Synthesis Of Biodiesel From Palm Oil Through Electrolysis Process By Means Of Silver (Ag) Electrode

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Abstract— Biodiesel is main choice to resources energy on synthesis process technology. It is one of biofuels with methyl ester compounds from transesterification process or biofuels with short bounds of alcohol. One of source biofuels is from palm oil. Biodiesel of synthesis process technology still develops day by day which it is about electrolysis process to help of esterification reaction. Many advantage through this process is the highest yield and it can be occurred on ambient temperature. Biodiesel synthesis with refined bleached deodorized palm oil (RBDPO) is through electrolysis process that component operation need Ag electrode of 3 x 2 x 0.1 cm dimension, 1.0 – 3.0 electrode space with 15 volt and range of time process of 60 – 150 minutes. Oil/methanol of Molar ratio is 1:6 and uses mineral water 2% w/w and KOH 0.5% w/w. through this process which got the highest biodiesel yield at electrode space of 1.5 cm and time process of 90 minutes, is 98.15% with density of 0.8764 g/mL, viscosity of 3.8224 cSt, acid value of 0.2907 mgKOH/g and flash point of 162.778°C. All parameter occupied by biodiesel validity standard of SNI 7182:2015. GC-MS identified of methyl ester product which divided into methyl palmitate of 35.30% and methyl oleic of 49.73%.

Index Terms— biofuels, biodiesel, electrolysis, esterification, silver plate, transesterification, palm oil

1 INTRODUCTION

Biodiesel is one of resources energy which is wellknown as substituted currently fuel. That matter is having eminent than others such as safely use, can be resource, not contain toxic compunds, can be bounded, not contain sulfur and have good characteristic as lubricant. Generally, biodiesel created by transesterification process and esterification process which is using short-bound-alcohol like methanol, ethanol but catalyst process is. Catalyst to produce biodiesel currently uses homogen alkali such as NaOH, KOH (Leung et al, 2010) and homogen acidic such as H_2SO_4, HCl by Lam et al, 2010, and H_3PO_4 (Aransiola et al, 2014).

Transesterification or alcoholysis is conversion stepping from triglycerides (vegetable oil) to alkyl ester thoroughly reacted with alcohol and will be resulted excess product, glycerol. Monohydric alcohols are being source of alkyl truss which usually used methanol. It because is having cheap price and having high reactivity (called as methanolysis). Biodiesel is identically Fatty Acids Methyl Ester, FAME but acid used needs protractedly reaction and highly ratio of alcohol/oil molar until 245:1 (Zheng et al, 2006). Triglycerides of transesterification reaction proceed into methyl ester, it described in Fig.1 as seen as below:

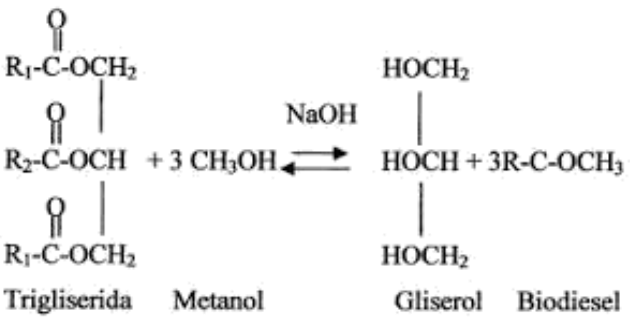


Fig.1. Transesterificate reaction

Homogen catalyst utilization is having disadvantage so it should be substituted with heterogen catalyst. It can be decrease cost of process, time of purification and also to decrease neutralize stepping which catalyst should separate and to recovery (Yan et al, 2010). Purification of methyl ester is more than 99%, yield is almost 100%. But Heterogen acid catalyst does catalytic activity is too low, it needs high temperature when reaction proceeded around 200°C and protractedly reacted was around 8-20 hours (Issariyakul and Dalai, 2014). Heterogen alkali catalyst will be limited of FFA compounds in low-quality feeding in waste cooking oil.

Conventional method of transesterification process encouraged scientist to find better other ways such as supercritical fluids method, microwave through transesterification process, ultrasonic, last but not least is about reactive distillation. These experiments developed electrical through transesterification process or electrolysis process.

Electrolysis method to synthesis biodiesel was reported by some scientist (Guan and Kusakabe, 2009 and Fereidooni and Mehrpooya, 2017). This method has some eminent such energy reduction it because used ambient temperature, to reduce water consumption until 90% part of biodiesel and had minimum waste (Putra et.al, 2015). Goal of this method is to produce much of ion OH^- (cathode side) which will be reacted with alcohol and resulted alkoksida. At the end, alkoksida ion reacts to triglycerides and creates biodiesel as product.

