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Lubricating performance of vegetable oils as environmentally friendly fluids

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Although vegetable oils provide good lubricity, they still need optimization by certain additive technology for practical applications. ZDTP improve antiwear properties of vegetable oils. However the additive performance depends on quality of the base oil. Antioxidants were applied to prevent the auto-oxidation of vegetable oils. Good synergistic effect of anti-wear and anti-oxidant additives was confirmed.

Keywords: Vegetable oils, Antiwear properties, Antioxidants, peroxide value

1. INTRODUCTION

Recently, vegetable oils have been recognized as ecologically acceptable lubricating fluid. In our previous work on improvement of vegetable oils as lubricating fluid, we have found that certain additive technology may offer practical solutions [1,2]. For example, friction modifiers and antiwear additives much improve performance of vegetable oils. However, vegetable oils are unstable when they are compared to mineral based ones. Peroxides are generated during the reaction. The intermediates show destructive effect by decomposing antiwear additives. In this work, our attention was paid to improve antiwear effect of additives by inhibition of autoxidation during use.

2. EXPERIMENTAL

The properties of rapeseed oil are listed in Table 1. Structure and abbreviations of additives are shown in Figure 1. The antiwear properties of vegetable oils were evaluated by means of the four-ball test, which is regulated by ASTM D 4172. The delta wear, which is the difference between the wear scar diameter and the Hertz diameter, is reported [3]. Oxidation test was performed by the following procedure. 500g of rapeseed oil were placed in a round-bottomed flask, fitted with a gas inlet tube and a condenser. Dry air was introduced at 200ml/min at 100℃. Then 10g of the resultant oil were picked out at the scheduled sampling time. The sample was subjected to the POV measurement and the four-ball test.

Table 1 Properties of rapeseed oil

TAN , mg KOH/g	POV , ppm	Viscosity, mm^ 2/s		VI
		40 ž	100 ž	
0.04	309	35.4	6.8	155

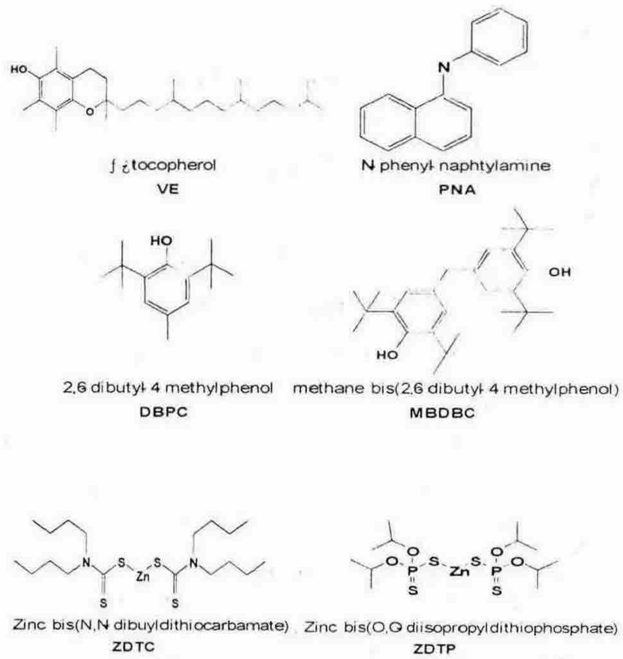

Figure 1 Structure of the additives

3. RESULTS AND DISCUSSION

We previously reported that peroxides react with ZDTP to give ineffective compounds as antiwear additives in mineral oil solutions [4]. The same phenomena were observed in vegetable oil solutions. As shown in Figure 2, additive effect of ZDTP decreases with increase of POV. It has been reported that peroxides may cause oxidative wear [5]. However, delta wear obtained by vegetable oil containing peroxides less than 900 ppm, was approximately 0.3mm. Therefore, peroxides themselves do not promote wear under these conditions.

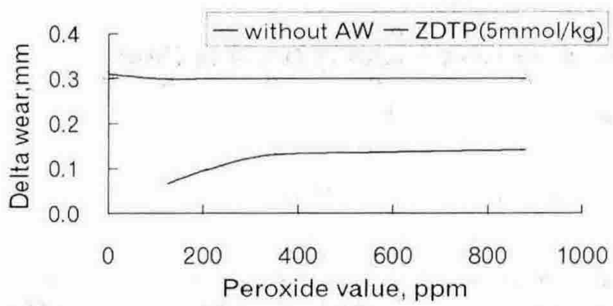

Figure 2 Effect of POV on antiwear with ZDTP

As Figure 3 shows, POV increases rapidly at the beginning of the reaction. The POV reaches the maximum value of approximately 1500 ppm within 50 hours after the reaction start. Then the value decreases to reach an equilibrium value of 400-500ppm. Total acid number and viscosity of the oxidized oil increased during the equilibrium stage.

