In-situ Monitoring of Carbon dioxide Emission from Combustion of Jatropha Oil by Infrared Emission Spectroscopy

Nelfa Desmira*, Shigeaki Morita and Kuniyuki Kitagawa

Ecotopia Science Institute, Nagoya University
Furi-cho, Chikusa-ku, Nagoya, Aichiken, Japan 464-8602
* Corresponding Author: Tel: +81- 52- 789-3915
E-mail: nelfad@esi.nagoya-u.ac.jp

Abstract

In this research, *in-situ* monitoring of CO_2 emission of jatropha oil was performed by using infrared (IR) emission spectroscopy. The presence of CO, H_2O and NO were also investigated in this research. Moreover, 2D distribution of CO_2 emission intensity was visualized for this oil using an IR camera. A conventional burner from Indonesia, with a preheating system which is required for viscous vegetable oil combustion, called *semawar*, was adopted.

Key words: Jatropha Oil, Infrared Spectroscopy, Carbon dioxide

Introduction

The depletion of oil and natural gas resources has become a serious problem in the near future due to the mass consumption and unrenewability source. From such a view point, more renewable energy resources are required. Vegetable oil have considered as a promising candidate to replace the fossil fuels due to their capability to reduce CO_2 emission to the atmosphere, energetic crops, and renewability [1]. Unfortunately, the disadvantage of the vegetable oils that they are also food crops, which means that the fuel from vegetable oils is considered as a food competitor. Jatropha oil does not have this disadvantage since Jatropha is not a food crop; in fact it is toxic to both human and animal. In the recent years, the jatropha oil has been considered as a potential alternative biodiesel replacing fossil fuel by blend it with diesel or straightly use. Due to this reason, it is important to acquire the useful information on their combustion characteristics and emissions emitted from their combustion process.

Some research has been engaged in emission characteristics of jatropha oil as a fuel [2-4]. Unfortunately, the investigation using spectroscopic measurement method has not been observed so far, especially for CO_2 and CO emissions. Hence in this research, spectroscopic observation of emission characteristic of CO_2 and CO emitted from preheated jatropha oil combustion is conducted.

In our previous research [2], the combustion characteristics (thermal distributions and flame stabilities) and chemical species related to emissions (NO, OH and C_2) have investigated using video thermal camera and Uv-Vis spectroscopic measurements. However, CO_2 and CO were difficult to observe using those aforementioned measurement tools. Thus, in this research the presences of CO_2 and CO were measured by IR imaging in order to complete the emission characteristics of jatropha oil as a prominent candidate for renewable energy source.

Table 1. Characteristics of Jatropha Oil and Diesel Oil

	Jatropha Oil	Diesel Oil
Viscosity (mm^2/s)	55	3-7.5
Net Calorific Value (kJ/kg)	38.85	43.8
Cetane Number	45	50
Flash Point (°C)	240	93
Density at 20°C	920	836

The characteristics of Jatropha oil compared to Diesel oil are listed in Table 1 [3]. The net calorific value and cetane number of Jatropha oil are not too far different than diesel oil. The flash point is lower, but it is an advantage for safe transport. The main problem of Jatropha oil, as owned by other vegetable oils, is the high viscosity. It can be solved by using a preheat system or an engine modification.

Experiment

In this study a burner used as a stove in Indonesia, *semawar* stove, is applied, as depicted in Figure 1.

This burner has the preheating system which is required for SVO combustion. Preheating is effective to reduce the viscosity of Jatropha oil and elevates the oil temperature closer to the ignition temperature of the oil leading to more efficient atomization and ignition. The outside part of the burner is burned by using ethanol fuel until a temperature of flash point reaches and the Jatropha oil fuel are properly ignited after it becomes fine particulates through the inside sprayer (diameter = 0.5mm).

