Disk-like compounds showing low traction coefficient under EHL contacts

Ken Kawata
Advanced Core Technology Laboratories, Fuji Photo Film Co., Ltd
Nakanuma 210, Minamiashigara, Kanagawa 250-0193 Japan
TEL:0465-73-7057, FAX:0465-73-7932, Email: ken_kawata@fujifilm.co.jp

ABSTRACT

The temperature dependence of traction coefficient was evaluated for some kinds of disk-shaped liquid crystal compounds by using the Reciprocating type (SRV) friction/wear tester under EHL contacts. Regardless of disk-shaped frame structure, all of these compounds were found to show traction coefficients of less than 0.04 within each liquid crystal temperature range, and moreover under the extreme pressure condition of about several hundred MPa.

1. INTRODUCTION

Rod-like liquid crystals, as used in liquid crystal displays, have been heavily researched as electrorheological fluids aimed at active control of friction by the electric orientation control of liquid crystal molecules, utilizing anisotropic low viscosity, namely Miesowics viscosity [1], derived from anisotropic orientation of molecular aggregates. There have been, however, very few if any studies of the friction properties of discotic liquid crystals [2], probably because they usually show relatively high transition temperature range and high viscosity and also might be impractical except use as optical compensation film for LCDs [3]. In this paper we show that discotic liquid crystals produce very low friction probably because they are able to align horizontally easier than rod-like molecules on a polar surface, namely glass, polymer film and so on [4].

In the tribological circumstances where strong shear forces are operating between polar surfaces like iron or ceramics, discotic liquid crystals would be easy to align homeotropically near both of the surfaces having nanometer order thickness and are expected to show low traction coefficient caused by extraordinarily low viscosity based on anisotropic orientation. They are also expected to provide better wear protection than rod-like liquid crystals because their shape enables them to effectively adsorb flat and cover on sheared surfaces. When such molecules that have a large and smooth π-conjugated plane like as graphite would be designed, both of above mentioned features sought in a lubricant might be accomplished.

2. EXPERIMENTAL

We have evaluated the temperature dependence of
traction coefficient under elastohydrodynamic (EHL) contacts, and correlated this with the meso-phase temperature of each liquid crystal as shown in Figure 1.

The traction coefficient was evaluated by a Reciprocating type (SRV) friction/wear tester as shown in Figure 2 and the experimental condition was shown in Table 1.

![Figure 2. Reciprocating parts.](image)

Table 1: Experimental condition

<table>
<thead>
<tr>
<th>Specimen</th>
<th>SUJ-2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cylinder</td>
<td>φ 15mm × 22mm</td>
</tr>
<tr>
<td>Plate</td>
<td>φ 24mm × 7mm</td>
</tr>
<tr>
<td>Roughness</td>
<td>0.45~0.65 μm</td>
</tr>
<tr>
<td>Amplitude</td>
<td>1.5mm</td>
</tr>
<tr>
<td>Frequency</td>
<td>50Hz</td>
</tr>
<tr>
<td>Temperature</td>
<td>more than LC phase</td>
</tr>
<tr>
<td>Pressure</td>
<td>30~300 MPa</td>
</tr>
</tbody>
</table>

3. RESULTS AND DISCUSSION

As shown in Figure 3, we found that thin layer of discotic liquid crystals within each range of liquid crystal forming temperatures have shown much lower traction coefficient value than a mineral oil or PAO which were of lower viscosity than the discotic ones in normal pressure. And the minimum values were just about 0.03 regardless of the considerable differences in chemical or the meso-phase structure.

![Figure 3. Temperature dependence on traction coefficient of DL-1 to DL-3.](image)

On shear surfaces, discotic liquid crystals usually align horizontally. So it is expected that the higher the orientation order is, the smaller “Miesowics viscosity” and also the traction coefficients are.

The structural difference between DL-4, liquid crystal, and DL-5, non-liquid crystal, is the substituted position of side chain end alkoxy group toward benzene ring. DL-4 shows as the same low traction coefficient as DL-1, DL-2 and DL-3. It is quite interesting that DL-5, non-liquid crystal, shows low traction coefficient under the same temperature range as DL-4.

![Figure 4. Temperature dependence on traction coefficient of DL-4 and DL-5.](image)

I suppose that under extreme pressure and shear force a thin layer of DL-5 should have aligned horizontally in the same high order as DL-4 by dissolving torsion of benzene ring with alkoxy chain to become flat configuration which should be unstable at normal pressure.

4. REFERENCES