

Engine Combustion Characteristics of Olefin-Rich Gasoline Derived from Fischer–Tropsch Synthesis

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Fischer-Tropsch (FT) synthesis has attracted considerable interest as a promising pathway for producing carbon-neutral fuels. However, FT-derived fuels predominantly consist of straight-chain paraffins and generally exhibit low octane numbers. As a result, severe engine knocking limits their direct use in gasoline engines, requiring upgrading processes to improve octane quality. In our previous studies, we proposed a hybrid catalyst system combining FT and acidic catalysts to crack heavy hydrocarbons and increase olefin selectivity. Because olefins generally exhibit higher octane numbers than paraffins with the same carbon number, improved knock resistance was expected. In the present study, surrogate fuels representing the composition of the catalyst-derived products were prepared and evaluated using a gasoline engine.

A single-cylinder gasoline engine was used for the evaluation. The primary performance indicators were knock intensity and the amount of combustion phasing retard required to avoid knocking. Primary Reference Fuel (PRF), which consists of mixtures of n-heptane and iso-octane and serves as the standard fuel for octane rating evaluation, was used as a reference fuel. The knock resistance of the surrogate fuel was assessed by comparing its engine performance with that of PRF fuels of different octane numbers. Assuming linear blending behavior, the estimated Research Octane Number (RON) of the surrogate fuel is approximately 60. However, as shown in Fig. 1, the knock resistance of the surrogate fuel at 1500 rpm was comparable to that of PRF70 under low-load conditions. As the engine load increased, the equivalent octane number also increased. Under near-wide-open-throttle conditions, knock resistance exceeding that of PRF80 was observed. These results indicate that the octane number represents knock resistance under specific engine operating conditions and does not necessarily correspond to knock resistance over the entire operating range. The apparent octane quality of the fuel was found to vary substantially with engine load. This behavior has not been clearly observed for conventional gasoline fuels and may become more pronounced for fuels with significantly different compositions. Therefore, the distinct composition of the present surrogate fuel is likely responsible for amplifying the dependence of knock resistance on engine operating conditions.

To further investigate this phenomenon, chemical kinetic simulations were performed. A PRF fuel and an olefin-rich fuel with equivalent RONs were prepared, and ignition delay times were systematically calculated over a wide range of temperatures and pressures. The results revealed that the olefin-rich fuel exhibited longer ignition delay times under high-pressure and low-temperature conditions, whereas shorter ignition delay times were observed under low-pressure and high-temperature conditions. These trends are consistent with the engine experiments, in which the olefin-rich fuel demonstrated enhanced knock resistance under high-load operating conditions. The results suggest that the knock resistance of olefin-rich fuels is more strongly influenced by in-cylinder thermodynamic conditions than that of conventional gasoline fuels. Under high-pressure conditions, the olefin-rich fuel exhibited knock resistance that exceeded that expected from its RON value. This finding indicates that RON alone may not adequately represent the anti-knock performance of fuels with unconventional compositions.

Although this tendency has not been clearly observed for conventional gasoline fuels, it is inferred that the unique composition of the olefin-rich fuel amplified the dependence of knock resistance on operating conditions. These findings suggest the potential applicability of olefin-rich FT-derived fuels to modern high-pressure engine systems, such as downsized turbocharged engines and series-hybrid powertrains, which frequently operate under high-load and high-pressure conditions.

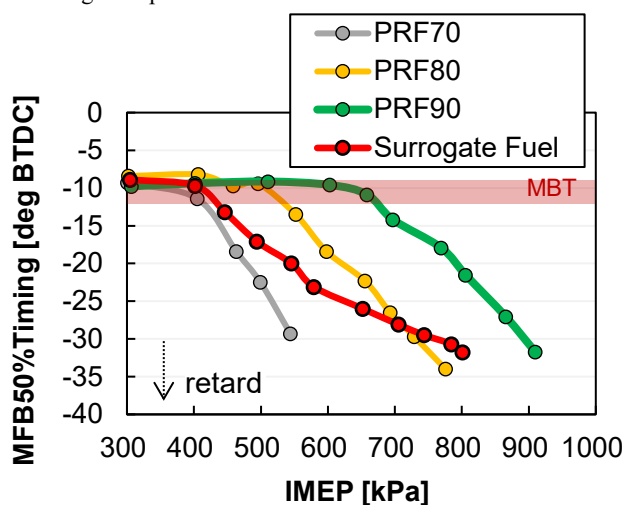


Fig.1 Knock Resistance Characteristics of the Surrogate Fuel as a Function of Engine Load