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The Friction Properties of Fluorinated Polymer Langmuir-Blodgett Films

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The friction properties of a series of poly (*N*-polyfluoroalkylacrylamides) and their copolymer LB films were investigated to utilize the polymer LB films for a new type of an ultrathin solid lubrication film. The friction coefficients of the homopolymer LB films change with fluoroalkyl chain length. The friction coefficients for the LB films of copolymer with the corresponding *N*-alkylacylamides decrease with mole fraction of the alkylacrylamide comonomer. The friction properties in the polymer LB films are discussed from the factors of surface structure and chemical composition of surface.

Keywords: Langmuir-Blodgett film; fluorinated polymer; copolymer; friction; lubricant

INTRODUCTION

Recently, the tribological behaviors of fluorinated ultrathin organic films have received much attention from the standpoint of reducing friction and wear which is one of the most important requirements for improving the performance of magnetic disks. Since the Langmuir-Blodgett (LB) technique is known to provide organic ultrathin films with controlled thickness of molecular scale and with well-defined molecular orientation, LB films is expected for application to no-wear and low frictional lubricant[1-2].

Fluorinated materials are known to have low-surface energy and chemical

satbility; therefore fluorinated polymer LB film is expected as a novel type of solid lubricant. We have previously demonstrated that poly(*N*-polyfluoroalkylacrylamide) gives a fairly uniform polymer LB film[3]. In this work, the frictional properties of a series of poly(*N*-polyfluoroalkylacrylamides) and their copolymer LB films were investigated aiming to fabricate a novel type of solid lubricant.

EXPERIMENTAL

Fabrication of poly(*N*-polyfluoroalkylacrylamide) and poly(N-decylacrylamide-*co*-*N*-*1H,1H*-pentadecafluoro-octylacrylamide) copolymer LB films and general properties were in detail described in the previous paper[3]. The structures of

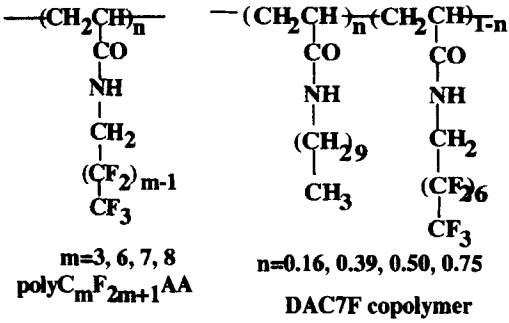

FIGURE 1 The structures of fluorinated polymers.

the polymers used in this study are shown in Figure 1. The deposition of the monolayers were carried out with an automatic Langmuir trough (Kyowa Kaimen Kagaku HBM-AP using a Willhelmy type film balance). The monolayers of the fluorinated polymers were spread from a freon solution (10^{-3}mol/l) onto distilled, deionized water at 25 ℃. The condensed monolayers on the water surface were transferred onto hydrophobic slide glasses with 2 layers forming Y-type LB film. Frictional forces of all of the LB films were measured with a back-to-forth sliding friction meter (HEIDON14D, Shintoukagaku) using a sapphire tip

at a sliding speed of 1.0mm/s under a 10g loading weight in eleven transits. The kinetic friction coefficient (f) of the LB films was calculated by dividing the average value (F) of the frictional force during the tenth transit by loading weight (W), i.e. $_{y}f$=F/W.

RESULTS AND DISCUSSION

The critical surface energy determined from Zisman plots and frictioncoefficients

TABLE I The friction coefficient and critical surface energy of fluorinated homopolymer LB films

Polymer	pC3F7AA	pC6F13AA	pC7F15AA	pC8F17AA
Friction coefficient	0.31	0.23	0.28	0.23
Surface energy (mN/m)	14.2	12.6	11.0	9.2

of fluorinated homopolymer LB films are summarized in Table I. The friction coefficients for the LB films with the odd-number carbon chain length (pC_3F_7AA, $pC_7F_{15}AA$) are relatively larger than that of LB films with the even-number carbon chain length ($pC_6F_{13}AA$, $pC_8F_{17}AA$). On the other hand, the critical surface energy of the fluorinated polymer LB films apparently decreases with increasing fluoroalkyl chain length, which is a tendency similar to the molecular packing in the monolayers estimated from the isotherms, that is, the monolayers with more highly packing give the surface with low critical surface energy. It is of interest that the dependence of the friction coefficient and the crtitical surface energy on the fluoroalkyl chain lenght is quite different respectively. Futher detailed study is in progress.

Figure 2 shows the kinetic friction coefficients for DAC7F copolymer LB films as a function of DA mole friction. The kinetic friction coefficients for DAC7F copolymer LB films decrease with the DA mole friction. This result is

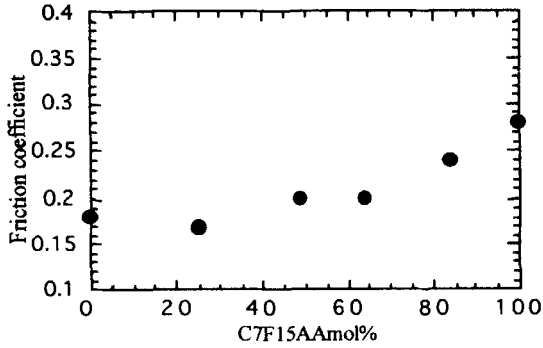

FIGURE 2 The friction coefficients of DAC7F copolymer LB films

consistent with the observation by AFM measurement for low molecular compound LB films: the frictional force of perfluorocarbon and semifluorocarbon chain surface were larger than those of hydrocarbons[4], wherethe frictional property of LB films is mainly decided by flexible groups on the surface as a lubricate layer. It may be attributed to chain interdigitation, which is the most important molecular mechanism for friction hydrocarbon surface and easier movement of surface atoms due to the greater space available by replacing CF_3 with the CH_3[6]. The frictional property of the copolymer LB films can be explained by the same mechanism. The frictional behavior of the copolymer is different from the results obtained in a series of poly(*N*-polyfluoroalkylacrylamides) LB films.

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