

Comparison of Laminar Burning Velocities Between e-Fuels and Conventional Fuels

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With the aim of applying carbon-neutral synthetic fuels (e-fuels) to spark-ignition engines, this study comparatively evaluates the laminar burning velocities and flame stretch responses of multi-component synthetic fuels (prototype FT gasoline and MtG fuel) against conventional regular gasoline. To eliminate the complex variables present in actual engines and assess fundamental, fuel-specific combustion characteristics, the research focused on spherically propagating premixed flames within a constant-volume combustion vessel. During the experiments, to prevent compositional deviation caused by differences in volatility when vaporizing multi-component fuels, a method was developed to directly inject liquid fuel into the vessel for mixing with air. This approach enabled accurate measurements while strictly maintaining the actual fuel composition.

The experimental results confirmed that differences in the molecular structures of the fuels significantly affect combustion behavior. Under stoichiometric ($\Phi=1.0$) and lean ($\Phi=0.84$) conditions, the prototype FT gasoline exhibited the highest laminar burning velocity and demonstrated low sensitivity to flame stretch, tending to suppress any reduction in velocity. Conversely, the MtG fuel showed a lower burning velocity across all conditions and exhibited high sensitivity to flame stretch. However, under highly lean conditions ($\Phi=0.67$), this trend changed drastically. A reversal phenomenon was observed where the burning velocity of the prototype FT gasoline dropped significantly, falling below that of regular gasoline. Furthermore, under these highly lean conditions, the FT gasoline also became more susceptible to burning velocity reductions caused by flame stretch.

To elucidate the mechanism behind this anomalous decrease in burning velocity for the prototype FT gasoline under highly lean conditions, a one-dimensional chemical kinetic analysis was conducted. The analysis revealed that stable "pentenyl radicals," generated from the abundant olefin components in the prototype FT gasoline, are the primary cause. Because pentenyl radicals possess a highly stable structure, they accumulate in the preheat zone located just upstream of the main combustion zone. Within this preheat zone, they consume large quantities of crucial active species essential for combustion progression, such as OH and HO₂ radicals. This radical-scavenging effect suppresses the overall flame reaction, ultimately triggering the significant decrease in burning velocity observed under highly lean conditions.

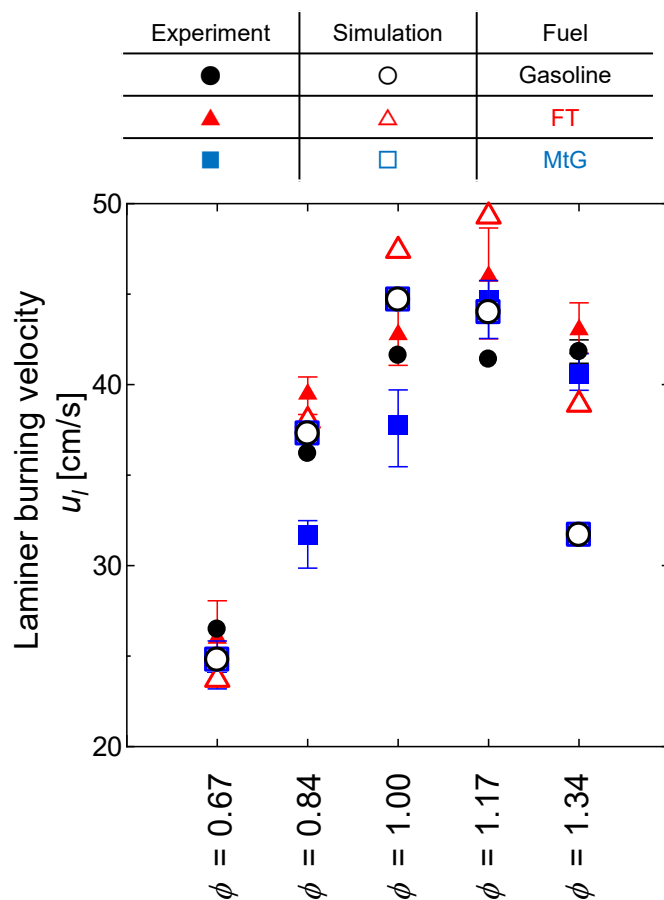


Fig. 1 Comparison of experimental and numerical results.