HEMOLYSIS OF DLC FILMS COATED ON POLYMERIC MATERIALS

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Introduction

Diamond-like carbon (DLC) films have received much attention owing to their attractive properties which are close to those of diamond: low friction, extreme hardness, high thermal conductivity, high electrical resistivity, corrosion resistance against chemicals, low roughness, and good biocompatibility[1)]. Furthermore, DLC films deposited from radio frequency (r.f.) plasma chemical vapor deposition (CVD) can be easily fabricated on many substrates at room temperature. Due to their interesting advantages, DLC films have been developed for application as biomedical, electronic, and mechanical materials (e.g. coatings on contact lenses). In the previous study we have investigated DLC films as coatings of polymeric materials with good blood compatibility. Another problem of blood contact devices is the need to improve hemolysis. In order to reduce the hemolysis, fine coatings are tried to artificial organs using many techniques.

Experimental procedures

Several kind of polymeric materials are applied as biomaterials. Polycarbonate, Polyvinyl chloride, and silicone are utilized to the materials of the bottom plates. At room temperature, the DLC films have been deposited on the surface of the plate located at bottom of the blood bag. The thickness of all the DLC films was kept at about 300nm. A schematic diagram of the experimental apparatus for evaluating the hemolysis is shown in Figure 1. The system consists of a roller pump, blood reservoir bag, flow meter, tubes, and test section. This system was developed for the evaluation of the hemolysis against new biomaterials[2)]. In order to compare the hemolysis effect of the DLC films, the volume of hemolysis was estimated by in vitro tests. The volume of hemolysis is measured with a constant interval of time.

The physical and chemical properties of the DLC films before and after the experiment were investigated by scanning electron microscope (SEM), atomic force microscopy (AFM), infrared spectroscopy, Raman spectroscopy, and electron spectroscopy of chemical analysis (ESCA)[3)].

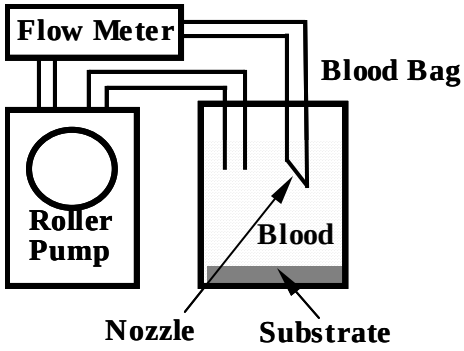

Figure 1. Schematic representation of the measurement circuit for hemolysis.

Results and discussion

Figure 2 shows the results of the hemolysis test when the Polyvinyl chloride (PVC) is used to the bottom plates with and without DLC coating. The hemolysis volume is proportionally increased with experiment time. The DLC film coating decrased the volume of hemolysis as compared

to the normal PVC material and its standard difference was apparently confirmed by mathematical calculation.

On the other hand, dominant difference of the DLC coating has not obtained on the silicone and polycarbonate materials. In both case, the absolute values of hemolysis were small quantity because of their favorable property for hemolysis.

Before and after the hemolysis experiment, no significant change was observed on all DLC coated surfaces by SEM analysis. The DLC coating reduced the surface friction of the polymeric materials. The atomic compounds formed on the sample surface before and after the DLC coating was analyzed by ESCA. The ESCA results indicated that chlorine $Cl_{2P3/2}$ signal notably appears on the PVC sample surface as shown in Figure 3. The *Cl* signal was not observed from the DLC coating sample on PVC substrate. The C_{1S} signal with a shoulder corresponding chloride layer appears on the PVC surface though the signal of the DLC coated PVC shows only carbon peak at 284.3eV. The volume of the hemolysis was dependent on the atomic composition of the samples and their surface frictions.

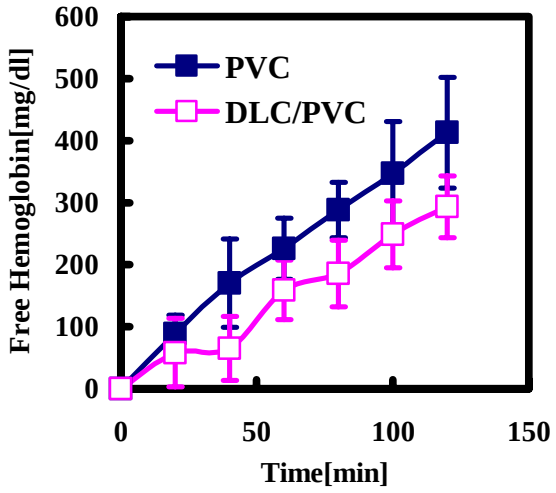

Figure 2. The volume of free hemoglobin as a function of interval time.

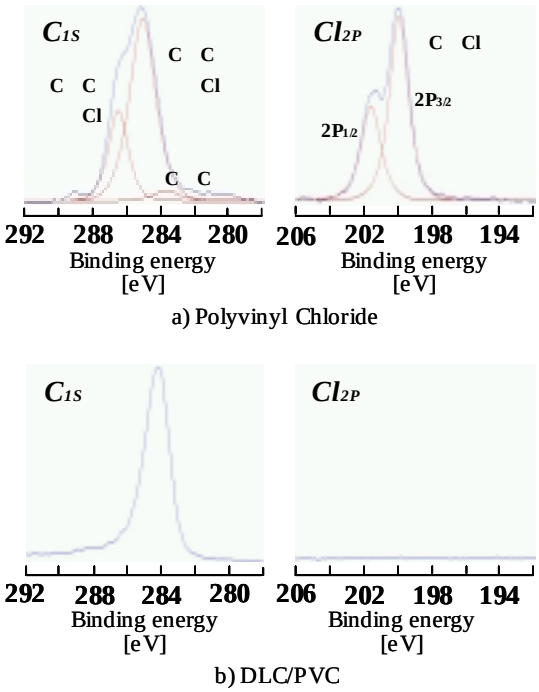

Figure 3. ESCA spectra of sample surfaces.

Summary

Remarkable improvement of hemolysis was obtained by the coating of the DLC films, in especially Polyvinyl chloride with toxicity. The surface condition of the materials is most important for the hemolysis.

References

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