講演番号 369

Evaluation of Base-Fuel Dependence on Ignition-Suppression Effect of ETBE Using a High-Pressure Shock Tube

Ken Satokawa [1)] Tomohiro Hamasaki [1)] Reina Okamura [1)] Akira Miyoshi [2)] Kazuo Takahashi [3)]

1) Sophia University, Graduate School of Applied Chemistry
7-1 Kioi-cho, Chiyoda-ku, Tokyo 102-8554, Japan
2) Hiroshima University, Graduate School of Advanced Science and Engineering
1-4-1 Kagamiyama, Higashihiroshima-shi, Hiroshima 739-8527, Japan
3) Sophia University, Department of Materials and Life Sciences
7-1 Kioi-cho, Chiyoda-ku, Tokyo 102-8554, Japan
(E-mail: takaha@sophia.ac.jp)

KEY WORDS: Heat engine, Spark ignition engine, Combustion analysis, Automotive Fuel, Shock Tube [A1]

Improving the thermal efficiency of automotive gasoline engines is an important issue as a measure against global warming. To resolve this problem, it is necessary to optimize gasoline fuel to ensure high engine performance is fully demonstrated. We have been focusing on ethanol (EtOH) not only for its ability to reduce CO_2 emissions as a biofuel, but also for its extremely high knocking resistance. In the previous study, we have shown that the ignition-suppressing effect of EtOH is weakened when the base fuel contains light olefins (e.g., 1-pentene) and aromatics (e.g., toluene). In the present paper, we evaluated the base-fuel dependence on ignition suppression of ethyl *tert*-butyl ether (ETBE), which is another bio-derived fuel. Measurements of ignition delay times using a high-pressure shock tube and computer simulations based on chemical kinetics were performed to investigate the chemical interaction between ETBE and each component in the base fuels, and the results were compared with those for EtOH.

Figure 1 shows the measured ignition delay times (τ) for fuels adding 23 vol% ETBE to four different base fuels: PRF90, PRF94O30, PRF73A30, and PRF83O15A15. Similar to EtOH, ETBE has an ignition-suppressing effect on any base fuels. However, the autoignition behaviors of ETBE-added fuels maintain negative temperature coefficient (NTC) regions derived from the base fuels, in contrast to those of EtOH-added fuels. Consequently, the base-fuel dependence for the ignition-suppressing effect of ETBE changes in a complex manner depending on the temperature. At 750 K, where knocking characteristics can be evaluated, the ignition-suppressing effect of ETBE showed much weaker base-fuel dependence than that of EtOH, and was almost similar across the base fuels.

To chemically understand the difference in the base-fuel dependence of the ignition-suppressing effects of ETBE and EtOH, the ratios of consumption rates for EtOH and ETBE during the ignition induction periods were calculated. As shown in Fig. 2 (a), EtOH is consumed almost entirely through reactions with HO_2 radicals, while in the case of ETBE, the contribution of reactions with HO_2 radicals is limited to approximately 80 %, and the contribution of OH radicals is also significant (see Fig. 2 (b)). These results show that while EtOH generates only HO_2 radicals as chain carriers, ETBE generates not only HO_2 but also OH radicals. The reactivity of HO_2 radicals is low and differs greatly in hydrocarbons, so that the ignition-suppressing effect of EtOH depends on the base-fuels. In contrast, since OH radicals easily react with all hydrocarbons, the ignition-suppressing effect of ETBE does not clearly depend on the base fuels.

Timings of the chain carriers formed in the ETBE and EtOH-added systems were calculated using virtual reaction simulation. The calculations showed that HO_2 radicals derived from EtOH were generated 1000 times faster than the chain carriers (HO_2 and OH radicals) derived from hydrocarbons in the base fuels. In contrast, HO_2 radicals derived from ETBE were generated almost simultaneously with chain carriers derived from the base fuels. This difference in the timing of HO_2 radical formation is also the reason why the base-fuel dependence is observed in the EtOH-added system but not in the ETBE-added system.

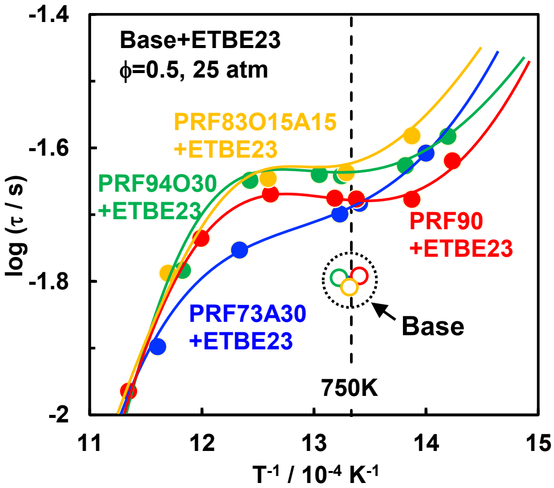

Fig. 1 Ignition delay times (τ) measured for mixtures with 23 vol% ETBE added to different base fuels.

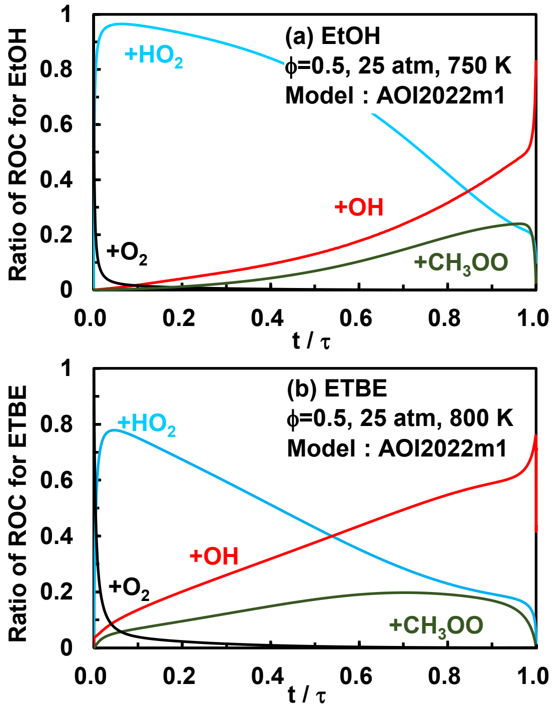

Fig. 2 Ratio of ROC for (a) EtOH at 750 K and (b) ETBE at 800 K.