

Reduction of soot precursor by ethanol decomposition before diesel combustion

Mechanical Engineering, Hirofumi NOGE

INTRODUCTION

A huge number of the studies on soot reduction during diesel combustion have been reported, there are less study cases for the relation between thermal decomposition and soot reduction before diesel combustion. Diesel combustion is controlled by ignition delay period that starts thermal decomposition. Demonstrating this chemical reaction will predict soot formation more clearly and suggest a new combustion concept to prevent soot generation.

Ethanol, which is from renewable energy resources, is a very important energy. It is mainly used as an alternative, neat fuel to replace reformulated gasoline. Also, effect of ethanol blending on performance and emissions of a DI-diesel engine were studied⁽¹⁾.

The purpose of the present work is to investigate the chemical effect of reducing soot precursor by ethanol before diesel combustion.

EXPERIMENT

A plug flow reactor system presented in Fig.1 consists of an evaporator, a high temperature reactor with infrared reflex furnace (Shinkuriko E401), temperature controller (Shinkuriko TPC-1000) and gas analysis part can simulate “before diesel combustion” atmosphere. The gas analysis apparatus has a gas chromatograph (GC) equipped with FID and TCD (Yanaco G3800). Thermally decomposed hydrocarbons and soot precursor were sampled on a teflon filter (MILLIPORE FHLPO4700 d=47mm hole=0.45 μ m) and weighted before and after collection. A soxhlet extraction was carried out to separate soluble organic fraction (SOF) from PM that was eluted into dichloromethane (DCM).

Two kinds of fuels were analyzed: an aliphatic diesel fuel 0-Solvent that is composed of three saturated hydrocarbons,

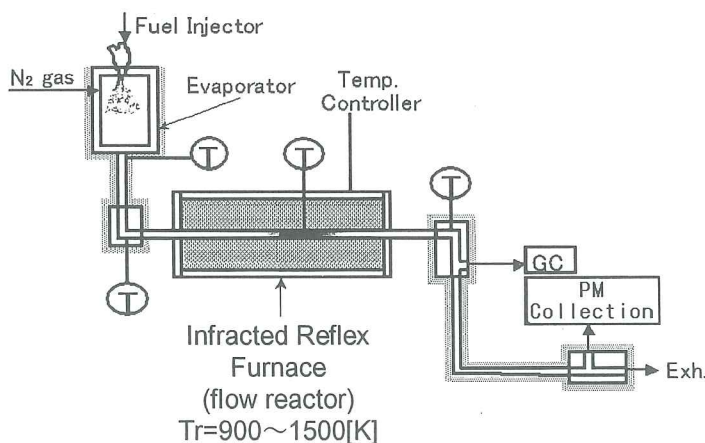


Fig.1 Schematic diagram of plug flow reactor system

$C_{12}H_{26}$: 27wt.%, $C_{13}H_{28}$: 47wt.% and $C_{14}H_{30}$: 26wt.% and ethanol, C_2H_5OH : 99.5vol.%.

RESULTS AND DISCUSSION

Fig.2 shows unburned hydrocarbons (UHC) +soot precursor produced by thermal decomposition of solvent or ethanol before diesel combustion. In the solvent, reactor temperature $Tr=1500K$, the concentration increases with fuel-nitrogen ratio F/N. In the ethanol, the concentrations are less than solvent fuel. Ethanol includes OH bond in its molecular structure, which probably promotes oxidation of decomposed hydrocarbons, preventing generation of soot precursor

species such as C_2H_2 and polycyclic aromatic hydrocarbons (PAHs).

The UHC+soot precursor collected on the teflon filters are presented in Fig.3. The solvent fuel shows brown color that is recognized by M. S. Skjøth-Rasmussen et al.⁽⁵⁾ who indicate the color is caused by PAHs condensation. On the visual of ethanol samples, delicate light yellow colors are observed and prove non-soot tendency.