In this experiment, electrolysis method to synthesis biodiesel from crude palm oil used Ag as electrode and strong alkali as electrolyte without co-solvent. Time of reaction and span of electrode as changing variable are some item to research so it will find the best condition on transesterification process.

2 METHOD

Raw material of this process palm oil RBDPO and chemical compound is methanol, KOH 0.5% w/w, ionized water, Silver plate (Ag), 3 cm x 2 cm x 0.1 cm. Stepping process of this experiment shown fig. 2.

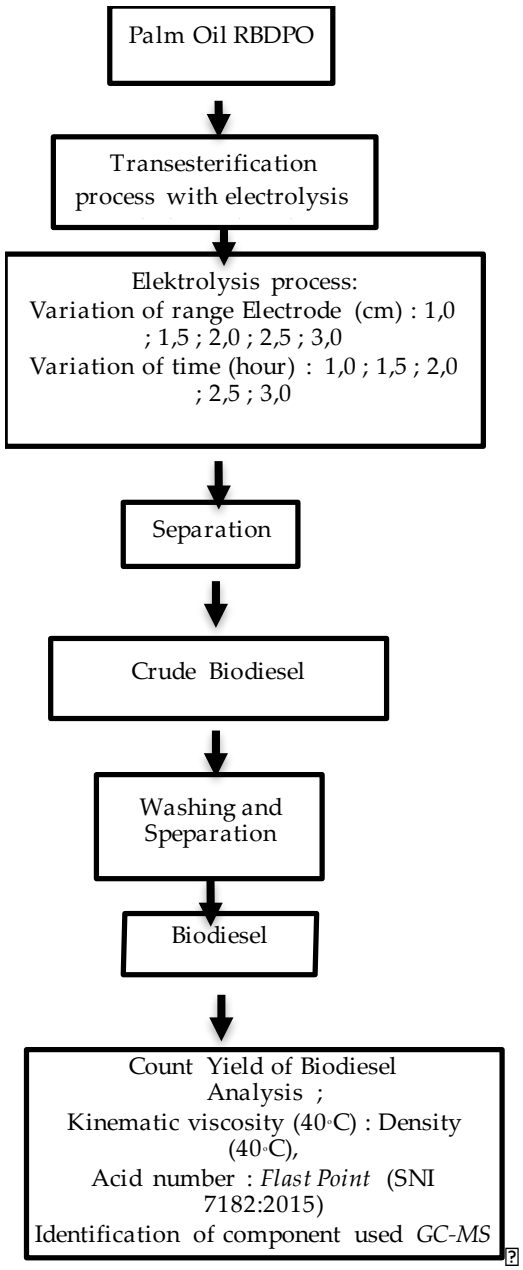
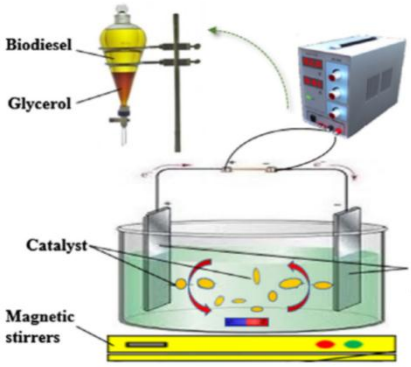


Fig. 2. Flow chart of research

2.1. Electrolysis process.

Installed electrolysis equipments such as power supply DC, cable, Ag plate with variation of range space is 1,0 – 3,0 cm, chemical glass 250 ml and hot plate shown at picture 3. Molar ratio between oil and methanol is 1:6 equally 75 ml : 19.5 ml. Methanol and solid of KOH 0.5% from oil weight entries to chemical glass 100 ml, mixed until KOH perfectly to be solution. Next, added some demineralized water 2 % from solution weight. Installed equipment such picture 3 and make variation of space plate of 1.0 – 3.0 cm. Turned power supply 15 volt with mixture process. Until 15 volt, crude palm oil is onto solution. Electrolysis process will do with variation time of 60 – 150 minutes. After that, it will be finished with separation process.

