Utilization of Diffusive Double Layer to Lubrication Mechanism of Nanomachine

By Takashi NAKANO, Satoshi MOMOZONO and Shin-ichi AIZAWA

Corresponding author Takashi NAKANO
Address 2-12-1 Oookayama Meguro-ku Tokyo Japan 152-8552
Tel/Fax 81-3-5734-2796
E-mail nakanot@mep.titech.ac.jp

Abstract

In this study, new lubrication mechanism for nanomachine is proposed. This mechanism utilizes the effect of diffusive double layer observed in hydrophobic colloidal solution. Basic idea of the theory is inspired by the research for possible mechanism of bacterial flagellar motor.

Bacterial flagellar motor has structure that resemble journal bearing . This structure is called PL ring. Our earlier investigation shows load capacitance of PL ring generated by hydrodynamic effects is less than 0.1pN. On the other hand estimated load to PL ring is order of 1pN. Furthermore, intermolecular force between rod and journal is order of 100pN. So we conclude that PL ring resembles journal bearing only in shape and new lubrication mechanism is necessary to explain the lubrication behavior of PL ring.

In our earlier analysis, the effects of diffusive double layer were taken into account to explain lubrication behavior of PL ring. By using DVLO theory of colloidal solution, we estimated the load capacitance generated by this mechanism. Resulting load capacitance is large enough to sustain applied load to PL ring. Based on these results, we further develop this idea to quantitative analysis. We applied this new lubrication theory to nano-scale tribology.

Our lubrication theory is based on the thermodynamical theory of hydrophobic colloidal solution. We applied the theory to two dimensional journal bearing. Load capacitance is calculated numerically.

Calculated load capacitance is order of 100 pN that is considerably large compared with the load capacitance obtained by hydrodynamic lubrication.

These results show this mechanism gives enough load capacitance to sustain PL ring of bacterial flagellar motor. These results also show that the effects of diffusive double layer can be candidate for possible lubrication method of nanomachine.