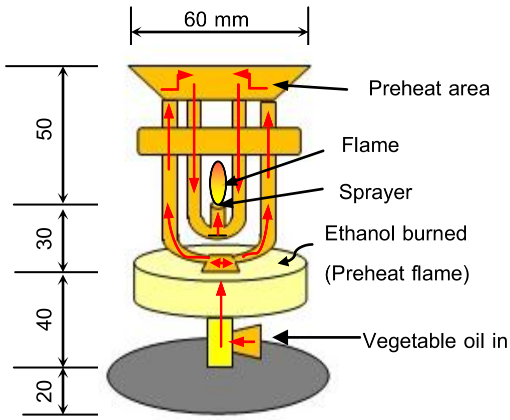

Figure 1 Detailed illustration of the burner

Figure 2 shows a schematic illustration of a combustion system used in the present study. A traditional stove in Indonesia, so-called *semawar* stove, was used as a burner. A fuel of jatropha oil was stocked in a fuel tank. The fuel tank was fed to the burner through a fuel pipe using an air compressor. Temperature of the preheated fuel was monitored by a thermocouple. The fuel pipe is made of copper and has length of 1 m due to high thermal conductivity before injected into the burner

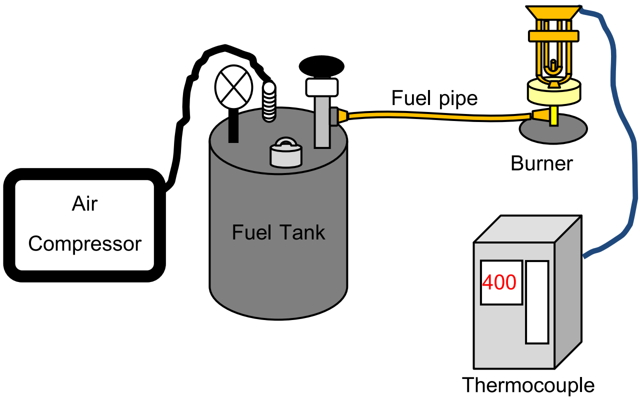

Figure 1 Schematic illustration of a combustion system

Figure 2 shows a detailed illustration of the fuel tank which was used to keep jatropha oil before being flown to the burner through fuel pipe with compressed air pressure tank system. The maximum pressure of tank allowed is 0.25Mpa and able has maximum capacity of 2 dm^3 of oil.

1. Pressure Gauge
2. Air form compressor in
3. Valve (Open and Shut the oil into the burner)
4. Oil in and out

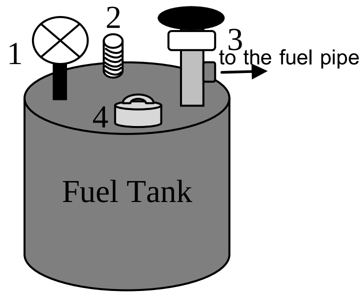

Figure 2 Detailed illustration of the fuel tank

Figure 3 shows the schematic diagram of the experimental apparatus to measure IR spectra CO_2 and CO developed in this work. FTS-3000, Varian type of FT-IR was using. Scan speed is 20 KHz, sensitivity is 1, wave number resolution is 0.25cm^{-1} and cumulated number is 16 times, were selected as a measurement condition, respectively.

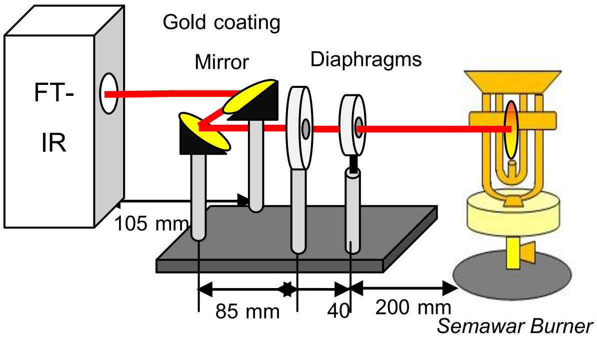

Figure 3 The schematic diagram of experimental method

The visualization of CO_2 was performed using Infrared camera (InfraRec Analyzer NS9500STD) as shown in Figure 3. The range of temperature is 200-1000 ^{O}C, sensitivity is 1, amount of pictures are 64 and temperature level is 100. CO_2 bandpass filter was applied at the camera in order to visualize the CO_2 emission emitted from the combustion.

