Test temperature dependence of transesterification of triolein under ultrasonic irradiation condition

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1. Introduction

Increased environmental concerns, market policies, and several socioeconomic aspects are driving industry to come up with alternative fuels. Such as being biodiesel. Biodiesel is the fuel made up of alcohol esters which are derived from oils and fats from renewable biological sources. This new fuel seems to emit far less regulated pollutants than standard diesel fuel [1].

Vegetable oils and animal fats are comprised of complex mixtures of triglycerides (TGs) and other minor components, such as free fatty acids (FFAs) of variable lengths (12-24 carbons). Biodiesel is usually produced through a chemical process called transesterification, whereby TGs react with a low molecular weight alcohol in the presence of a catalyst to produce a complex mixture of fatty acid alkyl esters (biodiesel) and glycerol [2]. TGs must be converted to simple esters to achieve desirable flow properties and combustion characteristics for use in diesel engines. There are difference processes that can be applied to synthesize biodiesel: (1) base-catalyzed transesterification [3], (2) acid-catalyzed transesterification [4], (3) intergrated acid-catalyzed pre-esterification of FFAs and base-catalyzed transesterification [5], (4) enzyme-catalyzed transesterification [6], (5) hydrolysis and acid-catalyzed esterification, (6) pyrolysis [7], and (7) supercritical alcohol transesterification [8].

Today, mixing/heating is one of the process of choice used in industrial application in over 85 biodiesel plants worldwide [9]. Ultrasonic irradiation with a low frequency is a useful tool for emulsification of immiscible liquids. The collapse of the cavitation bubbles disrupts the phase boundary and cause emulsification, by ultrasonic jets that impinge one liquid to another [10]. The aim of the present work was to study the trasesterification of triolein as a fuction of test temperature using the short-chain alcohols (methanol and ethanol) and the base-catalyst (NaOH and KOH) under the ultrasonic irradiation condition.

2. Method

Sodium hydroxide (NaOH) (>96%) and potassium hydroxide (KOH) (>96%) were purchased from Wako Chemicals and used after milling, to facilitate the dissolution in alcohol. The alcohols employed in the reactions (methanol, ethanol), from Wako Chemicals had more than 99% purity and were used as received.

The transesterification of triolein with methanol and ethanol was conducted at 40 kHz: Molar ratio of alcohol to triolein 6:1 and base-catalyzed concentration 1%. The test temperature was in the range of 3°C to 50°C.

The ultrasonic reactions were performed using Honda Electronics Ultrasonic Cleaners WS 1200-40, with a total power of 1200 W, working power being set at 70% and samples were analyzed for triglyceride, diglyceride, monoglyceride, total methyl ester, and glycerol content by using the High Performance Liquid Chromatography (HPLC) (Shimadzu, SCL-10Asp)

3. Results

![Fig. 1 The relationships between methyl ester concentration and irradiation time at various temperature, molar ratio 6:1 and KOH 1%](image-url)

Fig. 1 shows the relationships between methyl ester concentration and irradiation time at various temperature, molar ratio 6:1 and KOH 1%. The methyl ester concentration increased rapidly as...
soon as the ultrasonic irradiation was applied. Then it increased linearly with irradiation time and reached a steady state irrespective of test temperature. A rate at the linear increased in methyl ester concentration depended upon test temperature. In addition, an irradiation time at which the methyl ester concentration reaches the state tended to increased with decreasing test temperature. The Fig. 2 show the relationship between the ethyl ester concentration and irradiation time at various temperature, molar ratio 6:1 and KOH 1%. The results obtained were almost the same as those in Fig.1.

![Fig. 2 Effect of temperature on transesterification of TGs and ethanol at molar ratio 6:1, KOH 1%](image)

Fig. 3 shows the rate from Fig.1 at the linear increase in methyl ester concentration as a function of a reciprocal of test temperature. It was found that the relationships consisted of two lines below and above 20°C (1/T=0.0034). The slope of the straight line above 20°C was much smaller than that below 20°C.

![Fig. 3 kinetics parameter of transesterification of TGs and methanol at molar ratio 6:1, KOH 1%](image)

The rate constant, v, for each of the reaction was determined from the slope of the plot of % conversion versus reaction time (t). Each transesterification reaction had its own V value which varied from one reaction to another depending on the reaction parameters. These kinetic data would be useful for designing a reactor system for the transesterification of TGs under ultrasonic irradiation condition.

**References**