Background

- Fast Pyrolysis Bio-Oil (FPBO), a biomass-derived fuel, is studied to fuel stationary diesel engine for combined heat and power (CHP) generation.

- The special properties of FPBO make the direct application in diesel engines very constrained: high water content (15-30 wt%), solid content, high viscosity, poor ignition quality, etc.

- Blending FPBO with n-butanol can improve the stability and atomization characteristics, reducing viscosity and surface tension, and preventing polymerization.

- Additional ignition improver (e.g., 2-ethylhexyl nitrate, EHN) is in need of FPBO/alcohol blends to meet the requirement of compression ignition in the diesel engine.

- Ignition and combustion characteristics of FPBOs-butanol blends with addition of EHN is investigated in this study.

Method: Experimental Setup - CRU

- The Combustion Research Unit (CRU) is employed to provide a well-defined and quiescent boundary condition for the investigation of ignition and combustion characteristics.

- Effects of EHN content on n-butanol are first investigated:
  - EHN mass fraction: 2%, 4%, 6%, 8%, 10%
  - Different chamber wall temperature: 520, 550, 580 °C

- Effects of FPBO content on FPBO/n-butanol with EHN addition of 5% are then studied:
  - FPBO mass fraction: 0%, 3%, 5%, 15%, 20%, 25%, 30%
  - Different chamber wall temperature: 490, 505, 520, 535, 550, 565, 580 °C

- Other fixed operation conditions: initial chamber pressure of 30 bar, injection pressure of 1500 bar, and injection duration of 5.5 ms.

![Figure 1: Left: the photo of CRU. Right: the schematic of the constant volume combustion chamber (CVCC) in the CRU.](image)

Method: Data Processing & Definitions

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![Figure 2: A typical example of chamber pressure, pressure rise rate (PRR), and mass fraction burned (MFB) profiles (FPBO-30 at 580 °C).](image)

Results

- Effects of EHN proportion

- Effects of FPBO proportion

Conclusion

- N-butanol + EHN: the increase of EHN proportion from 2% to 8% could effectively advance the low-temperature heat release phase, and hence shorten the ignition delay. The temperature is the dominant factor for combustion phasing and combustion duration.

- FPBO + N-butanol + 5%EHN: FPBO proportion has negligible effect on ignition delay in the chamber wall temperature range of 490 - 580 °C since its chemical reactivity is lower than n-butanol. The increase of FPBO proportion leads to a delayed combustion phasing and a prolonged combustion duration, while these effects become less obvious at the elevated temperature.

- Chamber wall temperature has a significant influence on the ignition and combustion processes of FPBOs-butanol blends. A negative temperature coefficient (NTC) phenomenon was observed around a chamber wall temperature of 550 °C.

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