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Characterization of methyl ester compound of biodiesel from industrial liquid waste of crude palm oil processing

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A B S T R A C T

The second generation of Bioenergy: a study of CPO liquid waste-based biodiesel production technology has been conducted. The aims of this study were to obtain biodiesel from Industrial liquid waste of CPO processing and to identify the kind of methyl-ester compound of the biodiesel. The production of biodiesel was applied in two steps of reactions; esterification reaction using H_2SO_4 and transesterification using CaO catalyst at 60 °C for 2 h. GC-MS analysis result showed that methyl ester from liquid waste of CPO contains methyl hexadecanoate 12.87%, methyl 9-octadecanoate 19.98%, methyl octadecanoate 5.71%, and methyl 8,11-octadecadienoate 10.22%.

1. Introduction

The need for fuel increases along with the development of industry and population in Indonesia. The greatest fuel consumption is identified in the sector of industry and transportation. The increased utilization of fuel causes fuel insufficiency [1]. In 1970s, the production of unrefined oil in Indonesia reached 18 million barrels per day and it decreases to 700,000 barrels per day today [2]. Limited investment in new oil resource exploration and increased domestic fuel consumption turn Indonesia to be oil importer [3]. Furthermore, the use of fossil-based fuel is not considered environmentally friendly because it boosts the concentration of carbon dioxide (CO_2). This gas triggers greenhouse effect that contributes to the event of global warming [4,5]. For these reasons, the development of alternative energy resources should be carried out to substitute diesel-based fuel. One alternative energy resource which is widely developed is biodiesel [6]. Biodiesel (methyl-ester) is an option proposed to substitute fuel-based fuel because it is vegetable oil-based fuel which is renewable and environmentally friendly [7]. Compared to other fuel, biodiesel is biodegradable and non-toxic; it also has low CO_2 emission and sulfuric gas content [8].

Many varieties of oil have been examined to be processed as biodiesel, for instance, vegetable oil, animal fat, algae oil, and vegetable oil waste [9]. One of potential raw materials to produce biodiesel is crude palm oil (CPO) [10]. Indonesia and Malaysia are the major producers of CPO in the world that make them capable of developing CPO-based biodiesel [11–13]. The abundant oil content of palm tree makes CPO potential to produce biodiesel [14]. The utilization of CPO of agricultural and victuals needs as the raw material of biodiesel is categorized as the first generation of biodiesel [15]. However, the use of the CPO as vegetable-based fuel sets off competition with the need for foodstuff [16]. Besides, the price of CPO increases constantly that makes it uneconomical to be processed as long-term bio-energy.

Liquid waste of palm oil is one of the renewable raw materials of biodiesel. The use of agricultural raw material is abundant and does not clash with the need for foodstuff is categorized as the second generation of biodiesel [17]. Liquid waste of palm oil has 0.5–1% of oil content which can be processed as biodiesel [18]. The great amount of palm oil liquid waste within palm oil processing is considered as environmental pollution; in spite of that fact, it is a quite potential raw material to be processed as vegetable-based fuel which is economical in price and sumptuous in supply.

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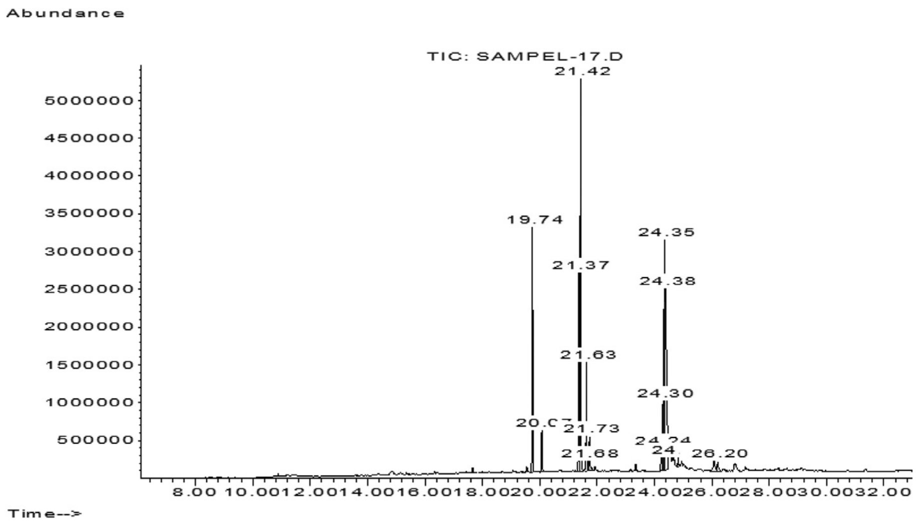

