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Evaluation of Biodiesel from Animal Fats by Gas Chromatography, FTIR Spectroscopy and Spray Behavior

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Abstract. This paper evaluated overall properties of biodiesel (BD) from lard and beef tallow, based on analytical methods of gas chromatography analysis and Fourier Transform Infrared (FTIR) spectroscopy. This study also investigated the effects of BD properties on spray formation characteristics, at various injection pressures and particle size distributions, of the exhaust gas from a diesel engine. The results of analytical experiment indicated that the animal fat BD mainly consists of saturated fatty acids. Therefore, alternative fuel with high cetane number can be produced from animal fats. Compared with diesel fuel, animal fat BD has shown different spray patterns and smoke emission particle distributions. Sauter Mean Diameter (SMD) was slightly higher for BD droplets, while smoke particle size and density after the burning of droplets decreased for BD blends, due to more complete combustion. On the whole, it is concluded that the animal fat BD properties were in reasonable agreement with the international ASTM D6751, EN 14214 and Korean national standards of BD.

Keywords: Renewable energy, Animal fat, Biodiesel, Chromatography, Spectroscopy, FTIR

1 Introduction

Renewable fuels have recently received increasing attention, due to depletion of crude oil resources, and air pollution resulting from the exhaust emissions of various vehicles. BD has many advantages, when compared with conventional diesel fuel. The most important advantages of biodiesel are its renewability, lower sulfur and aromatic content, higher cetane number, and faster biodegradability[1].

In the present study, the overall physical and chemical properties of BD from lard and beef tallow (beef-T) are analyzed, by using GC, and FTIR analysis. Also, this

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research comparatively investigates the direct effects of BD properties on the spray characteristics of experimental fuels, and the particle size distribution of exhaust smoke, after burning of injected fuels.

2 Materials and Methods

Commercial purified lard and beef-T was provided by Samyang (South Korea), and used without any further purification. Methanol (99.5 wt.%), potassium hydroxide powder (95 wt.%) and hexane were purchased from Samchun Pure Chemical Co., Ltd. (South Korea). The animal fat BD was produced by the same method as described in a previous study[2-6]. All properties of BD were analyzed by the Korean Institute of Petroleum Management (Table 1), and BD properties were in reasonable agreement with the ASTM D6751 and EN 14214 standards. The predicted cetane numbers of BD samples were calculated according to Ramos et al.[7] and Bamgboye and Hansen[8].

A spray system was used to analyze the spray behavior of experimental fuels. This equipment consisted of injectors, an injector trigger, fuel supply equipment, and a laser diffraction particle analyzer (LDPA-Sympatec KF-Vario/ Germany).

3 Results and Discussion

Figure 1 shows the SMD and span factor (SF) of the droplet size distribution, according to the experimental fuels and injection pressures. SMD is defined as the diameter of the droplet whose ratio of volume-to-surface area is equal to that of the spray. The SMD became smaller, as a result of an increase in the injection pressure, for all experimental fuels. It can be seen that the SMDs of animal fat BD were slightly higher than those of diesel fuel, because of higher viscosity. As reported by other groups, the SMD of BD could be 5–40 % higher, than that for diesel fuel.

Figure 2 shows the droplet size distribution, and the accumulation volume of experimental fuels versus injection pressures. The accumulation volume distribution moved toward the small droplet size direction, for animal fat BD.

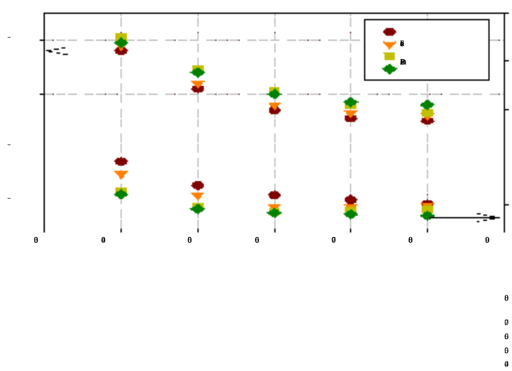

Fig. 1. Variation of SMD and span factor of experimental fuels

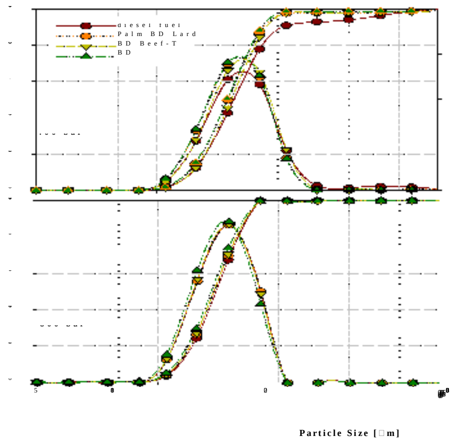

Fig. 2. Droplet size distribution of experimental fuels

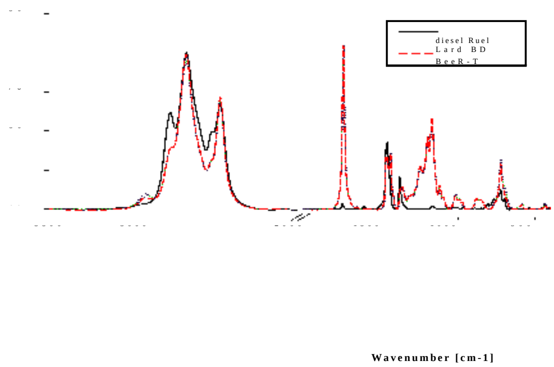

Fig. 3. FTIR spectra of experimental fuels

FTIR represents the spectrum of absorption of all the chemical bonds, such as C–H, [illegible] as expected, very similar, since the two compounds have almost the same chemical groups.

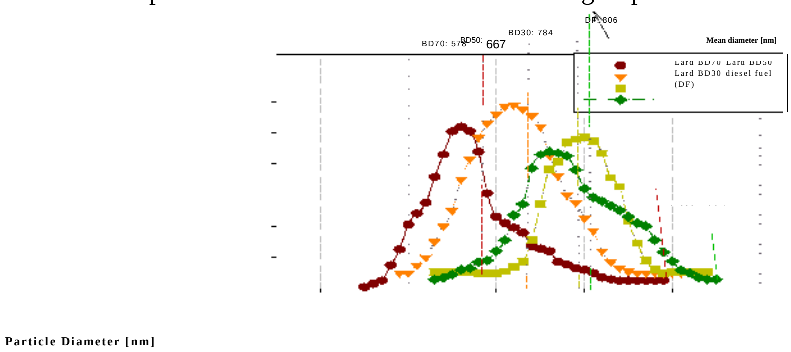

Fig. 4. Particle number and size distribution of experimental fuels

4 Conclusion

From the result of analytical analysis, the FAMEs composition and chemical functional group structures of lard and beef-T were very similar to each other. The main difference between animal fat and vegetable oil based BD was the FAMEs composition. Vegetable oil BD has high content of UFAs, while animal fat BD contains more amounts of SFAs. Hence, alternative fuel with higher CN can be produced from animal fats. However, animal fat BD has unfavorable characteristics of cold-temperature properties, because of the higher palmitic and stearic acids content. BD blending rate in a diesel fuel leads to increase in the SMD of injected droplets, whereas smoke density and particle size decreased significantly, due to higher oxygen content, and more complete burning of BD. The final product properties fulfilled all the requirements of international EN, ASTM standards and Korean national BD standards. Furthermore, this study result indicates animal fats can be an interesting low-cost alternative feedstock to produce high quality BD, and animal fats have a great potential to increase the BD production amount.

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