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SPECTROSCOPIC OBSERVATION ON THE COMBUSTION CHARACTERISTICS OF JAPANESE TRADITIONAL OIL LAMP

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ABSTRACT

In this research, spectroscopic measurement has been made to investigate the combustion characteristics of a Japanese traditional oil lamp, called *toumyou,* that has been used since ancient periods until present. Combustion characteristics, i.e. flame stability and temperature, were analyzed by using a temperature video camera. Spectral emission intensity of hydroxyl (OH) radical (band head of 310 nm) was measured by using a UV-visible spectrometer and visualized by a CCD camera while the brightness was measured using a lux meter. The experimental result showed that the flames of vegetable oils burned were stable and temperatures ranged over about 1000-2500ºC. In addition, the emission intensity of OH radical was successfully detected by the UV-visible spectrometry and visualized by the CCD Camera. The emission intensities of OH radical from flames of coconut oil and palm oil were higher than those of other tested vegetable oils. From measurement using a lux meter, it was obtained that coconut oil gives the brightest flame.

Keywords : Combustion characteristics, OH radical, vegetable oil.

ABSTRAK

Penelitian ini dilakukan untuk memeriksa karakteristik pembakaran dan emisi dari lampu minyak tradisional Jepang yang telah digunakan sejak jaman kuno sampai sekarang. Karakteristik pembakaran, dalam hal ini kestabilan api dan temperatur, diperiksa dengan menggunakan temperature video kamera. Intensitas emisi dari radikal hydroxyl (OH) dengan panjang gelombang spectra 310nm diperiksa dengan memakai UV-visible spectrometry dan divisualisasikan dengan kamera CCD, sedangkan kekuatan cahaya dari setiap minyak nabati diperiksa dengan luxmeter. Hasil eksperimen menunjukan bahwa api yang dihasilkan oleh setiap minyak-minyak nabati yang dipakai untuk pemakaian lampu minyak bersifat stabil dan temperaturnya berkisar antara 1000-2500ºC. Kemudian, intensitas emisi radikal OH dari minyak-minyak nabati tersebut dideteksi dengan menggunakan UV-visible spectrometry dan divisualisasikan dengan kamera CCD. Intensitas emisi dari radikal OH minyak kelapa dan minyak kelapa sawit terdeteksi lebih kuat dibandingkan minyak lainnya. Dari pengukuran menggunakan lux meter, dapat ditunjukkan bahwa minyak kelapa memberikan nyala paling terang.

Kata Kunci *: Karakteristik pembakaran, radikal OH, minyak nabati.*

INTRODUCTION

Japanese traditional oil lamps called *Toumyou* (*Tou* means fire for lighting and *myou* means bright)in Japanese have been used mainly for temples and shrines since the old period, i.e. Edo Period [1], before gas and electricity being appeared. The oil lamp uses wicks, made of grass, called *Toushin*,

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which is placed in a special plate or glass jar filled with vegetable oil as the fuel. Nowadays, temples and some private houses still use this kind of oil lamp for praying purpose among Japanese Buddhists. Especially during a ceremony such as a festival period obon (praying for ancestor), graves around temples are all lit with oil lamp lights. Offerings of oil lamps are also customary in Japanese Buddhist funerals.

Since the utilization of this oil lamp is still abundant in Japan, it is interesting scientifically to analyze the flame stability, thermal characteristics, and spectral emission intensity of OH radical during combustion on vegetable oil of oil lamps. Various kinds of vegetable oils such as palm oil, olive oil, coconut oil, soybean oil and rice brain oil, were examined in order to observe the effect of fuel property on combustion characteristics and spectral emission intensities. Furthermore, the flame brightness with different vegetable oils was also investigated using lux meter.

EXPERIMENTAL WORK

Figure 1 shows a schematic diagram of the measurement system. The measurement system consists of the temperature video camera, the UV-Vis multichannel spectrometer, the CCD camera and the lux meter. In order to monitor 2D temperature distribution and flame stability of oil lamp, the thermal video camera developed in our lab was used [2].