Fig. 1. GC-MS Chromatogram of biodiesel samples.

Direct use of vegetable oil as the fuel of diesel (biodiesel) still exhibits a weakness in term of its higher viscosity than diesel petroleum. This high viscosity of vegetable oil disturbs the process of injection and atomization of fuel [19]. To overcome these problems, the process of converting vegetable oil into methyl-ester through the transesterification process with catalyst should be carried out [20].

Transesterification process can be carried out by using homogenous, heterogeneous, or enzymatic catalyst. Homogenous catalyst is a catalyst with the same phase as its catalyst reagent, while the heterogeneous catalyst is a catalyst with different phase to its reagent [9]. The use of homogenous catalyst such as sodium hydroxide (NaOH) and potassium hydroxide (KOH) is more effective than heterogeneous catalyst. The result of methyl ester conversion which is carried out using liquid alkaline catalyst can reach out 98%, while the result of methyl ester conversion which is carried out using liquid acid catalyst can reach out 99%. The only problem that occurs when producing biodiesel by using up liquid alkaline catalyst is the complexity of separating the biodiesel and the catalysts because liquid acidic and alkaline catalysts in glycerol partially dissolve in biodiesel [21]. In addition to that, liquid catalyst used to produce biodiesel is corrosive and not reusable [9].

Enzymatic catalyst in transesterification is one of the alternative methods since enzyme can broaden the reaction rate than the usual reaction [22]. Transesterification reaction makes use of an enzyme that can work in low temperature and produce high, environmentally friendly methyl ester yield [23]. Enzymatic catalyst is used in esterification and transesterification to produce methyl-ester [24]. Many recent researches use heterogeneous catalyst since it is more economical, easily separated, reusable, and non-corrosive [25,26].

Potassium oxide (CaO) catalyst is an alkaline earth metal oxide catalyst which is quite potential to be developed because it has good activities and produces an optimal yield of biodiesel in soy oil [27]. Therefore, this study attempted to process liquid waste of palm oil through the esterification process using sulfuric acid (H_2SO_4) and transesterfication process using CaO catalyst.

2. Experimental

2.1. Degumming process

150 mL of CPO industrial liquid waste is heated in the temperature of 104 °C for an hour while being distilled. Then, 6 mL of H_3PO_4 85% is added up and distilled for 30 min. The sample is

Table 1
Methyl ester of biodiesel according to the results of GC-MS analysis.

Retention time, Rt (minutes)	Compounds identified	Molecular formula	Composition (%)
19.74	Methyl hexadecanoate	$C_{17}H_{34}O_2$	12.87
20.07; 24.82	Hexadecanoate acid	$C_{16}H_{32}O_2$	3.23
21.37	Methyl 8,11-octadecadienoate	$C_{19}H_{34}O_2$	10.22
21.42	Methyl 9-octadecenoate	$C_{19}H_{36}O_2$	19.98
21.63	Methyl octadecanoate	$C_{19}H_{38}O_2$	5.71
21.68	9,12-octadecadienoate acid	$C_{18}H_{32}O_2$	0.50
21.73; 26.20	9-octadecenoate acid	$C_{18}H_{34}O_2$	3.38
24.24	cyclohexane	C_6H_{12}	1.32
24.30	Propanenitrile	C3H5N	4.33
24.35	3-butyl phenol	C10H14O	6.39
24.38	Phenol	C_6H_6O	0.948