Fig.4 shows the concentrations of light hydrocarbon produced by thermal decomposition of solvent at $T_r=1500K$. C_2H_4 , C_2H_2 , CH_4 concentrations are comparatively higher than the others. C_2H_4 is produced mainly, which is typical β -rule of liquid alkane molecule at pyrolysis atmosphere. On the thermal decomposition of ethanol in Fig.5, light hydrocarbons are produced in order of $CH_4 > C_2H_4 > n-C_4H_{10}$. The decomposition of ethanol more generates saturate hydrocarbons, which reaction is provably caused by OH bond in its structure, than unsaturated ones.

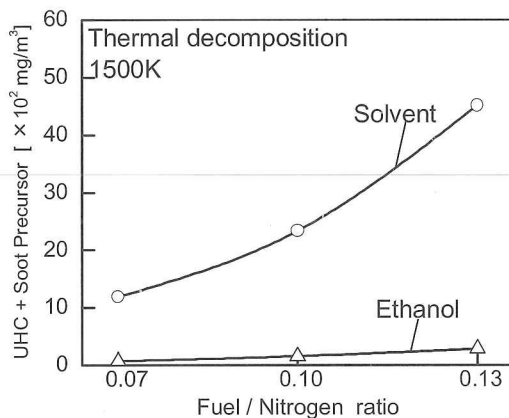


Fig.2 The concentration of UHC + Soot precursor generated by solvent and ethanol

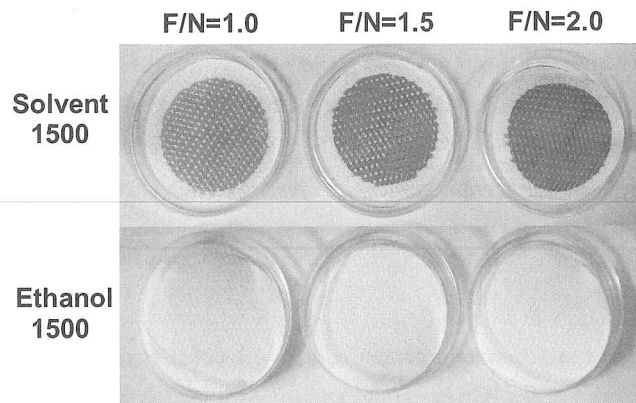


Fig.3 Visual representation of filter deposits

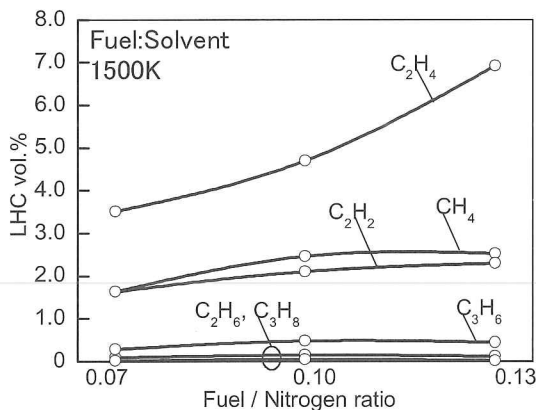


Fig.4 The LHC produced by thermal decomposition of solvent

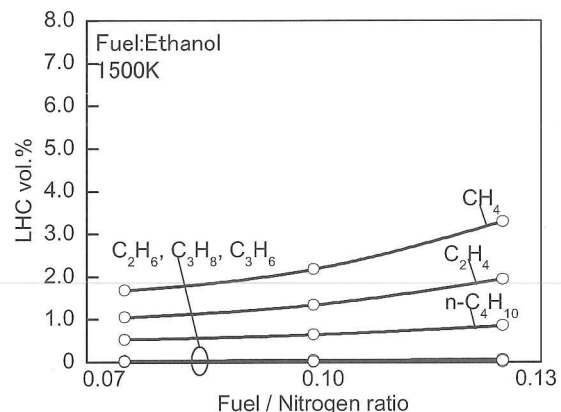


Fig.5 The LHC produced by thermal decomposition of ethanol

CONCLUSIONS

- (1) In the ethanol, unburned hydrocarbons (UHC) +soot precursor concentrations in the thermal decomposition are less than solvent.
- (2) The visualization of ethanol sample filters show delicate light yellow colors, demonstrating non-soot tendency.
- (3) The ethanol decomposition more generates saturate hydrocarbon in order of $CH_4 > C_2H_4 > n-C_4H_{10}$.

REFERENCES

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