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THE WEAR OF DIAMOND-LIKE CARBON BY MOLYBDENUM BASED PARTICLES UNDER BOUNDARY LUBRICATION

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ABSTRACT

This work compares the tensile (uniaxial tension test) stiffness of different meshes used as prostheses in pelvic floor repair surgeries. Five different commercial meshes were analysed, all made from polypropylene but with different geometries: Aris™, TVTO™, Uretex™, Avaulta™ and Auto Suture ™. The mechanical tests performed allowed to identify significant differences on the mechanical properties of the polypropylene meshes used in urogynecology surgeries.

Keywords: biomechanics, polypropylene, prosthesis, urogynecology.

INTRODUCTION

In the automobile engine fields, it is generally required that piston ring and liner should be rubbed by engine oil to prevent wear, reduce friction coefficient to achieve low energy consumption. One of the most optimistic materials to adapt such requirement is Diamond-Like Carbon (DLC) coating. It has the potential to reduce friction coefficient because of its chemical inertness, higher hardness rather than conventional steel, very smooth surface can give us excellent tribological performance in some cases. However, some of the chemical additives which are included in the engine oil cause to enhance wear of DLC. Many of research works of the effect of chemical interaction between additives and DLC were reported (Komori, 2016) (Feo, 2016), but the detail wear mechanism of DLC is still unclear because those chemical additives in oil are able to change its chemical shape during friction test. To clarify the effect of degradable material such as molybdenum based particles derived from MoDTC, the authors were carried out friction test with those particles (Tokoroyama, 2016) (Tokoroyama, 2017), then it was revealed that MoO_3 was able to enhance wear acceleration of amorphous hydrogenated carbon (a-C:H) rather than silicon doped a-C:H (DLC-Si). In this study, Mo based materials (pure Mo, Mo_2C, MoS_2 and power type MoDTC) were selected to add them into base oil to clarify wear acceleration possibility of a-C:H and DLC-Si.

The friction test was conducted by Ball-on-Disk (BoD) type friction tester. The a-C:H or DLC-Si specimen was set on oil bath stage which was connected to motor with a coupling, and it was supported by two axial bearings. Normal load and friction force was measured by strain gauges which were set on leaf springs as load and friction force sensor. The body of leaf spring was made by stainless steel. The load sensor was connected to X-Z stage, and the normal load was applied by pressing a counter material by Z-axis position change. The strain of normal load and friction force was magnified by the strain amplifier to voltage value, then, the value was transmitted to PC through data logger as 10 data per second (sampling frequency was 10 Hz). The counter material was stainless steel ball (SUJ2) with 8 mm diameter which was cleaned by 15 min. in acetone ultrasonically before friction test. The friction test speed was approximately 50 mm/s and the total number of sliding cycles was 1500 cycles. The normal load was approximately 1 N.

RESULTS AND CONCLUSIONS

The specific wear rate of a-C:H is shown in Figure 1(a); Figure 1(b) shows its enlargement as representative data. In the case of adding Mo_2C in Fig. 1(a) clearly indicated that Mo_2C had most effective wear acceleration material rather than others. On the other hand, in the case of pure Mo and MoS_2 in Figure 1(b) clearly showed that both materials did not enhance wear acceleration of a-C:H. The MoDTC particle and MoO_3 showed wear acceleration rather than Mo or MoS_2. The hardness of Mo_2C was measured by nano-indentation tester which revealed that its hardness was approximately 14.7 GPa. Those results indicated that Mo_2C acted as abrasive particles, which is similar to polishing/rapping in manufacturing field. The Surface Enhanced Raman Spectroscopy (SERS) was conducted to inside/outside of wear scar on the a-C:H. The I_D/I_G ratio, G peak position and FWHM (Full Width Half Maximum) of before and after friction increased from 0.52 to 0.54 (I_D/I_G), 1569 cm^{-1} to 1571 cm^{-1} and 114 cm^{-1} to 116 cm^{-1}, however, the changes of them was truly small. Therefore, the structure of a-C:H did not change to graphite like structure, it meant that Mo_2C did not interact chemically between a-C:H during friction.

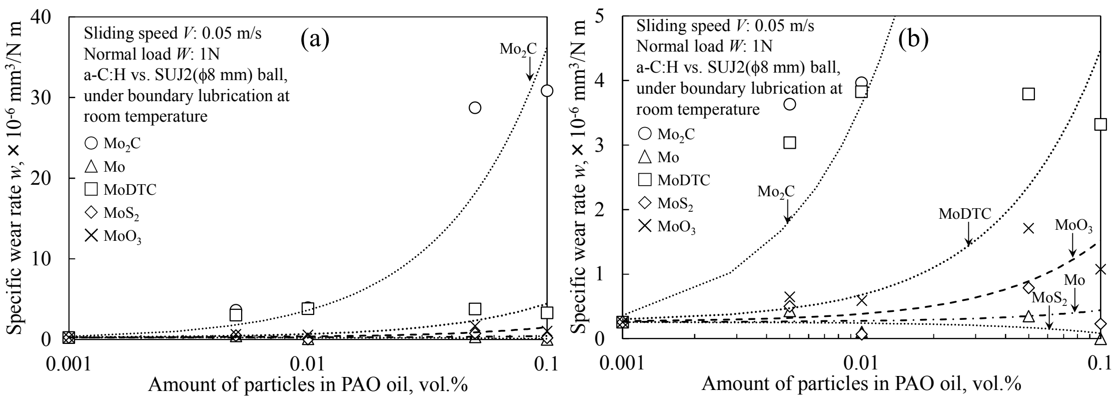

Fig. 1 - (a) Specific wear rate of a-C:H under several particles; (b) enlargement of (a)

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