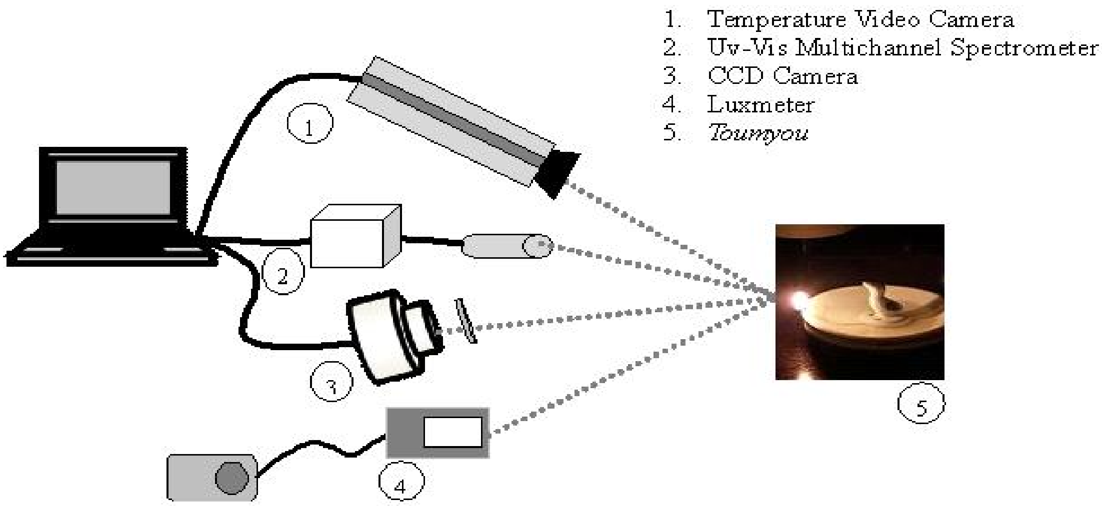

Figure 1. Schematic Diagram of Measurement System.

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This temperature video camera adopts the heat image analysis system based on a narrow band two-color method. 100 temperature images were recorded at frame rate of 120 fps, the gain was set at 6 and the shutter speed 1/30 ms. The spectral emission intensity of OH radical emitted at the wavelength 310nm (band head) was observed using the ultraviolet-visible (Uv-Vis) multichannel spectrometer. OH radical was also visualized by the CCD camera fitted with a bandpass filter of 310nm. The brightness of the flame with each vegetable oil was measured using the lux meter. All the measurement equipments were located at a distance of 500 mm from the flame.

RESULTS AND DISCUSSION

Figure 2 shows the average temperature and flame stability (rsd/relative standard deviation) profiles of the oil lamps flame with different vegetable oils. The experimental result shows that the flame with different vegetable oils were stable (see the low rsd in the inner region of Figure 2) and the temperatures measured range over about 1000-2500ºC. The temperature of the coconut oil flame is the highest compared to the others due to the high heating value (HHV) and cetane number [3]. The most saturated fatty acids present in coconut oil compared to those of the other oils [4].

