Impact of lubricant oil additives on the performance of three way catalysts

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Introduction

Lubricant additives are being widely used in engines to improve efficiency and durability. Currently, zinc dialkyl-dithiophosphate (ZDDP) is the most common anti-wear (AW) additive. However, ZDDP will form ash during engine combustion and deactivate emissions control catalysts. Therefore, there is a need to develop alternative, ashless, and more effective AW additives with less impact on emissions control systems. In a collaboration between Oak Ridge National Laboratory (ORNL) and General Motors Company (GM), a group of oil-miscible ionic liquids (ILs) have been developed as next-generation AW additives [1,2] and the first prototype IL-additized ultra-low viscosity engine oil has demonstrated >2% improved fuel economy [3]. In this work we investigated the impact of the IL on the performance and long term durability of emissions control catalysts. Accelerated aging of three way catalysts (TWCs) with different AW additives (ZDDP *vs* IL) has been conducted to compare their impacts on the TWC performance in engine emissions control.

Materials and Methods

A genset system for accelerated catalyst aging was established at ORNL to compare the impacts of ZDDP and IL on TWC performance. For catalyst aging, 7.5 gallons of gasoline that was mixed with about 35 g of IL or ZDDP was consumed in a time period of more than 20 hours; this is the expected exposure over the lifetime of the vehicle with 1% IL/ZDDP in the lubricant. A close-coupled TWC was provided by GM that had been thermally aged to 150,000 miles, or the equivalent of Full-Useful-Life (FUL); thus it was in a state that was most sensitive to the P-containing compounds. Large catalyst cores were extracted from the TWCs for the genset (42 mm OD and 155 mm in length) and smaller cores were extracted for catalyst performance tests (11 mm x 11 mm x 50 mm). A bench flow reactor at ORNL was used to evaluate the performance of the aged TWCs. Reaction conditions were 0.1% C_3H_6, 1.8% CO, 0.12% NO, 1.59% O_2, 0.6% H_2, 5% H_2O, 5% CO_2, and balance N_2. Space velocity (SV) was 75,000 h^{-1}. Temperature ramped from 100 to 550 °C at 2 °C/min.

Results and Discussion

In order to clarify the impacts of ZDDP and IL exposure on the catalytic performance of TWCs, small cores from the FUL-TWCs were evaluated in a bench core reactor before and after aging. The light-off temperature profiles of NO, CO, and C_3H_6 as a function of furnace temperatures are exhibited in Figures 1 a-c. As it can be seen, ZDDP-aged TWC shows an obvious deactivation sign, as evidenced by the significant drop of NO conversion with the temperature increase. Moreover, compared with ZDDP, IL aging shows less impact on the TWC performance. Figure 1d shows the light-off temperature for 50% conversion (T50) of NO, CO, and C_3H_6. The T50 of NO conversion for FUL+IL is 241 °C, which is comparable to FUL+{No additive} (247 °C) but dramatically lower than FUL+ZDDP (272 °C). Similar phenomena are observed for the T50 cases of C_3H_6 and CO as well. These results illustrate that, as a lubricant additive, IL has moderately less impact on the TWC performance compared with ZDDP. The exact nature of the interaction on the catalyst is currently being investigated and will be reported at the conference.

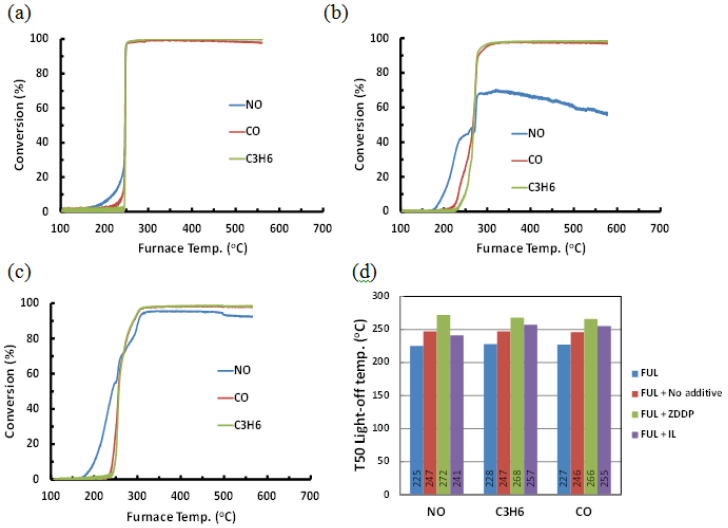

Figure 1. NO, CO, and C_3H_6 light-off curves for (a) FUL-TWC aged by gasoline without anti-wear additive [FUL+No additive], (b) FUL-TWC aged by gasoline + 1% ZDDP [FUL+ZDDP], and (c) FUL-TWC aged by gasoline + 1% IL [FUL+IL], and (d) T50 light-off temperatures for NO, C_3H_6, and CO conversion.

Significance

The results of this research clarified the impacts of the different lubricant additives (ZDDP *vs* IL) on the performance of TWCs. It is demonstrated that, as a lubricant additive, IL has moderately less impact on the TWC performance compared with ZDDP. This study provides critical knowledge that can be used to guide future studies to develop more efficient and cost-effective lubricant AW additives.

References

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