Fig. 3. Scheme of the electrolysis cell (Fereidooni dan



Perak Mehrpooya, 2017)

2.2. Biodiesel Purification.

Separated upper layer (biodiesel) and bottom layer (glycerol and other impurities) with funnel. Next, washing biodiesel with hot water which is total volume 1:1 to biodiesel volume. Washing process did until pH 7 and upper layer as biodiesel could be absorbed. Biodiesel separated from solution and it will be heated at temperature of 100oC. This step implied to separate methanol and ion water from upper layer. And then, product will be analyzed such as yield, biodiesel kinematic viscosity (40°C), density, flash point, GC-MS and acid number

3 RESULT AND DISCUSSION

Palm oil proceed to be biodiesel through electrolysis process with argentum (Ag) electrode. Electrolysis method mainly gives electricity energy to palm oil and methanol solution thoroughly transesterification. Amount of energy is 15 volt in anode and Ag cathode which is oxidize reaction and reduction reaction. This process uses change variable of electrode space because it gives impact amount of electric current on electrolysis process (Moeksin et al., 2017)

Reaction between KOH and H2O added to electrolysis cell. Water as much as 2 % from total weight of solution will impact to water compound provide in cathode so it could be descending to get hydroxyl ion, water addition keeps in 2% if more than 2% will be caused another reaction, hydrolysis (Fereidooni et al., 2017).

From anode side, oxygen and hydroxide will be created as result as oxidize reaction from water. Cathode electrode will produce hydroxyl ion and hydrogen.

Cathode (-) : $4\ H_2O_{(l)} + 4\ e^- \rightarrow 2\ H_{2(g)} + 4\ OH^-$.. (1)

Anode (+) : $2\ H_2O_{(l)} \rightarrow O_{2(g)} + 4\ H^+_{(aq)} + 4\ e^-$ .. (2)

Cell reaction : $2\ H_2O_{(l)} \rightarrow 2\ H_{2(g)} + O_{2(g)}$ ……*[(1) + (2)]*

Reaction above explained to create hydroxyl ion from cathode side. Hydroxyl ion is a compound which will be reacted with methanol to create methoxide ion. This ion is tough of nucleophilic so it can eradicate carbonyl group in triglycerides molecule. This process will be realized methyl ester and glycerol (Fereidooni et al., 2018)

3.1 Biodiesel Quality Test and Its compound Identification

Biodiesel is one of product from electrolysis process with space variable of 1.5 cm and time of process is 90 minutes. Test validation of compounds used to GC-MS. This test is to know compound contains in biodiesel sample. Methyl ester contains shown on fig. 4 and table 1.

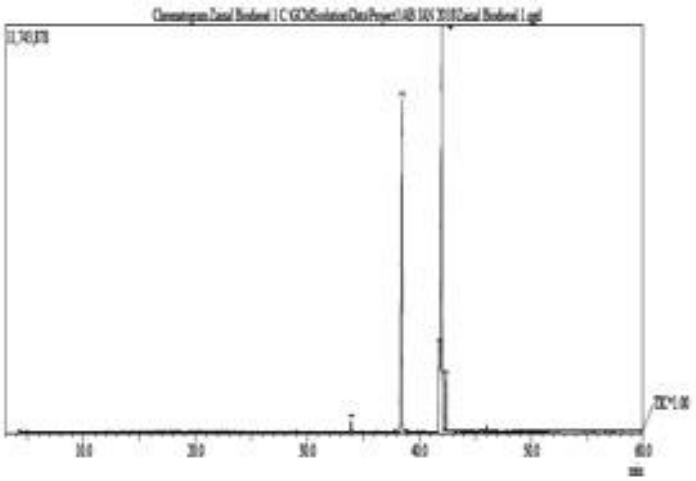


Fig. 4. Biodiesel chromatogram with mole ratio of oil : methanol of 1 : 6 and KOH 0,5%

Biodiesel compounds analyzed to peak of fragmentation which it get by identification at methyl ester based on similiarity of standard compounds. Compounds will be said similiar if the standar is having same molecule weight, same of fragment pattern and high of index similiarity. Contains of methyl ester on biodiesel shown at table 1. Main components of biodiesel are methyl palmitate and methyl oleat whereas suits of palm oil contain. Main component shown on biodiesel conversion table which contains of methyl palmitate of 35.30% and methyl oleat of 49.73%. another compounds on GC-MS analysis detected methyl ester from fatty acid such as methyl miristat, methyl linoleat and methyl stearat.

TABLE 1.
BIODIESEL COMPONENTS USED GC-MS ANALYSIS

Peak	Compound	Value (%)	Similarity Index (SI)
1	Metil Miristat	0,61	94
2	Metil Palmitat	35,30	94
3	Metil Linoleat	10,76	91
4	Metil Oleat	49,73	95
5	Metil Stearat	3,60	96

Quality of biodiesel product described through characteristic test validation on all parameter which it should occupy biodiesel standard by SNI 7182:2015. Product should be fulfilled with density of 0.8764 g/ml, viscosity of 3.8224 cSt, value acid of 0.2907 mgKOH/g and flash point of 162.778°C.

3.2. Electrode Space Effect to Biodiesel Yield

Transesterification reaction through electrolysis to assist process or electro catalyst used to energy for electron transfer from each electrode. Space each electrode gave huge impact at transesterification process related of energy amount to change crude palm oil to be. This research will be knew how space of electrode gives leverage of transesterification reaction to result biodiesel.