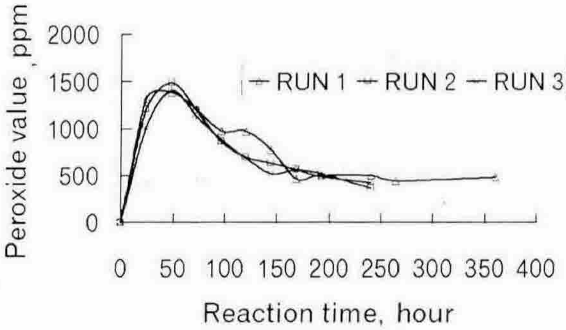

Figure 3 Results of the oxidation test

Results with antioxidants at 1wt% are shown in the Figure 4. VE exhibited almost no effect in preventing generation of peroxides. Rate of POV increase with PNA showed little letted. The maximum value of POV in the presence of PNA was approximately 1000ppm. Rate of POV increase with DBPC-containing and MBDBC-containing sample was much lower. The sample did not reach the maximum value even after 240 hours reaction. ZDTC-containing gave excellent results.

Figure 5 shows antiwear effects of ZDTP in the oils after 240 hours oxidation. Almost no effect on antiwear was observed with antioxidant-free, VE-containing PNA-containing samples. Excellent wear reduction was observed with DBPC, MBDBC, and ZDTC samples. Here we achieved good synergy of antioxidant and antiwear additives. No relationship between POV and wear prevention can be find out from Figure 4 and Figure 5. It seems to be inconsistent with the results presented by Figure 2. However, we understand that the phenomena are due to difference of the oxidation stage. Figure 4 represents the results at the initial stage of the oxidation, where contents of organic oxides are negligible. On the contrary, Figure 5 represents "the equilibrium stage" where organic oxides are present in the solution. As we have reported previously, certain organic oxides promote decomposition of ZDTP [4].

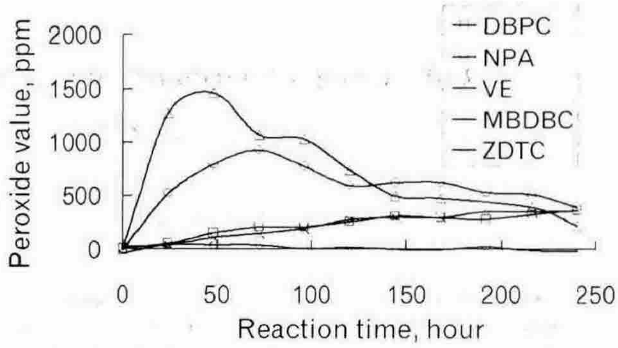

Figure 4 Results of the oxidation test

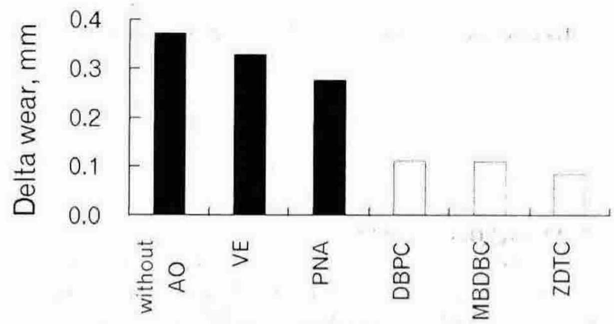

Figure 5 Effect of ZDTP on antiwear

4. CONCLUSIONS

1. DBPC, MBDBC and ZDTC inhibit formation of peroxides, where as PNA and VE gave poor results.
2. At an initial oxidation stage, AW properties of ZDTP depend on POV. Less content of peroxides are desirable for good wear reduction.
3. At an equilibrium stage of oxidation, AW properties of ZDTP depend not only on POV.
4. Combination of AO and AW additives may provide practical lubricants.

5. ACKNOWLEDGEMENTS

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6. REFERENCES

[1] I.Minami,H.S.Hong, N.C. Mathur,"Lubrication Performance of Model Organic Compounds in High Oleic Sunflower oil" Journal of Synthetic Lubrication, vol.16, No.1, pp.3-12, 1999

[2] I.Minami,S.Mitsumune,"Antiwear Properties of Phosphorous Containing Compounds in Vegetable Oils" Tribology Letters, in press

[3] D.E.Weller,Jr.,J.M.Perez,"A Study of the Effect of Chemical Structure on Friction and wear: Part I- Synthetic Ester Base Fluids"Lubrication Engineering, vol. 56, No11, pp. 39-44, 2000

[4] I.Minami,"Influence of Aldehydes in Make-up Oils on Antioxidation Properties" Lubrication Science, vol. 7, No4, pp. 319-321, 1996

[5] F.Rounds,"Effects of Hydroperoxides on Wear-as Measured in Four-Ball Wear Tests" Trbology Transactions, vol. 36, No2, pp. 297-303, 1993