Combustion performance of palm oil and rapeseed oil methyl ester for automobile

Guang Wu [1], Yongbin Lai[1], Tong Wu[1], Long Wang[1], Yijun Zhou[1] and Xiu Chen[2, a]

[1] School of Mechanical Engineering, Anhui University of Science & Technology, Huainan 232001, China;

[2] School of Chemical Engineering, Anhui University of Science & Technology, Huainan 232001, China.

[a]Corresponding author: Xiu Chen, chenxiuhn@163.com

Abstract

The chemical composition of biodiesel was analyzed by GC-MS. Combustion performance of biodiesel was studied by TG-DSC and collision theory. Combustion performance index CPI was put forward for describing biodiesel combustion performance. The reactive atom combustion mechanism was put forward. Biodiesel combustion process comprised three steps, viz., volatilizing, dissociating and combining. The study showed that the biodiesel was mainly composed of fatty acid methyl ester (FAME): $C_{14:0}$-$C_{24:0}$, $C_{16:1}$-$C_{22:1}$, $C_{18:2}$ and $C_{18:3}$. Biodiesel had a good burnability. CPI of palm oil methyl ester (POME) and rapeseed oil methyl ester (ROME) were 4.97E-05 and 3.65E-05, respectively. The combustion characteristic of POME was better than that of ROME.

Keywords

Biodiesel, Combustion performance, palm oil, rapeseed oil.

1. Introduction

The combustion and emission performance of biodiesel were studied mainly by the bench test of engine [1-2]. The bench test needed engine and sample dosage very much, such as several tens of kilograms. The thermal analysis was one of the most common methods for investigating combustion performance. It needed sample dosage very few, such as about 10 mg. It was very few for investigating biodiesel by thermal analysis [3-6].

In this study, we investigated the combustion characteristics of POME and ROME by TG-DSC.

2. Materials and methods

2.1 Materials

POME and ROME are all prepared by our laboratory. All other reagents were of analytical grade.

2.2 Chemical composition

Biodiesel was determined by GC-MS (Finnigan, Trace MS, FID, USA), equipped with a capillary column (DB-WAX, 30 m × 0.25 mm × 0.25μm). The carrier gas was helium (0.8 mL/min). The sample injection volume was 1μL. Temperature program was started at 160 °C, staying at this temperature for 0.5 min, heated to 215 °C at 6 °C /min, then heated to 230 °C at 3 °C /min, staying at this temperature for 13 min.

2.3 Thermal analysis

TG, DTG and DSC curves were obtained in a STA-449C (Netzsch, Germany), in N2/air atmosphere with a flow of 50 mL/min, at heating rates of 10 °C/min and interval of temperature of 25-600°C.

3. Combustion performance indexes

$$CPI = \frac{(\mathrm{d}M/\mathrm{d}\tau)_{\max} \cdot (\mathrm{d}M/\mathrm{d}\tau)_{\mathrm{mean}} \cdot Q}{T_i^2 \cdot T_{\mathrm{b}}}$$

Where $(\mathrm{d}M/\mathrm{d}\tau)_{max}$ is the maximum combusting rate, viz., peak value of DTG curve in air atmosphere, mg/min. $(\mathrm{d}M/\mathrm{d}\tau)_{mean}$ is the mean combusting rate, viz., half peak value of DTG curve in air atmosphere, mg/min. Q is combustion heat, viz., peak area of DSC curve in air atmosphere, *J/g*. Tb is burnout temperature, viz., temperature at 95% weight loss in air atmosphere, K. T_i is igniting temperature. Igniting temperature definition is shown in Fig.1.

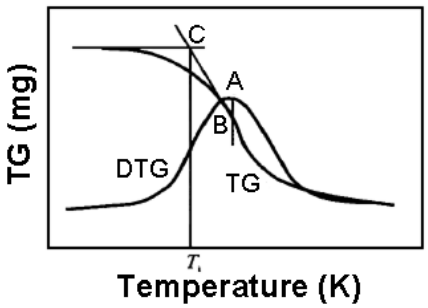

Fig.1. Schematic diagram of igniting temperature definition

4. Results and discussion

4.1 Chemical composition

The main chemical composition of POME and ROME by GC-MS are shown in Table 1.

Table 1 Main composition (wt.%) of biodiesel

Biodiesel	$C_{14:0}$	$C_{16:0}$	$C_{18:0}$	$C_{20:0}$	$C_{22:0}$	$C_{24:0}$	$C_{16:1}$	$C_{18:1}$	$C_{20:1}$	$C_{22:1}$	$C_{18:2}$	$C_{18:3}$
POME	1.44	26.95	6.40	0.72	0.21	0.14	0.42	42.13	0.34	0.15	18.20	1.59
ROME	0.33	9.35	3.51	0.79	0.49	0.22	0.44	40.33	3.05	6.95	25.25	7.38

Note: $C_{m:n}$ is the shorthand of FAME; *m* means the number of carbon atom in fatty acid group.; *n* means the number of double bond.

