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Laminar burning characteristics of 2-methylfuran and isooctane blend fuels

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HIGHLIGHTS

- We studied laminar burning characteristics of MF–isooctane blended fuels.
- The highest un-stretched flame speeds occur in a range of Φ 1.1–1.2.
- Markstein number and burning velocities of MF20 and MF50 are presented.
- MF fraction has larger effects on burning velocities at higher temperatures.

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ABSTRACT

2-Methylfuran (MF) has become very attractive due to the recent breakthrough in its production method using the process of dehydration and hydrogenolysis of fructose. MF–gasoline blended fuel has been considered as a potential choice of alternative fuel pathway for spark ignition (SI) engines, as have other biofuel blends. Isooctane is used to represent gasoline in fundamental studies of gasoline blended fuels, however, little is known about the laminar burning characteristics of MF–isooctane blended fuels. In this study, high-speed schlieren photography is used to investigate the laminar burning characteristics of gaseous MF–isooctane at varying temperatures and equivalence ratios with an initial pressure of 0.1 MPa in a constant-volume vessel. The outwardly spherical flame method is used to determine the stretched flame speeds. The un-stretched flame speeds, Markstein lengths, Markstein number, laminar burning velocities and laminar burning flux of MF20 (20% MF and 80% isooctane) and MF50 (50% MF and 50% isooctane) under different equivalence ratios and temperatures are then deduced and compared to MF and isooctane. The results show that the un-stretched flame speeds and laminar burning velocities of MF20 and MF50 are between those of MF and isooctane under all conditions. The peak un-stretched flame speeds of the blends occur in an equivalence ratio range of 1.1–1.2 at all temperatures, closer to the case of MF at higher temperatures. Both blended fuels have Markstein lengths closer to isooctane at an equivalence ratio lower than 1.2 at all temperatures. The burning velocities of MF50 are very close to the average values for MF and isooctane, particularly at 393 K. MF in the blended fuel presents larger effects on burning velocities at higher temperatures.

1. Introduction

Alternative bio-fuels present a potential pathway to provide sustainable–renewable sources and address the challenging issues of fossil fuel depletion and global warming. Previous research on alternative fuels has been wide ranging [1–3] and fuels that can be produced from celluloses have been considered as the most promising candidates. Ethanol has been thought of as the market-leading gasoline alternative [4–6] due to its mature mass production methods [7,8]. However, a new production method for furan-type fuels has been developed in recent years [9] since high efficiency was achieved in producing 2,5-dimethylfuran (DMF) and 2-methylfuran (MF) from celluloses, indicating the prospect of industrial mass production [9–11]. MF and DMF have become quite attractive in alternate fuel studies because of their similarities to gasoline.

Table 1 shows the properties of MF and gasoline [12,13]. The properties of isooctane are also presented here because isooctane has been used as a representative component for gasoline in many studies [14].

The authors' group has studied previously the combustion and emissions of DMF and MF in a direct-injection spark-ignition (DISI)

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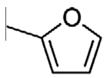
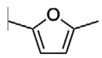
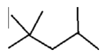
Table 1
Properties of the test fuels compared to gasoline and DMF [12,13].

	MF	DMF	Isooctane	Gasoline
Chemical formula				C2–C14
H/C ratio	1.2	1.333	2.25	1.795
O/C ratio	0.2	0.167	0	0
Gravimetric oxygen content (%)	19.51	16.67	0	0
Density @ 20 C (kg/m^3)	913.2	889.7	691.9	744.6
Research Octane Number (RON)	103	101.3	100	96.8
Motor Octane Number (MON)	86	88.1	100	85.7
Stoichiometric air–fuel ratio	10.05	10.72	15.13	14.46
LHV (MJ/kg)	31.2	32.89	44.3	42.9
LHV (MJ/L)	28.5	29.3	30.66	31.9
Heat of vaporization (kJ/kg)	358.4	332	307.63	373
Initial boiling point (_C)	64.7	92	99	32.8