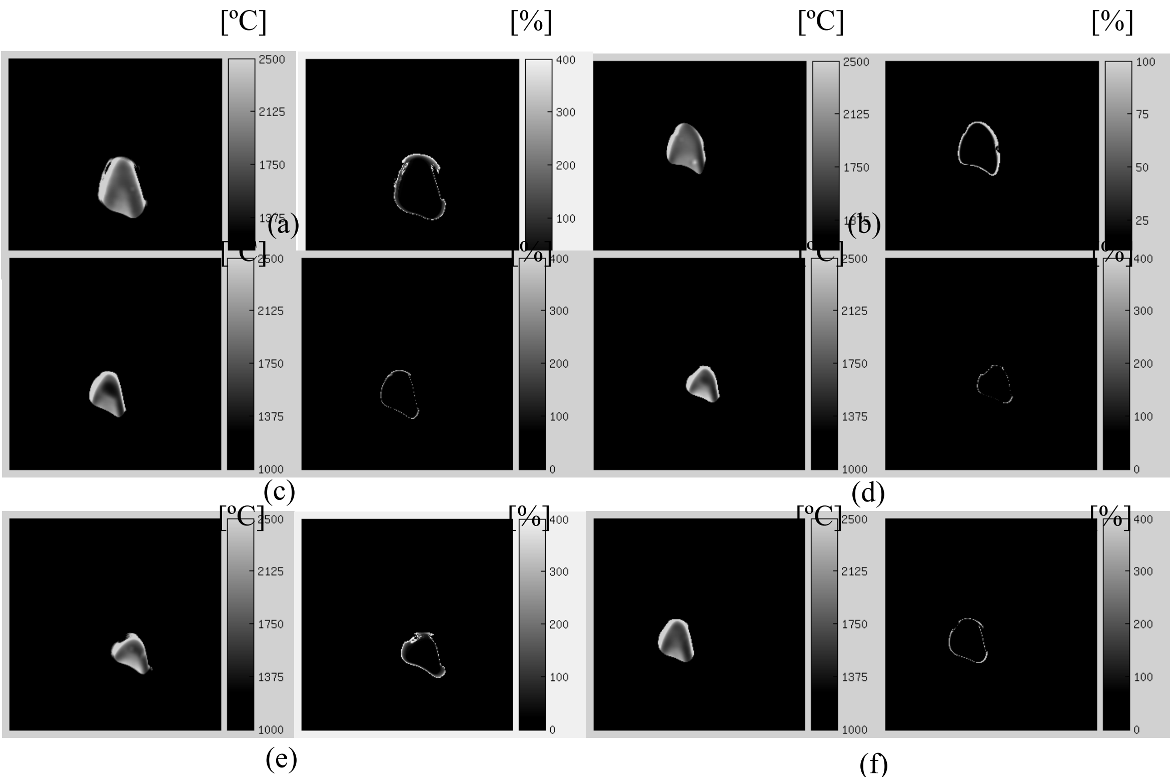

Figure 2. 2D Average temperature distributions and flame stability (rsd) profiles of flames on oil lamps using various vegetable oils: (a) Rapeseed Oil, (b) Coconut Oil, (c) Olive Oil, (d) Palm Oil (e) Rice Bran Oil and (f) Soybean Oil.

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Figure 3 shows the spectral of OH emission for various vegetable oils. The coconut and palm oils exhibit the higher intensity among the others mainly due to the higher temperature. In contrary, the intensity for rice bran oil was the lowest due to the low temperature. These OH images clearly reflect high temperature flames.