4.2 Combustion performance

TG-DSC and TG-DTG curves of POME and ROME are shown in Fig.2 and Fig.3, respectively.

From Fig.2 and Fig.3, biodiesel had a good burnability. CPI of POME and ROME were 4.97E-05 and 3.65E-05, respectively. And the combustion performance of biodiesel was better with increasing the amount of SFAME. It was chiefly because the higher SFAME content was beneficial for volatilizing, dissociating and combining of biodiesel.

5. Conclusion

Based on the results of this study, we concluded that:

Combustion performance index was put forward for describing biodiesel combustion. Combustion performance indexes of POME and ROME were 4.97E-05 and 3.65E-05, respectively.

Biodiesel had a good burnability. Combustion characteristic for biodiesel was better with increasing SFAME and length of carbon-chain, decreasing UFAME and unsaturated degree.

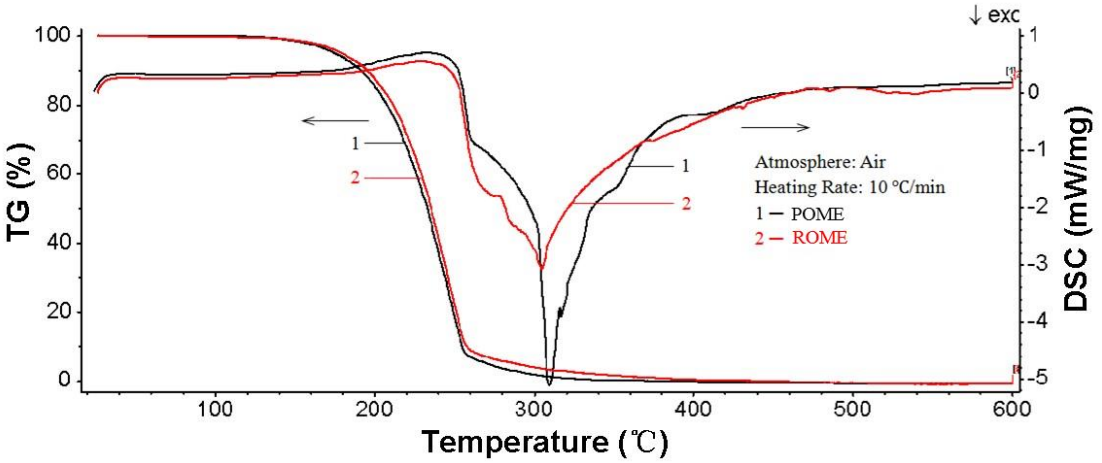

Fig.2. TG-DSC curves of POME and ROME

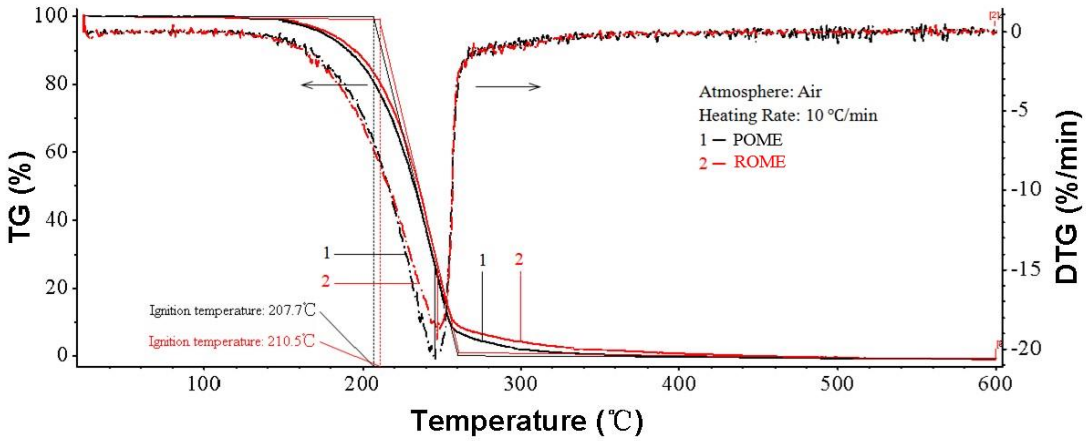

Fig.3. TG-DTG curves of POME and ROME

Acknowledgements

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