Tribological Performance of Nano-Diamond for Water Lubrication

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Tribology is the science and technology of interactive surfaces in relative motion. Friction and wear can be controlled by good lubricants. Energy and resources can be reduced by decreasing friction and wear, that is, dissipating energy and materials at sliding contacts. Diamond, diamond-like carbons and nano-diamonds have been applied for friction control and very low-friction coefficient was obtained by the application under different conditions. Recently, eco-friendly lubricants which do not contain heavy metals, sulfur and phosphorous as additives are increasingly demanded and new lubricants without mineral and synthetic oils are also expected to be developed in order to reduce environmental load. Although water is favorable fluid as eco-friendly lubricant, it cannot be used as industrial lubricants because the viscosity of water is too low for hydrodynamic lubrication. Animal joints show a very low friction coefficient by water lubrication because they have complex interface structures at joint surfaces to reserve water at the interface. In this paper, we applied hydrophilic nano-diamond to reduce friction coefficient for water lubrication.

Hydrogels were used as a base material for water lubrication. Friction tests were carried out with a sapphire slider-ball under the condition of 10 to 40 mN of load and 20 Hz of vibration in water. Friction coefficient was monitored during the tests. Water with one or five weight percent of nano-diamond was used as a lubricant. When silicon plate was used instead of hydrogel, friction coefficient was high and silicon surface was scratched by mechanical contacts with nano-diamond. On the other hand, friction coefficient gradually decreased to low value of 0.03 with sliding time when nano-diamond was used with hydrophilic hydrogel. The running-in process can be explained by dispersion of coagulated nano-diamond by friction. There was no wear mark on slider surface even after mechanical contact with nano-diamond. However, nano-diamond was not effective for friction tests with hydrophobic hydrogel even in water.

The effect of co-additives in water was examined and it was found that some additives were effective to obtain better tribological performance for water lubrication. A possible model for the lubricating property of nano-diamond in water will be discussed in the presentation.