STUDY ON LUBRICATION PROPERTIES OF CARBOXYMETHYL CELLULOSE AS A NOVEL ADDITIVE IN WATER-BASED STOCK

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ABSTRACT

This paper reports cellulose derivative—carboxymethyl cellulose (CMC) as a novel additive in a water-based stock (water content above 95 wt.%). Cellulose is one of the richest renewable resources on earth and has many peculiar qualities. Several cellulose derivatives such as CMC can easily dissolve in water and form stable thin film on the surface of metal. Several apparatus involving four-ball machine were used to investigate lubrication properties of the based stock containing CMC. The worn surfaces were observed with a scanning electron microscope. As the results, the anti-wear ability of the base stock is effectively increased by addition of a small amount (0.7 wt.%) of CMC. The additive with peculiar molecular structure contributes to abate the adhesion and scuffing of frictional pair effectively, hence improves the anti-wear ability of the base stock. Thus CMC provides a potential application in the field of water-based stock lubrication.

Keywords: carboxymethyl cellulose; cellulose derivative; additive; lubrication properties; water-based stock.

1. INTRODUCTION

Cellulose [Fig.1 (a)] is one of the richest renewable resources on earth [1]. As a cheap natural polymer, cellulose has many peculiar qualities, such as hydrophilicity, non-toxicity, safety, biocompatibility and biodegradability[1,2]. As there are abundant hydroxyl groups in its molecules, cellulose derivatives can be obtained by means of various chemical reactions[2,3]. Several cellulose derivatives such as carboxymethyl cellulose (CMC) [Fig.1 (b)] can easily dissolve in water [2] and instantaneously form stable thin film on surface of metal. In this paper we used CMC as a novel additive in a water-based stock (water content above 95 wt.%). Several apparatus involving four-ball machine were used to investigate lubrication properties of CMC as additive in the water-based stock.

2. EXPERIMENTAL METHODS

Aqueous solution containing 2 wt.% of triethanolamine and 0.5 wt.% of OPZ (a water-soluble zinc alkoxyphosphate which was produced in our lab, [4]) was chosen as the base stock. CMC which was purchased from market was refined and then used as lubricant additive in the base stock. The lubrication measurements were carried out by a MQ-800 four-ball tribotester at a rotational speed of 1450 rpm and at a temperature of 20 °C. Wear scar diameter (WSD) was measured under a load of 392N and a test duration of 30 min. The wear scar in four-ball testing was observed with a JSM-35 model scanning electron microscope (SEM).
3. RESULTS AND DISCUSSION

3.1. Effect of the CMC content on WSD

The WSD represents the anti-wear capacity of the lubricant. The dependence of the WSD data on concentration (wt.%) of CMC are given in Fig.2. It shows that proper addition of CMC can decrease the WSD of the base stock. When CMC’s content reach 0.7 wt.%, the WSD is minimum to 0.37 mm. Whereas under the same testing condition, the WSD of the base stock is 0.45 mm. This infer that CMC has pretty anti-wear performance in water fluid.

Fig.2. Effect of CMC content on WSD.

3.2. Effect of friction time on WSD

The dependence of friction time on WSD is shown in Fig.3. The running-in time of base stock with 0.7 wt.% of CMC is much shorter than that of the base stock, which indicates further that the presence of CMC can strengthen the anti-wear performance of the base stock.

Fig.3. Effect of friction time on WSD of the base stock, and the base stock with 0.7 wt.% of CMC.

3.3. Analyses of the worn surfaces

The worn surfaces observed by SEM (Fig.4.) show that the wear scar obtained with 0.7 wt.% of CMC additive is obviously smaller and exhibits mild scratches, but in comparison, larger wear scar and sharp tracks are observed in the absence of CMC. The long chains of CMC molecules are reasonable to consider anti-wear for their flexibilities. Meanwhile, CMC is nanometer tiny structure, which can penetrate into rubbing surfaces. As there are abundant carboxyl and hydroxyl groups in its molecules, CMC may be easily absorbed on the surface of metal and form stable thin film there. Further, there are many rigid hexatomic rings in the molecular structure of CMC. So CMC may effectively support and isolate two relative motion surfaces, and therefore abate the adhesion and scuffing of the frictional pair. Thus the anti-wear performance of the base stock is improved.

Fig.4. SEM images of worn surfaces of steel balls lubricated with: (a) the base stock, (b) the base stock with 0.7 wt.% of CMC. (c) magnified image of (a), (d) magnified image of (b)

4. CONCLUSION

As a novel kind of lubricant additive in the water-base stock, CMC can improve the anti-wear ability effectively. CMC with peculiar molecular structure contributed to abate the adhesion and scuffing of the frictional pair, hence improved the anti-wear ability of the base stock. As it is abundant, low cost, biodegradable and favorable for environmental protection, CMC provides a potential application in the field of water-based stock lubrication.

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