In situ observation of human γ-globulin behavior on joint prosthesis material

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Joint prosthesis is rubbed in natural synovial fluid. Constituents included in natural synovial fluid adsorb on the surface and influence tribological property. Authors investigated behavior of bovine serum albumin (BSA) film under shear stress by using electrochemical method. BSA was easily desorbed by shear stress, and re-adsorbed under shear. It was concluded that weak adsorption of BSA molecules induces low shear resistance, hence, optimum protein film structure constructed two types of proteins with lamellar structure showed low shear resistance. In this study, human γ-globulin (HGG) behavior was investigated to clarify effect of shear force on HGG film formation.

CoCrMo alloy (ASTMF 75) disk and ultra-high molecular weight polyethylene (UHMWPE, GUR1050) pin with spherical end was employed for rubbing combination. The specimens were set on electrochemical cell mounted in reciprocating tribometer. Electrochemical cell was filled with PBS including HGG 0.7 mass%. Frictional force and potential between lubricant and CoCrMo alloy was recorded during test. Load was 6.54 N (Herzian maximum contact pressure 24.8 MPa), sliding speed was 10mm/s (1 Hz) and sliding distance was 18 m (1800 sec). Potential was recorded before and after rubbing for 10 min. Additional experiment was conducted to clarify adsorption structure of HGG. HGG adsorption amount and film thickness was measured by using surface plasmon resonance (SPR) and ellipsometry respectively. For SPR measurement, thin gold film was necessary, so that glass plate substrate with thin gold film was used for
SPR and ellipsometry measurement. The grass plate substrate was rubbed against poly vinyl alcohol (PVA) hydrogel in HGG solution.

Frictional coefficient in HGG solution was stable. Therefore it is considered that HGG film was stable. Potential drop, which is defined from the difference between potential before rubbing and minimum potential during rubbing, was little compared to that in BSA solution. Potential decrease indicates desorption of protein molecules. Therefore, small potential drop means little desorption of HGG molecules. That is also indicates HGG adsorption strength is high compared with that of BSA.

HGG shows much adsorption and maintain uniform film compared to BSA, so that HGG film is constructed on CoCrMo alloy surface.

Film thickness was under 6 nm. HGG is elliptical shape with 12 x 6 nm in PBS pH7.4. Therefore, HGG adsorbed with side domain. Adsorption amount was varied with sliding distance. Long sliding distance enhanced HGG adsorption until 120 m. From adsorption results, HGG formed multi-layer over 60 m sliding distance, film thickness was less than 6 nm. That indicates HGG molecules were thinner by shear force. Therefore, it is considered that HGG molecule was deformed by shear force, and changed conformation during rubbing. That is one reason of HGG showed little adsorption from CoCrMo alloy.

It was shown that HGG film was stable for shear force from these investigation. The structure which has excellent tribological property was lamellar structure. HGG molecules are strong adsorption and forms stable film on CoCrMo alloy surface, which different behavior from BSA molecules, so that lamellar structure was conducted.