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ZDDP- An Inevitable Lubricant Additive for Engine Oils

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***Abstract*— Zinc dialkyldithiophosphate (ZDDP) has been widely used as an additive in lubricating oil, especially engine oil, because of its excellent antiwear and anti-oxidation properties. ZDDP's properties partly contribute to the P, S and Zn elements contained in its molecule structure. The phosphorus element would make the catalysts, equipped in the exhaust gas converter of the automobile, be poisoned and finally lose their efficacy. Moreover, the zinc salts produced by ZDDP in tribological condition might cause the electrolytic corrosion. There is a request from automaker to oil industry to eliminate ZDDP, or at least reduce it to 0.05 per cent but till date, the oil industry finds uncomfortable with reducing the level below 0.08 per cent. No new antiwear additives to eliminate or reduce ZDDP have been found until now. This review paper supports that there is no alternative for ZDDP.**

***Keywords*—Additive, Antiwear, ZDDP, Load Carrying Capacity.**

I. INTRODUCTION

Zinc Dialkyldithiophosphates, or ZDTPs, are oil soluble chemicals which are used as additives in lubricating oils for internal combustion engines and transmissions. ZDTPs are a key component of modern engine oils, and while they represent only a small fraction of the total engine oil, they play a vital role providing wear protection of key metal-metal contact points in engines and transmissions. This results in extended engine and transmission life. Because they contain sulfur, ZDTPs also provide oxidation protection which extends the life of the engine oil. With this dual protection role, ZDTPs are sometimes referred to as "multifunctional" additives.

Figure-1 below shows a representative chemical structure of a ZDTP. ZDTPs are manufactured by reacting various types of alcohols with phosphorus pentasulfide, then neutralizing the resultant intermediate with zinc oxide. The phosphorus – sulfur – zinc linkage is key to understanding how a ZDTP protects engines from wear [1].

Figure-1: Chemical Structure of a ZDDP

ZDTPs appear as gold colored liquids with a thickness or viscosity similar to heavy syrup. They are not soluble in water, and because they are denser than water, they will sink in a water environment. They are readily soluble in oil and lighter weight hydrocarbons such as gasoline. ZDTPs have very low vapor pressure and little noticeable odor at ambient temperatures. When heated however, they have a sulfurous odor, similar to that of burning rubber. Since ZDTPs are present in a small amount in lubricating oils, this odor is not noticeable during normal operation.

II. RESEARCH REVIEW

The synergistic effort of the benzothiazole derivative containing dialkyldithiocarbamate (BSD) with ZDDP. Four oil samples were prepared. For each sample, the total concentration of both BSD and ZDDP in base oil is fixed at 0.5 per cent and the concentration of BSD and ZDDP, respectively, was changed according different ratio. The antiwear properties of four samples were evaluated by using a four-ball machine at the load of 490N (50 kg) and sliding time of 15 min [2].

Table1: Performance comparison between ZDDP and BSD [2]

Additive	Concentration (per cent)	Pb value (kg)	WSD (mm) 30 kg	WSD (mm) 50 kg
Base oil		40	0.58	Seizure
ZDDP	0.5	78	0.38	0.49
BSD	0.5	70	0.46	0.89

There is synergism effort between ZDDP and BSD. We may use BSD to partially replace ZDDP without satisfying the lubricating performance.

A Novel borate ester derivative containing dialkylthiophosphate groups (coded to BDDP for simplicity) was synthesized and characterized. Compared with ZDDP, BDDP as additive in synthetic ester (Esterex A51) shows better load-carrying and friction-reducing property. Meanwhile, BDDP can improve the antiwear performance of the base oil evidently.

But its antiwear property is slightly worse than that of ZDDP. The decomposed borate ester adsorbed on worn surface. S and P element in BDDP reacted with metal and generated FePO4, Fex(SO4)y, both of which contributed to the formation of boundary lubricating film. BDDP exhibits better thermal stability than ZDDP. BDDP has high efficiency in controlling the oxidation of Esterex A51. However, the antioxidative property of ZDDP is better than that of BDDP [3].

Vegetable oils can contribute toward the goal of energy independence and security due to their naturally renewable resource. They are promising candidates as base fluids for ecofriendly lubricants because of their excellent lubricity, biodegradability, good viscosity-temperature characteristics, and low evaporation loss. Their use, however, is restricted due to low thermo-oxidative stability and poor cold-flow behavior. This paper presents a systematic approach to improve their oxidation behavior by searching for a suitable additive combination. The study of antioxidant/antiwear additive synergism was investigated on a set of four antioxidants and three antiwear additives in vegetable oils using pressure differential scanning calorimetry (PDSC) and a rotary bomb oxidation test (RBOT). The results indicate that dialkyldithiocarbamate antioxidant performed better than diphenylamine and hindered phenol. The zinc dialkyldithiocarbamate antioxidant showed excellent synergism with antiwear additive antimony dithiocarbamates [4].

In another study, it has been investigated that the ZDDP has very good anti wear abilities. Addition of 0.25% (v/v) ZDDP by thirteen times. The presence of same amount of ZDDP increases the load carrying capacity of contaminated lubricant by five times. ZDDP also help in reducing three body wear, particularly when abrasive contaminants are present in the lubricants [5]. The Result is summarized in table 2.

Table 2: **Tabulation of Results**

Sample	Timken Ok Load (Pound)	Weight of Bullet before Test (gm)	Weight of Bullet after Test (gm)	Wear Weight Loss (gm)	Percentage Wear Wight Loss (%)	Scar Diameter (Major) (mm)	Scar Diameter (Minor) (mm)
(A) Raw Base Oil	40	29.3549	29.3035	0.514	**0.1750**	10.00	6.076
(B) Base oil+0.25% ZDDP	520	29.3300	29.3100	0.200	**0.0681**	7.00	4.076
(C) 0.1% Sand Particles + (B)	200	29.3408	29.3054	0.354	**0.1206**	8.028	5.0008

III. CONCLUSION

The studies shows that Zinc dialkyl dio thio phosphate (ZDDP) is a very good anti wear agent known till date. Even in the presence of contaminants it improves the load carrying capacity to a remarkable value.

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