ADSORPTION PROPERTY OF ULTRA-THIN PFPE LUBRICANT WITH IONIC END-GROUPFOR DLC SURFACE

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I. INTRODUCTION

Ionic liquids have low vapor pressure and high thermal resistance. Therefore, an ionic liquid may be a candidate as a lubricant material for magnetic disks used in heat-assisted magnetic recording (HAMR) drives. Liu et al. previously compared the tribological properties and thermal stability of an ionic liquid with those of perfluoropolyether (PFPE) lubricants Krytox and X1P; the ionic liquid showed better friction behavior and thermal stability than the other lubricants [1]. The thermal stability of a lubricant film is needed in the head-disk interface (HDI) of HAMR drives. Kondo et al. synthesized a novel perfluoropolyether (PFPE) ionic liquid whose terminal group is an ammonium salt with a carboxylic group and confirmed that it exhibited superior frictional properties when compared to the conventional PFPEs [2]. Hatsuda et al. developed a new thermally stable protic ionic liquid (PIL) or PIL-type lubricants and found that a higher ΔpKa—the difference in pKa value between an acid and a base—is effective at improving thermal stability [3]. Gong et al. evaluated room-temperature ionic liquids for HAMR application and concluded that the ionic lubricants were considerably more thermally stable than Zdol and Zteraol [4].

In this study, we focused on the adsorption properties of a PFPE lubricant with ionic end-groups and a diamond-like carbon (DLC) surface in order to apply the lubricant to improve the thermal stability for HAMR media. The study also compared two types of PFPE lubricant films in terms of their affinities to DLC surfaces. One lubricant material (SNH2) was Demnum main-chain with single ionic end-group and the other lubricant material (Z-tetraol) was Fomblin main-chain with double hydroxyl end-groups.

II. EXPERIMENT

A PFPE lubricant with a Demnum main-chain and an amine salt end-group called SNH2 was prepared as shown in Fig. 1-(b). Z-tetraol was prepared as a reference, shown in Fig. 1-(a). Normal dip coating and electric-field-assisted dip (EFAD) coating were applied to the lubrication [5]. A photographic image of the EFAD coating tool is shown in Fig. 2. Cu electrode plates in the lubricant solution were placed parallel to each side of the disk surface. Electrode pins contacted the edge of disks. A DC voltage was applied between the disk and electrode plates while dipping the disk and the electrodes in the lubricant solution, resulting in an electric field between the electrode plates and disk surfaces. In this experiment, the dipping duration was 180 s, the withdrawal speed was 2 mm/s, and the distance between each electrode plate and the center of the disk was 12.5 mm. A voltage of 10 V corresponds to an electric field of 0.8 kV/m.

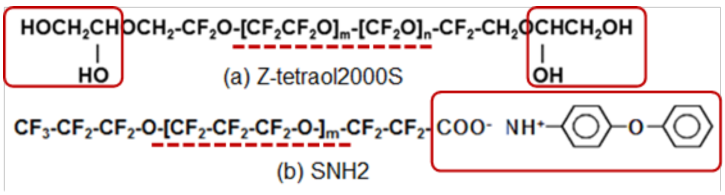

Fig. 1 Lubricant chemical structure used in this study.

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III. RESULTS AND DISCUSSION

The lubricant thickness as a function of varying lubricant concentration in its solution is shown in Fig. 3. At lower lubricant concentration, the lubricant thickness of SNH2 was the same (10 Å @ 0.001 wt%) as that of Z-tetraol (10 Å @ 0.01 wt%). In addition, the thickness of SNH2 was found to increase in the positive electric field; however, it did not increase in the negative electric field. This is probably because the main-chain side on the SNH2 structure has a negative charge, which creates an attractive force between the lubricant molecules and the disk surface, thus helping the SNH2 main-chains to adsorb on the DLC surface.

Figure 4 shows the surface free energy of SNH2 films. The polar surface energy of the SNH2 film was much higher than that of the Z-tetraol film; this was thought to be because the ionic functionalities of mobile molecules had large polarity.

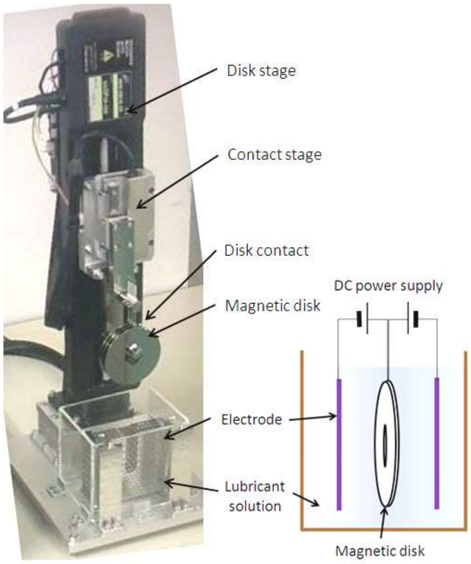

Fig. 2 Electric-field-assisted dip coating tool [5].

IV. CONCLUSION

We concluded that the PFPE lubricant with ionic end-groups needed UV treatment, although it had a large electrostatic interaction with the DLC surface.

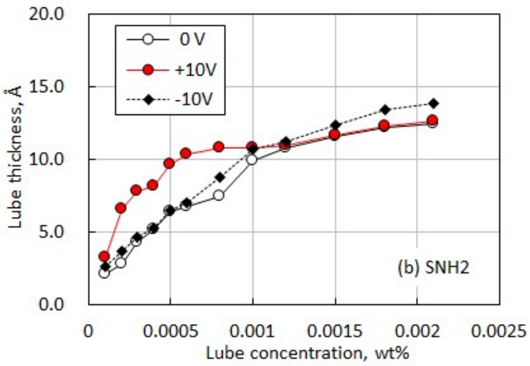

Fig. 3 Electric field assisted dip coating tool [5].

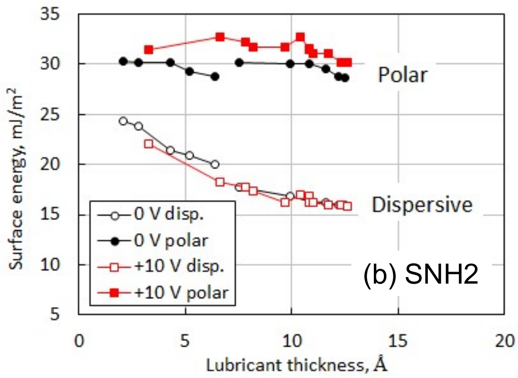

Fig. 4 Electric field assisted dip coating tool [5].

REFERENCES

1) W. Liu et al. "Tribological Behavior of Sialon Ceramics Sliding against Steel Lubricated by Fluorine-Containing Oils", Tribo. Inter., 35, 503–509, (2002).

2) Hirofumi Kondo, "Tribochemistry of Ionic Liquid Lubricant on Magnetic Media", Advances in Tribology,
Volume 2012, Article ID 526726, (2012).

3) Kouki Hatsuda et al., "Friction Properties of Ionic Liquid Lubricants under High Temperature", International Tribology Conference ITC2015, 18pG-05, (2015).

4) Xiao Gong et al., "Room-temperature Ionic Liquids (RTILs): Media Lubricants for Heatassisted Magnetic Recording (HAMR)? ", IEEE Trans. on Magn., DOI 10.1109/TMAG.2015.2438253, (2015).

5) Hiroshi Tani et al., "Electric-Field-Assisted Dip Coating Process of Ultrathin PFPE Lubricant Film for Magnetic Disks", IEEE Trans. on Magn., 45(10), 3636–3639, (2009).