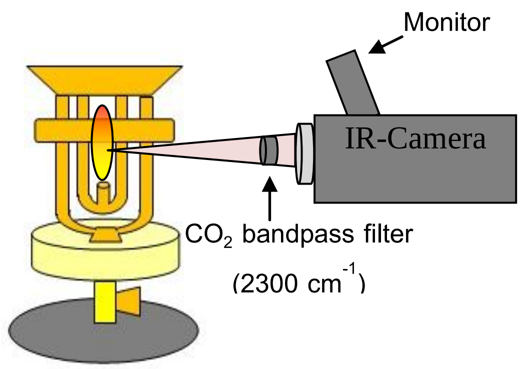

Figure 4 The schematic diagram of CO_2 visualization using IR-Camera

Results and Discussion

Figure 5 shows the result of *in-situ* monitoring of infrared emission spectrum emitted from jatropha oil combustion flame. The presence of C=O stretching (2300 cm^{-1}), C-O stretching (2120 cm^{-1}) , O-H stretching (4000 – 3100 cm^{-1}), O-H bending (2000 – 1200 cm^{-1}) and NO rovibration (1800 -1500 cm^{-1}) are obviously seen.

The high level of OH bending suspected arises not only from H_2O presence, but also from OH radical emission. The presences of high level of NO rovibration was similar as investigated in our previous research

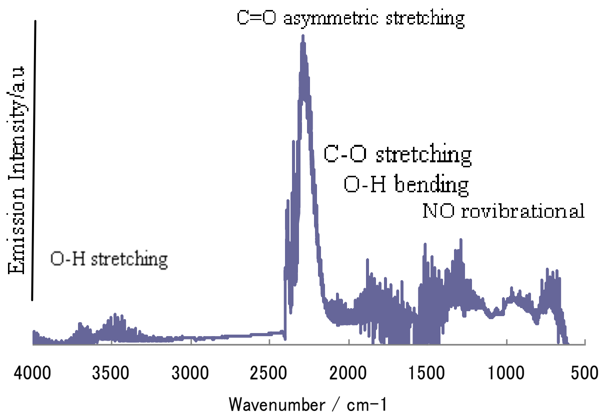

Figure 5 Infrared emission spectra of Jatropha Oil combustion flame

Figure 6 shows the visualization of CO_2 emission using the infrared camera. The CO_2 emission emitted from Jatropha oil combustion flame has a high intensity, as shown in Figure 4, especially the inner part due to the high temperature.

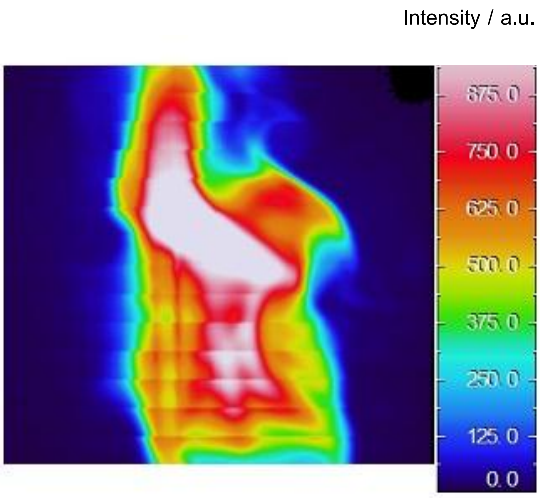

Figure 6 The visualization of CO_2 emission spectra

Conclusion

The presence of CO_2, CO, H_2O and NO from Jatropha oil combustion flame has been observed using FT-IR and CO_2 has been also visualized using infrared camera. The presence of O-H stretching and bending suspected not only comes from H_2O, but also comes from OH radical. NO rovibration has showed in high level, similar with result in our previous research.

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