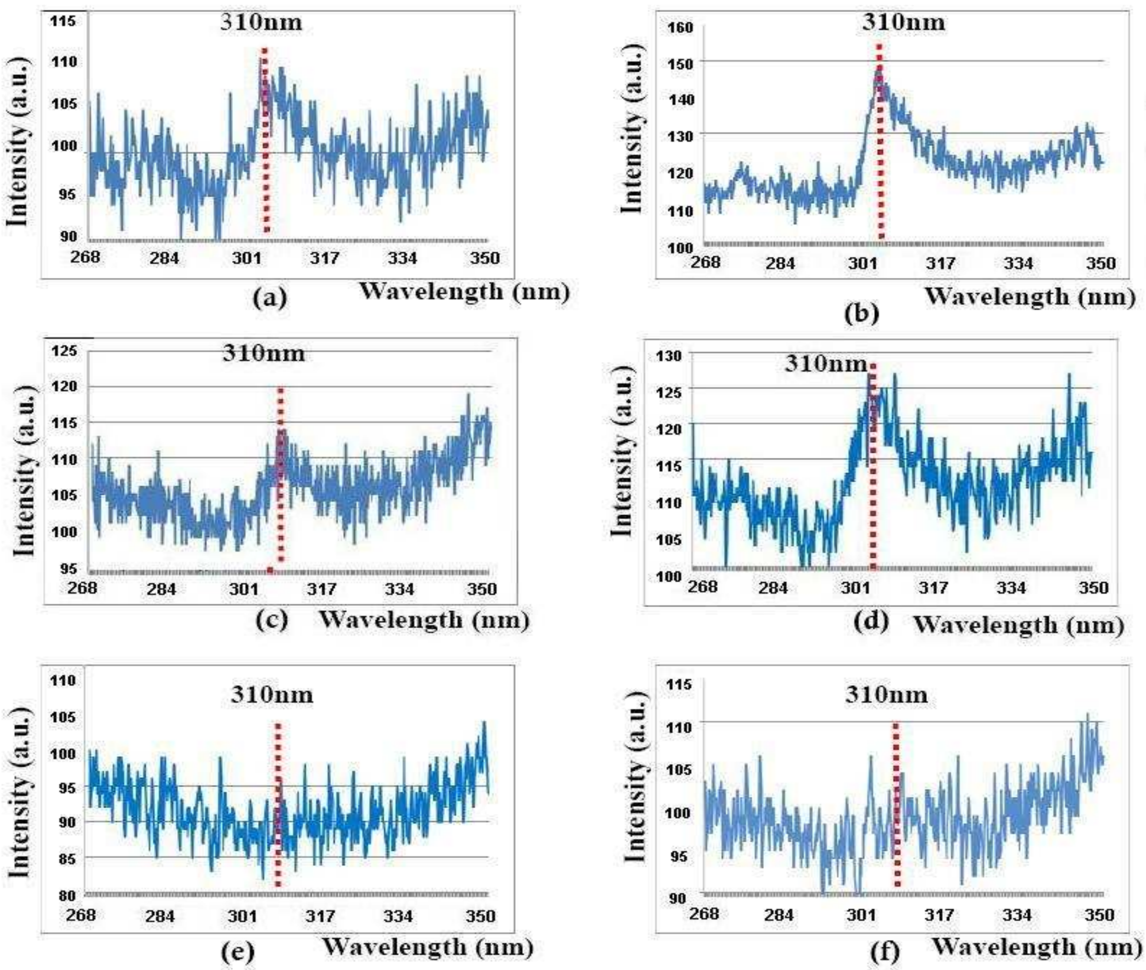

Figure 3. OH radical emitted from flames on oil lamps using various vegetable oils: (a) Rapeseed Oil, (b) Coconut Oil, (c) Olive Oil, (d) Palm Oil (e) Rice Bran Oil and (f) Soybean Oil.

The OH emission emitted from the oil lamp flames with various vegetable oils were visualized by the CCD camera as shown in Figure 4. The visualization of OH emission also demonstrates that the coconut oil exhibits the highest intensity while the rice bran oil was the lowest. The spectral emission intensity is given on the basis of the principle of Boltzmann distribution law [5] as a function of temperature and the number density of OH radical. The temperature is likely the main factor in this case as shown by the results. The relative number density of concentration, however, can be

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determined after the temperature correction based on the laws. Meanwhile, the measured brightness is also dependent on the temperature and soot particle concentration. Brightness measurement using a lux meter indicated that the coconut oil is the brightest compared to other oils.