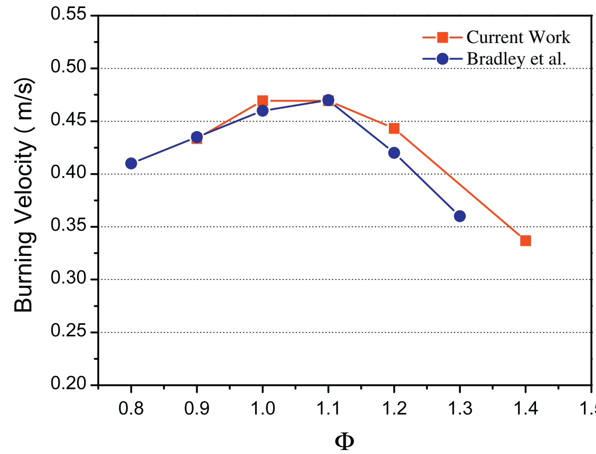


Fig. 3. Comparison of the laminar burning velocities from the current work and other researcher's results (isooctane, near 363 K) [40].

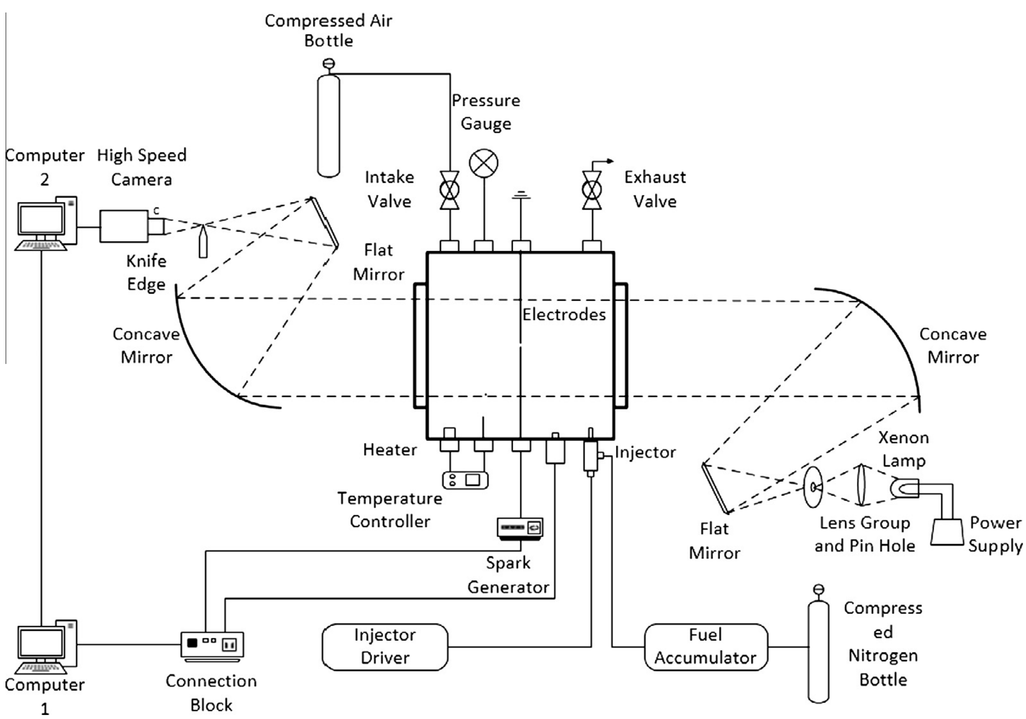


Fig. 1. Schlieren experimental setup.

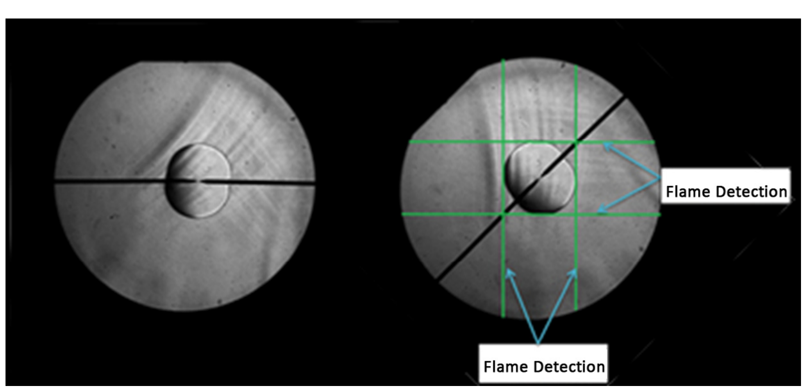


Fig. 2. Laminar flame radius detection (left: original; right: rotated).