Conversion of Palm Oil to Biodiesel Using TiO2/Monmorillorite (MMT) Composite Catalyst from Aceh Tamiang Bentonite

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***Abstract*—The main objective of this research is to produce TiO2/Monmorillorite (MMT) composites as a biodiesel catalyst characterized using X-ray diffraction (XRD). In addition, to see the percentage of biodiesel production, it will be characterized using Chromatography Mass Spectrometry (GC-MS). TiO2/MMT composites are used as a catalyst for the production of biodiesel from palm oil. The composite sample was prepared with using the solid state method and it was enough to mix TiO2 and MMT powder with a ratio of 25:75 wt%. In the biodiesel production process, the authors use the transesterification method, where the ratio between methanol and palm oil with a molar ratio of 12: 1 and TiO2/MMT composites catalyst is 3 grams. The transesterification process was carried out at a reaction temperature of 60° C for 3 hours. The results showed that the TiO2/MMT composites catalyst did not experience acid activation to produce biodiesel from palm oil. Fatty Acid Methyl Ester (FAME) produced in this process is 60.89%.**

Keywords—biodiesel, TiO2, monmorillorite, composite, bentonite

I. INTRODUCTION

Biodiesel is a biofuel that can be used to substitute fossil fuels, especially diesel oil. It also tackles environmental issues such as carbon monoxide and sulfur emission reduction [1]. Solar energy use can be improved by using biodiesel. Biodiesel can help to minimize the use of diesel oil. Entermorpha intestinalis, which is extracted for biodiesel production using zinc-based iron oxide nanocomposites as a catalyst [2], is one example of animal fats and microorganisms that can generate biodiesel [3]. CaO nanocatalysts are used to convert microalgae into biodiesel [4]. Furthermore, biodiesel can be made from vegetable oil, as demonstrated in previous studies, such as biodiesel made from flaxseed oil using a KOH catalyst [5]. Biodiesel production from soybean oil using a well-characterized active solid acid catalyst (SO_4^{2-}—ZnO dan SO_4^{2}/ZnO) [6]. In addition, using ZnO in bentonite, a biodiesel conversion of 88% of soybean oil was achieved [7]. Monmorillorite (MMT) has also been synthesized from bentonite for the purification of patchouli oil [8]. Bentonite is a local potential as a catalyst material in the study of biodiesel conversion from vegetable oils, such as palm oil, in Aceh Tamiang, Aceh, Indonesia. Indonesia is an agricultural country that produces the most palm oil in the world [9]. This, particularly biodiesel, can be used as a renewable energy source. Apart from palm oil, sludge palm oil also produces biodiesel through enzymatic esterification with immobilized lipase as a biocatalyst [10], with an alum catalyst for esterification and a KOH catalyst for transesterification [11].

Aside from ZnO, which is a metal oxide, TiO2 is a photocatalyst material. As a catalyst, TiO2/MMT composites were used, with MMT derived from the synthesis of bentonite in Aceh Tamiang, Aceh, Indonesia. This hasn't been looked at in terms of the transesterification process for making biodiesel from palm oil, so it'll be interesting to look into. With this context in mind, this research aims to generate a percentage of biodiesel from palm oil using a TiO2/MMT composite from Aceh Tamiang bentonite in Indonesia.

II. METHODS

Experiments in Aceh Tamiang, Indonesia, using MMT powder purified from natural bentonite [8]. By combining MMT powder with TiO_2 (Emsure), the solid-state approach is used to render composite samples [12]. The weight-to-composite ratio is 75:25 wt.%. At Universitas Syiah Kuala in Banda Aceh, Indonesia, TiO2/MMT composites were characterized using X-Ray Diffraction (XRD) by the Shimadzu Brand, Type: MAXima X XRD-7000. The molar ratio of methanol (Emsure) to palm oil (12: 1) was used to make biodiesel samples [7]. Transesterification is used in the processing of biodiesel. In a three-necked flask, palm oil and methanol are combined with 3 grams of TiO_2/MMT composites, and the reflux process is carried out for 3 hours at the optimal reaction temperature of 60 °C. At a speed of 250 rpm, the reflux mechanism was stirred. After 24 hours, this process produces two layers of liquid, namely biodiesel and glycerol, which are then separated. The percentage of biodiesel is measured using a GC-MS (Chromatography-Mass Spectrometry) system from Shimadzu (Type: QP2010 Plus) at Universitas Syiah Kuala in Banda Aceh, Indonesia.

III. Results and Discussion

The XRD strength plot for a TiO_2/MMT composite sample as a function of 2θ is shown in Figure 1. According to XRF findings in previous studies, MMT (JCPDS 96-901-0958) includes SiO_2 (Si = 25.04 wt.%, O = 45.71 wt.%), which is more dominant than Al, Fe, Ti, Ca, K, S [8]. This indicates that in MMT, low SiO_2 crystals are more commonly associated with the quartz process (JCPDS 96-900-9667). Anatase process identifies TiO_2 (JCPDS 96-710-3589). TiO_2 crystals separate MMT peaks but do not result in the creation of a new step. TiO_2 crystals peak at 2θ, with values of 25.48, 38.00, 48.18, 54.08, and 55.22. The SiO_2 crystal has 2θ peaks, which are 20.86 and 26.64. This indicates that TiO_2/MMT composites were successfully developed [13].