Electrode space at electrolysis process takes responsibility to electron average energy transformation (Taghevaei et al., 2012). Previously project, to short space each electrode implies to stable of electrolysis process (Moscosa et al., 2008)

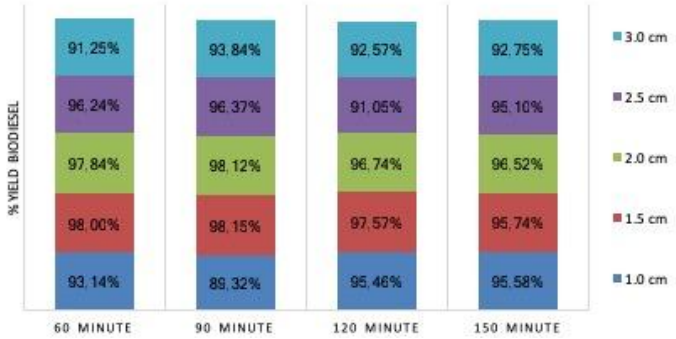


Fig. 5. Biodiesel yield on electrode space variation and time of reaction

Result of this research shown on picture 5 which electrode space of 1.0 cm has yield less than electrode space of 1.5 cm. Too short electrode space is having possibility to occur short electric current because resistance is too weak. Consumption energy on transesterification process is not optimum. In conclusion, electrode space of 1.5 cm can take optimize result.

And then, yield of electrode space with bigger range shows repetitively decrease pattern. It because interacts each molecule to weak when electrode space is overwhelming, it relates to ohm's law. Ohm's law of electric current is amount of voltage inversely proportional with obstacles if too huge obstacle is too small of electron amount for electron transfer occurring. Except that, electricity pole (volt/cm) resulted is also to small (Yudistira and Istadi, 2013). Impact of average electron energy is too small which created process of methoxide is being decrease to. Otherwise, cracking of triglycerides bounds is also descending.

Space of each electrode impacted to electron transfer velocity between anode as accepting electron and cathode as place of reduce reaction. Efficiency reduction at occurring process when space of each electrode is to large, it resulted huge of current obstacle and reduction of conductivity. At this condition, space leverage of yield shown too space of electrode will be reduce yield.

3.3. Impact of Time of Process to Biodiesel Yield

Transesterification process of another impacted factor is time of process. Biodiesel yield from crude palm oil through electrolysis process can be varied and seen in fig. 6.

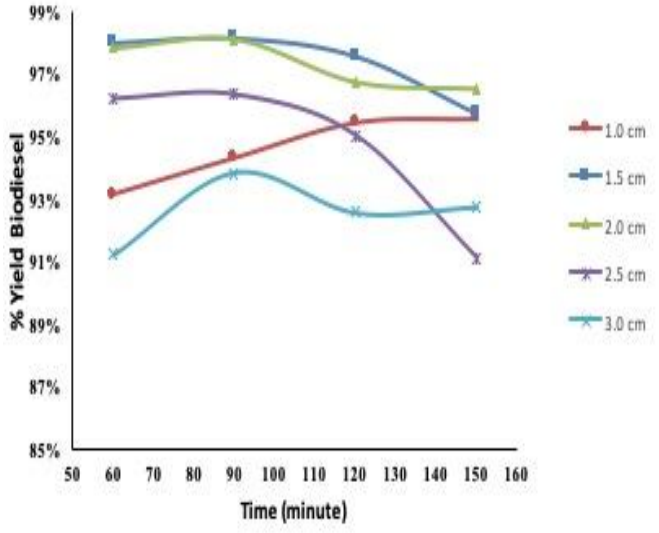


Fig. 6 Impact of time of process to yield of biodiesel

Biodiesel yield on each electrode space is almost having same pattern which is about started of reaction and it will be decrease in different time. It because of transesterification process as main reaction on biodiesel created is reversible which it reaction will be moved to the left and it effected small product (Guan and Kusakabe, 2019). Another factor is about ion amount so it can't be in long reaction because it can exterminate system and its reaction is too ease to the left. Best time on each space of electrode is 90 minutes.

Impact of time process and electrode space based on explanation above, it related with another process. If space of electrode is too small, process doesn't need much time. In otherwise, space of electrode is too large, process needs much time. Time impacting to yield is too much time of reaction, it will be resulted high yield but space of electrode needs distance.

4 Conclusion

Time process and electrode space impacted to biodiesel yield. Space of electrode is having short distance so process needs short time too. From this research, biodiesel result is having yield of 98.15% with experimental condition is space of electrode of 1.5 cm and time process of 90 minutes.

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