

# Characterization of Cellulosa Empty Palm Oil Bunches-Fiber Glass Membrane as Separator in Water Electrolyzer

Khairizar Sapwan, K. Sembiring, Tulus Ikhsan Nasution, Mutia Amalia, Rika Rahmayanti

Department of Physics, University of Sumatera Utara, Padang Bulan, Medan, Indonesia

## ABSTRACT

Characterizations of membranes made from cellulose empty palm oil bunches-fiber glass as H<sub>2</sub>O separators in water of electrolyzer has been done. The separators membrane was successfully made with a manual and simple technique, mixing cellulose fiber material produced from the modification of oil palm empty bunches fibers (OPEBF) with a steam explosion in 12 % NaOH immersion. Cellulose fiber mixed with fiber glass in the composition of 30:20:50 (%wt) and dried with variations in heating temperature 60°C, 70°C, 80°C, 90°C and 100°C to get a composite. The results of Characterization the ability of the membrane as a separator produce H<sub>2</sub> gas concentrations which is more increased than without using a separator. Where is the good and stable value for the membrane as a separator in heating temperature 70°C with a percentage of membrane porosity is 34.9%, the percent value of water absorption (swelling) is 46.93% and membrane conductivity is  $1.33 \times 10^{-10}$  S/cm and SEM results show sample in heating temperature 70°C has more homogeneity than others.

**Keywords :** Hybrid Composite, Cellulose Fiber, Epoxy Resin, Separator, Water Electrolyzer

## I. INTRODUCTION

The current energy and environmental crisis has become a global issue. Combustion of fuel and coal produces environmental pollution and CO<sub>2</sub> which results in global warming. Global warming can be characterized by climate change, drought, flooding etc. So, to solve the problem, a breakthrough and renewal is needed in terms of energy use, namely the use of alternative energy instead of fossil fuels. The use of alternative energy that is environmentally friendly can also help in preventing global warming compared to fossil energy that can damage the environment. It has been noted that energy reserves in the world are 891 billion tons for coal, 6,558 trillion cubic Feets for natural gas, and 1,668 billion barrels for petroleum<sup>[1]</sup>.

Therefore research is needed to produce alternative energy sources, one form of alternative energy that can overcome the problem that occurs is hydrogen gas<sup>[2]</sup>. Basically the concept of low carbon energy storage has an important role for the future and balancing supply that is not flexible with demand. Storage of renewable energy, especially hydrogen, is very interesting because of its abundance of elements, long-term durability, low potential costs and also the ability to transfer electricity to other energy sectors<sup>[3]</sup>.

## II. METHODS AND MATERIAL

Empty palm oil bunches fiber that has been chopped is cleaned and soaked with water for one night and then dried. After drying, cut into pieces with a size of 2-3 cm. Soaked with 2% (v/v) NaOH for one night. Then NaOH was soaked 12% (v / v) and steam explosion using autoclave for 2 hours with a

temperature of 130°C. Fiber was released from the autoclave. Washed to neutral pH. Then it is bleached using NaOH 17.5% (w / v), acetic acid 7.4% (v/v), NaOCl 10% (v / v) and H<sub>2</sub>O<sub>2</sub> 15% (v/ /v). Then filtered and washed with water. It is dried in an oven at 60°C. After that, the dried fiber is smoothed using a commercial blender. Then filtered using a 200 mesh filter.