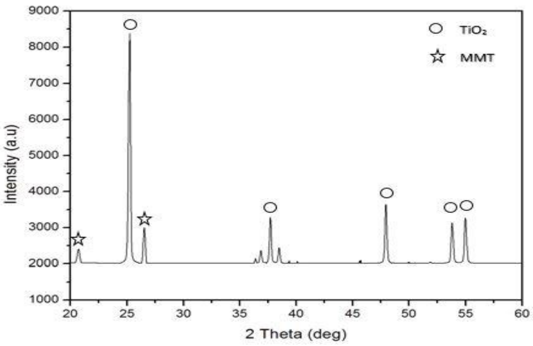

Fig. 1. XRD patterns of composite TiO_2/MMT.

The identification of FAME (Fatty Acid Methyl Ester) from the results of GC-MS research to produce biodiesel [14]. The goal is to figure out what the methyl ester building blocks are. Figure 2 and Table 1 display the percentage of the methyl ester component as a result of GC-MS analysis.

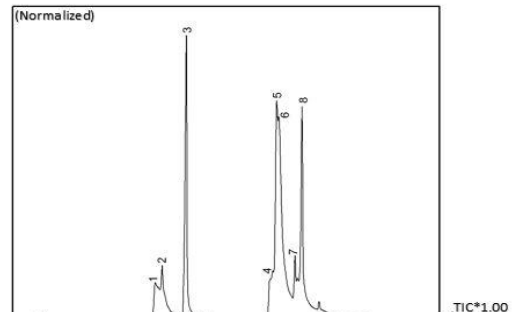

Fig. 2. GC-MS chromatogram of palm oil biodiesel product using TiO_2/MMT composite catalyst.

TABLE I. Identification and Composition of Biodiesel Products from Palm Oil with a TiO_2/MMT Composite Catalyst Using GC-MS.

Peak	Component	Formula	Cmposition (%)
1	Palmitic acid, methyl ester	$C_{17}H_{34}O_2$	4.12
2	Palmitic acid, methyl ester	$C_{17}H_{34}O_2$	7.34
4	10, 13-Octadecanoic acid,	$C_{19}H_{34}O_2$	3.32
5	methyl ester	$C_{19}H_{36}O_2$	17.16
6	Oleic acid methyl ester	$C_{19}H_{36}O_2$	28.95
	Oleic acid methyl ester		

Peak 1 in the methyl ester has a material palmitic acid ($C_{17}H_{34}O_2$) with a retention time of 20.00 and a composition of 4.12%, according to Figure 2 and Table 1. Peak 2 also contains palmitic acid, which has a retention time of 20.25 and a composition of 8.34%. Peak 4 indicates a material called 10, 13-Octadecanoic acid in ethyl ester ($C_{19}H_{34}O_2$) with a retention time of 24.15 and a 3.32% composition. Peak 5 with a retention period of 24.28 and composition of 17.16% suggests the presence of oleic acid ($C_{19}H_{36}O_2$) is the methyl ester. With a retention period of 24.35 and a composition of 28.95%, it's also at a peak of 6. Other acids that aren't in the methyl ester account for 39.10 %. Based on these findings in methyl ester, the total FAME obtained from palm oil by the transesterification method using a TiO_2/MMT composite catalyst is 60.89%. As an adsorbent, SiO_2 in MMT absorbs water and is a source of impurities in biodiesel processing [15], so that glycerol separation between FAME will happen right away MMT made from natural bentonite cannot convert palm oil to biodiesel [7], but TiO_2 metal oxide can improve transesterification catalyst activity [16]. This has been achieved to transform waste frying oil into biodiesel using a heterogeneous catalyst consisting of a mixture of metal oxides (ZrO_2/WO_3) [16].

IV. Conclusion

This study looked at MMT made from bentonite from Aceh Tamiang, Aceh, Indonesia, which was composited with TiO_2 (75:25 wt.%) for biodiesel production from palm oil. The separation of the crystalline peaks of SiO_2 and TiO_2 in TiO_2/MMT composites was demonstrated by XRD results. There was no acid activation in TiO_2/MMT composites, where TiO_2 could increase catalyst activity. The percentage of biodiesel produced was 60.89% under ideal conditions, which included a reaction temperature of 65 °C, a reaction time of 3 hours, a molar ratio of methanol to palm oil of 12:1, and a TiO_2/MMT composite catalyst loading of 3 grams. Based on these findings, TiO_2/MMT composites from Aceh Tamiang bentonite, Aceh, Indonesia, can convert palm oil to biodiesel; however, they must be checked with various catalysts, metal oxide, and biodiesel feedstock loading variations.

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