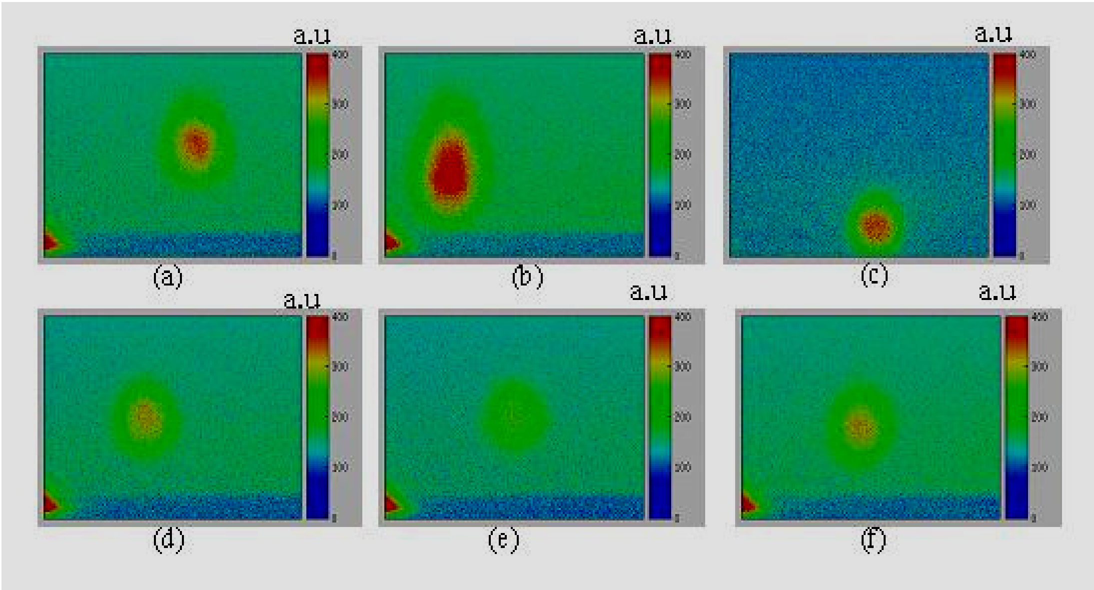

Figure 4. Visualization of OH radical emitted from flames on oil lamps using various vegetable oils: (a) Rapeseed Oil, (b) Coconut Oil, (c) Olive Oil, (d) Palm Oil (e) Rice Bran Oil and (f) Soybean Oil.

CONCLUSION

In this research, the combustion characteristics of a Japanese traditional oil lamp, called *toumyou,* has been investigated using temperature video camera, Uv-Vis multichannel spectrometer, CCD camera and luxmeter. Various kinds of vegetable oils such as palm oil, olive oil, coconut oil, soybean oil and rice brain oil, has been examined in order to observe the effect of fuel property on combustion characteristics and spectral emission intensities. The result has showed that the temperature of vegetable oil detected by thermal video camera ranged over about 1000-2500 ºC. Moreover, the vegetable oils examined for combustion on Japanese Votive Candle (*Toumyou*) has good flame stability.

Spectral emission of OH radical from the flames of oil lamps with various vegetable oils investigated has been able to detect by UV-visible spectrometry and visualized by CCD camera. The experimental result has showed that spectral emission of OH radical from the flames of coconut oil was superior compare to other vegetables, since its temperature was also higher, while Rice Bran Oil showed the minimum intensity of OH radical compare to those of other oils. Coconut oil gave the

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highest temperature compare to others. This is due to the high heating value and the highly saturated fatty acids contained in coconut oil compare to those of other oils. The results measured with the Lux-meter has indicated that coconut oil is the brightest compare to the other oils

REFERENCES

1. Mende, Kaoru. "Creation and Light, Design that use light and shade to mark the time." September 2007, http://www.nikon.com/about/feelnikon/light/chap03/sec03.htm (accessed November 2, 2010).
2. Desmira, Nelfa, Noriaki Matsui, Tatsuro Noba, Nagasaka Tatsuya, Kuniyuki Kitagawa. "Experimental Study on the Flame Stability, Thermal Characteristics and Emission Intensity of OH Radical of Japanese Traditional Votive Light Oil." Proceeding of 16th International Symposium on Advanced Techniques and Applications 2010, Kyungnam, South Korea.
3. Lujaji, F., A. Bereczky, L. Janosi, C.S. Novak and M. Mbarawa. "Cetane number and thermal properties of vegetable oil, biodiesel, 1-butanol and diesel blends." J*ournal of Thermal Analysis and Calorymeter*, vol. 102, no. 3 (2010): 1175-1181.
4. Antonio, Zamora, "Fats, Oils, Fatty Acids, Triglycerides." *Scientific Psychic*, 2005, http://www.scientificpsychic.com/fitness/fattyacids1.html (accessed November 2, 2010).
5. Siegel, Robert, John R. Howell. *Thermal radiation heat transfer*, volume 1, 4th edition. London: Taylor and Francis, 2002.