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Conversion of Soybean Oil to Jet Fuel-range Hydrocarbons with Sub-/Supercritical Water

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1. Introduction

Greenhouse gas (GHG) emissions from the transportation sector have risen rapidly over the past two decades, reaching about 2.8% of global CO_2 emissions from the fossil fuel combustion. The use of alternative jet fuel (AJF, defined as hydrocarbon fuels) derived from renewable resources could contribute to reduce CO_2 from the aviation sectors. Therefore, the production of sustainable and renewable AJF is highly required to achieve the goal of IATA (International Air Transport Association) for the reduction of aviation's lifecycle GHG emissions by 50% or more by 2050. Decarboxylation is a key process in the production of AJF from vegetable oils to be free of oxygen. In this study, we investigated the effect of sub- and supercritical water (subH_2O and scH_2O) on the degree of decarboxylation of soybean oil. The formed liquid product was examined by gas chromatography (GC) and elemental analyzer, and the mechanism of the decarboxylation reaction in sub- and scH_2O was discussed.

2. Materials and Methods

The sub- and scH_2O reaction was conducted in a lab-scale apparatus using 140 ml batch reactor, made of stainless steel. In a typical experiment, soybean oil with varying oil-to-water mass ratios (w/w) was added to the reactor. Afterward, N_2 gas was injected into the reactor to increase the system pressure to the desired values and to purge the reactor. The reactor was then heated at 380–450 °C. The reaction mixture was stirred at 500 rpm. After the reaction was completed, the reactor was immediately cooled down to room temperature [1]. Gas phase was gathered using a tedlar bag and analyzed using refinery gas analysis (RGA)–GC. The liquid phase was placed into a separatory funnel to separate oil phase and water phase by liquid–liquid extraction. The oil phase was analyzed using GC with a time of flight mass spectrometer (TOF/MS).

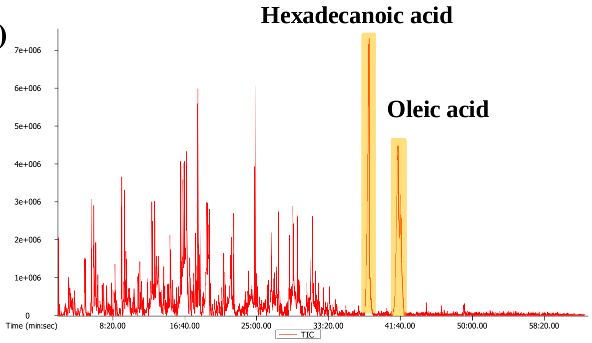
3. Results and discussion

In the GC-TOF/MS chromatograms of the products, complete conversion of soybean oil into various aliphatic and aromatic species in the oil product can be observed. As the time increased from 60 to 120 min, the residual oleic acid and hexadecenoic acid were converted to oxygen-free hydrocarbons. In addition, when the oil-to-water ratio varied from 1:4 to 2:1, the oleic acid can be completely converted at 5 MPa in 10 min. Because there are various conditions to decompose all the oleic acid, we have to find an optimized condition for range of hydrocarbon of bio jet-fuel. And we need to compare various temperature with same other conditions. The optimization of the subH_2O reaction will be discussed.

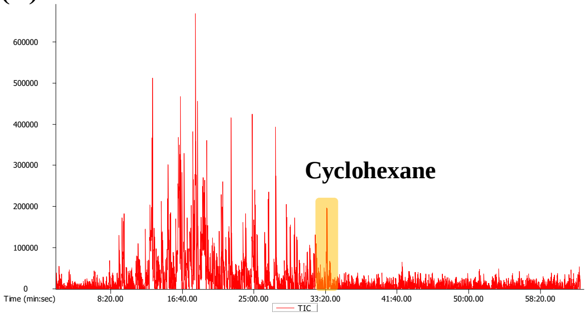
	Temperature (°C)	Ratio (Oil: water)	Time (Min)	Pressure (Bar)
(A)	400	1:4	60	290
(B)	400	1:4	120	210
(C)	400	2:1	10	50

Table 1. Condition of experiments

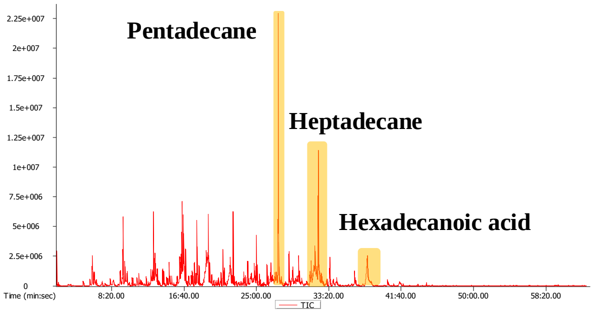
(A)



(B)



(C)



4. Conclusions

Among several studied conditions, the effect of pressure on decomposing the oleic acid was not significant rather than temperature, oil-to-water ratio and time. The products consisted of wide range of alkane, alkene, and aliphatic, aromatic, and cyclic compounds. We need further analysis to deduce potential compatibility of the liquid products with commercial jet-fuel from petroleum source.

Reference

[1] J. Lie, M.B. Rizkiana, F.E. Soetaredjo, Y.-H. Ju, S. Ismadji, M. Yuliana, Non-catalytic Transesterification of Waste Cooking Oil with High Free Fatty Acids Content Using Subcritical Methanol: Process Optimization and Evaluation, Waste and Biomass Valorization, 11 (2019) 5771-5781.