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ScienceDirect

Procedia Chemistry 9 (2014) 172 – 181

Procedia Chemistry

International Conference and Workshop on Chemical Engineering UNPAR 2013, ICCE UNPAR 2013

Effect of Bio-Based Catalyst in Biodiesel Synthesis

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Abstract

A cost-effective and environmentally friendly biodiesel synthesis has drawn attention in recent research activities. Used cooking oil which is known as waste is used in this study. The objectives of this research were to study an effect of biobased-catalyst which is used as supporting catalyst in simultaneous ozonolysis and transesterification for biodiesel synthesis and to study the effect of two steps process in biodiesel synthesis. The bio-based catalyst used in this process was empty palm bunch ash which was used as supporting catalyst for KOH. Two steps reaction were designed, the first step was run in a reactor at 30^{o}C with a continuous supply of ozone gas for 3 hours to cleave the unsaturated fatty acids at the double bonds. The second step was a follow up process after the first step without a supply of ozone gas, the temperature was increased up to 60^{o}C and the reaction continue for two hours. The second step aimed to convert saturated fatty acid which was not yet fully converted at the first step. Results of this study showed that 1.5% of KOH gave better performance in producing short chain methyl esters compared to 1 % of KOH in the first step process at various percent weight of ash. The highest short chain methyl esters and long chain methyl esters produced in the first step process were 85.722 mg/liter and 655.286 mg/liter respectively, which was used 17.3 weight % ash and 1.5 weight % KOH. Short chain methyl esters were produced as a result of unsaturated fatty acid cracked by ozonolysis. It is confirmed that a simultaneous ozonolysis and transesterification occurred in the first step process. In conclusion, the presence of bio-based catalyst as supporting catalyst for KOH to produce higher total methyl esters has been effective. The second step process in this experiment was not effective since the effect of reaction time can enhance the hydrolysis of esters as a reverse reaction of transesterification, resulted in loss of esters.

Peer-review under responsibility of the Organizing Committee of ICCE UNPAR 2013

Keywords: biodiesel synthesis; bio-based catalyst; ozonolysis; transesterification, biodiesel.

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doi:10.1016/j.proche.2014.05.021

1. Introduction

Biodiesel, an alternative renewable energy to compensate the increasing demand of petroleum diesel. It can reduce air pollutant emission and green house gases, as well as reducing long term engine wear in diesel engines. Most of the biodiesel produced today derived from soybean and palm oils which are renewable sources. As the traditional petroleum and diesel are non renewable and thus will last for a limited period of time. These non-renewable fuels also produce pollutants in the form of oxides of nitrogen, oxides of sulfur, oxides of carbon, lead etc. Hence, biodiesel is very important alternative energy as it can address the increased environmental pollution and depletion of the non-renewable fuels. Biodiesel is very promising alternative bio-fuel due to these following attractive attributes: it can be mixed at any proportion with diesel oil, hence it can be applied immediately in diesel engines without much modification; easy biodegradability and; 10 times less poisonous compared to the ordinary diesel oil. Therefore, in recent years, research has been directed to explore plant-based fuels. Different varieties of vegetable oils have been studied for biodiesel production such as, canola [1], palm [2], jatropha [3], palm kernel [4], sunflower [5] and coconut [6].Besides this research trend, a cost effective and environmentally friendly biodiesel synthesis has been a driving force behind this research activities, such as catalyst used in the synthesis[7]. There are many catalysts used in biodiesel synthesis such as cellulose, starch and activated carbon [8]. There are also modern heterogenous catalysts have been develop for biodiesel production, metal oxides and derivatives which are known as high activity, high selectivity and high water tolerance [9].

The raw material being used commercially is derived from edible fatty oils. Conventional catalysts such as NaOH and KOH catalyze the reaction. In this research, we are using used cooking oil as raw material to synthesis the biodiesel. We are also using bio-based catalyst to support the use of conventional catalyst. Ozone was used in this process to cleave the unsaturated fatty acids in used cooking oil. Therefore, used cooking oil has high potential as bio-fuel source. The local disposal of used frying oil becomes a huge problem due to the large volumes involved. In the fast-food business alone, a single branch which serves fried foods such as fried chicken, french fries and burgers can produce as much as 15 liters of used frying oil per day. Bio-based catalyst which is utilized in this study is empty palm bunch ash which is used as supporting catalyst for KOH. Both used cooking oil and empty palm bunch ash were used in this study to observe an effect of bio-based catalyst as supporting catalyst in simultaneous ozonolysis and transesterification for bio-diesel synthesis and also to observe an effect of two steps process in bio-diesel synthesis.

2.Materials and Methods

2.1.Materials

Used cooking oil from fast food restaurants, Methanol 96%, Potassium iodide, Magnesium sulphate anhydrate Potassium Hydroxide and Sodium Carbonate were supplied from Merck, Oxygen gas was purchase from Aneka Gas Industry. Empty palm bunch ash was kindly provided by Sinarmas Agribusiness. The eleven methyl ester standards (methyl hexanoate, methyl octanoate, methyl nonanoate, methyl myristate, methyl stearate, methyl laurate, methyl oleat, methyl palmitate, methyl arachidate, methyl heptadecanoate, methyl linoleate) used in this study were purchased from Sigma.

2.2. Experiment

Ash was soaked in methanol for overnight, mixed for one hour and filtered, then the methanol was taken to put in the reactor. The mol ratio of used cooking oil and methanol was 1 : 5 (v/v), methanol used in this experiment was the methanol used to soak the ash. Used cooking oil, methanol, Each of 1 and 1.5 weight % KOH were added to a 2 L stainless steel reactor equipped with a cooling system, stirrer, tube sparger and thermocouple. Ozone was produced from oxygen gas using VIRESCO ozone generator (Singapore). The ozone concentration in the feed gas