ASIATRIB 2002 International Conference
JEJU ISLAND, KOREA

ANTIWEAR FILM FORMATION BY COMPONENTS OF PASSENGER CAR MOTOR OILS

E. S. YAMAGUCHI, S. H. ROBY, M. M. FRANCISCO, and S. G. RUELAS

Chevron Oronite Company LLC
Richmond, California USA 94802

Engine testing of new low-sulfur, low-phosphorus antiwear components is expensive and time consuming so bench testing of potential candidates is highly desirable as a first step evaluation. Electrical contact resistance (ECR) has been shown to be a convenient method to assess antiwear film formation in a ball-on-flat bench wear test. Correlation of the bench test to fired engines was demonstrated for lubricants varying only in the type of detergent.

Previous papers have examined film formation by one and two component formulations of zinc dialkyldithiophosphate (ZnDTP) and detergents. In this study, the ECR technique is systematically extended to formulations including ZnDTP, detergent, and dispersant. Both type and level of components are considered and the implications for engine performance are discussed.

Keywords: Additives; zinc dialkyldithiophosphate; detergent; dispersant; wear; Electrical Contact Resistance

INTRODUCTION

Fully formulated engine oils are considerably more complicated than the one and two component systems from the earlier studies. Fully formulated gasoline engine oils typically contain one, perhaps two dispersants; one or two overbased detergents; an antiwear agent; oxidation inhibitors; corrosion inhibitors; foam inhibitors; viscosity modifiers; and pour point depressants. Most of these materials are surface active and may interfere with antiwear film formation.

Phosphorus, usually delivered as an element in ZnDTP, has been a mainstay for valve train wear protection in passenger car motor oils since the 1950's. However, some studies have indicated that phosphorus may poison catalytic converters used to reduce tailpipe emissions of unburned hydrocarbons and oxides of nitrogen. As the emission regulations tighten, the OEMs wish formulators to reduce phosphorus levels in the motor oil.

In the current study, the ECR method is applied to examining three-component low phosphorus formulations and determining which formulation variables determine adequate antiwear film formation.

EXPERIMENTAL

Simultaneous measurements of Electrical Contact Resistance (ECR) and coefficient of friction were made using a ball-on-disk tribometer. In brief, a ball was held in a collet against a rotating flat. Load was applied by dead weights. No break-in loads were applied. Friction was measured by a calibrated strain gauge. A typical ECR experiment is 20 minutes long. At the end of the ball-on-flat run, the test parts were removed, washed with a light hydrocarbon solvent, and retained for further analysis.

Three commercial lubricant additives were selected for study. The zinc dialkyldithiophosphate (ZnDTP) is made from a mixture of secondary alcohols. The dispersant is a high molecular weight succinimide, particularly suited for controlling sludge and varnish deposits. The third is a 250 TBN overbased detergent.

The additives were tested in a commercially available light mineral oil with a viscosity of 4 cSt at 100°C. The base oil contains essentially no sulfur, nitrogen, or aromatic components.

A series of blends were made to study systematically the influence of the type and concentration of additives on insulating film characteristics. The three additives were compounded in various concentrations to produce the nine blends. The maximum dosage reflects current usage in passenger car motor oils. The minimum (zero) dosage allows individual additive effects and two-way interactions to be isolated. This experimental design examines all combinations of the additives in the fewest possible runs. Finally, the proposed lower phosphorus formulations for future generations of passenger car motor oils are encompassed within the additive concentration ranges.

Figure 1 shows the ECR traces for Blends 1 through 9. Figure 1(a) contains the traces for the blends with no dispersant, Figure 1(b) those with high dispersant, and Figure 1(c) for the blend with medium levels of ZnDTP, detergent, and dispersant.

Figure 1 (a)
ECR Results for Blends 1-4 (No Dispersant)

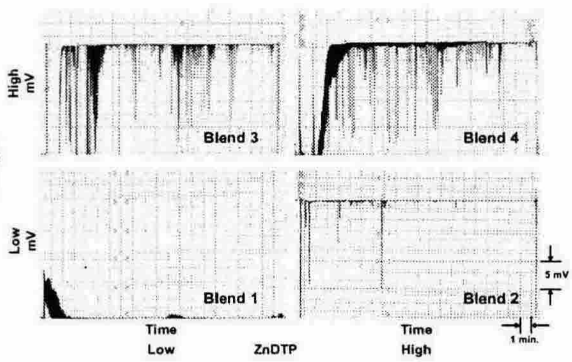


Figure 1 (b)
ECR Results for Blends 5-8 (High Dispersant)

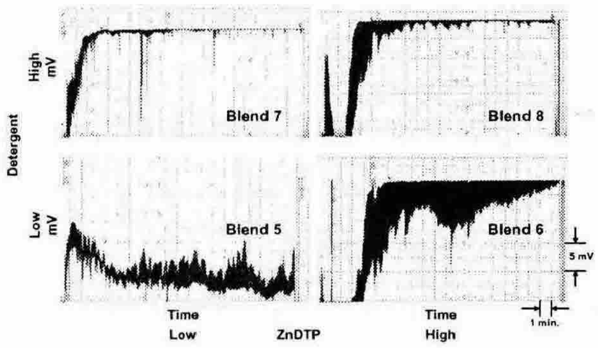
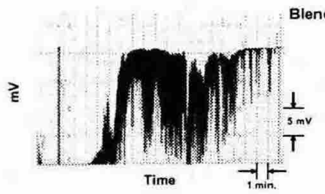


Figure 1 (c)
ECR Results for Blend 9
(Medium Dispersant, Detergent, ZnDTP)



CONCLUSIONS

a. The severely hydrotreated base oil alone is ineffective in forming an antiwear film;
b. ZnDTP alone quickly forms a nonconducting, durable antiwear film;
c. High TBN detergent forms a nonconducting, reasonably durable antiwear film;
d. Combinations of ZnDTP and high TBN detergent form nonconducting, less durable films;
e. Dispersant alone forms a poor, non-durable film;
f. Dispersant interferes with the ability of either ZnDTP or detergent to form a durable film;
g. Reducing the levels of ZnDTP, detergent, and dispersant simultaneously results in a less durable film that takes longer to form;
h. ECR experiments in simple systems have indicated that future low phosphorus engine oils will most likely require supplemental antiwear additives to maintain durable antiwear films; and finally,
i. ECR experiments are a quick, effective method to check for antiwear film formation and retention in low phosphorus engine oils.