophilicity. The MPC polymers can inhibit cell adhesion and activation. Thus, we can consider that the PMPC -grafted PEEK will show both excellent antithrombogenicity and mechanic al property.

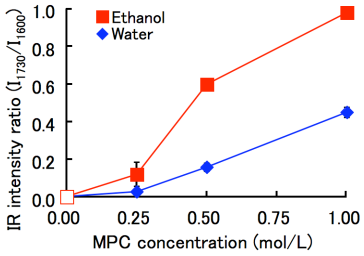

Fig. 1. IR intensity ratio of PMPC -grafted PEEK. Open marks: Untreated PEEK.

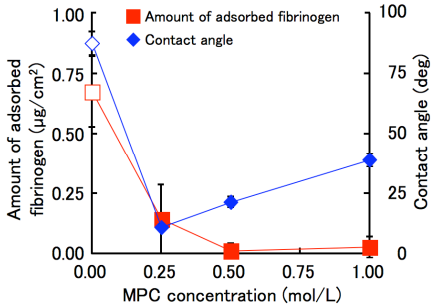

Fig. 2. Amount of adsorbed fibrinogen and statistic contact angle by water on the PMPC -grafted PEEK prepared in water. Open marks: Untreated PEEK.

Conclusions: It was successful to provide biocompatibility to PEEK surface by self -initiated photoinduced polymerization. The new materials will be useful for developing cardiovascular devices.

References: [1] Kyomoto M et al., Appl Mater Interfaces 2009:1;537-542.