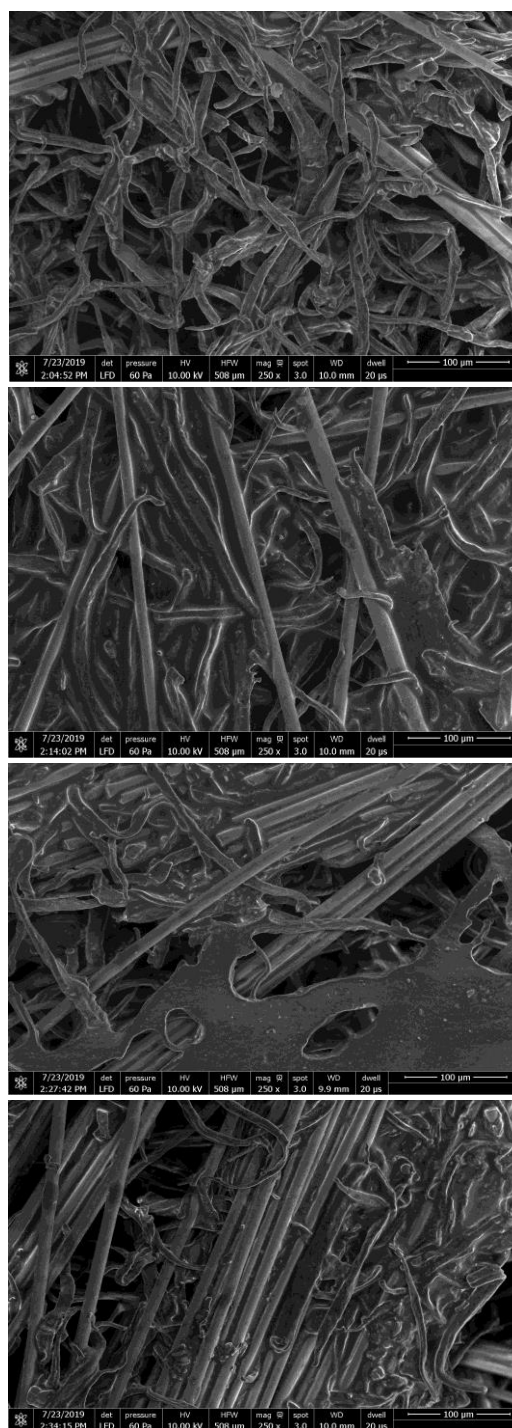
Characterization the ability of cellulose fiber membranes fiber glass as Hseparators and O<sub>2</sub> made from fillers and epoxy resins as matrices was carried out to see the performance improvement of mixing all ingredients. Tests carried out related to the ability of the membrane as a separator of hydrogen and oxygen gas were reviewed from the electrolysis process of water in Electrolyzer Characterization Chamber Water.

Characterization the ability of cellulose fiber membrane EFB fiber glass as a separator by placing a membrane between two iron plates into an Electrolyzer Characterization Chamber Water which is connected to the cathode pole and anode on the PSA (Power Supply Atten). Where the output of hydrogen gas and oxygen produced will flow into the Hydrogen & Oxygen Chamber through a hose that has been connected. Furthermore, the sensor readings contained in the Hydrogen & Oxygen Chamber are connected to the input terminal of the sensor system based on the Arduino UNO microcontroller. Where the test data will be recorded and displayed on the laptop screen using the PLX-DAQ data acquisition system.

The characterization of cellulose fiber membranes from oil palm empty bunches glass as separator was carried out by analyzing surface morphology using Scanning Electron Microscopy (SEM), the physical properties of membranes using porosity test and membrane electrical properties.

### III. RESULTS AND DISCUSSION

#### 1. Microstructure Analysis of Cellulose Fiber Membrane Sawit- Empty Fruit Bunch Oil Fiber glass Separatoras H<sub>2</sub>O



**Figure 1.** Scanning Electron Microscopy (SEM) with a magnification of 250X at Sample 1-4

Figure 1 shows that Sample 1 shows the surface morphology images there are cavities lots in large quantities in this sample mixture, where the brightly

colored part is the EFB cellulose fiber and bonded epoxy resin, while the dark colored part is the cavities formed between mixing the cellulose fiber OPEFB fibers and epoxy resin. Sample 2 shows the morphology of fiber glass and cellulose fiber from OPEFB fibers which begin to form cavities. The cavities in this sample began to decrease from the previous sample. Sample 3 shows the surface of fiber glass which begins to dominate and the cellulose fiber of the OPEFB forms a cavity but with a reduced number of cavities. Sample 4 shows the morphology of fiber glass that has dominated this sample because the number of masses fiber glass is increasing compared to the OPEFB cellulose fiber. In this sample, the OPEFB

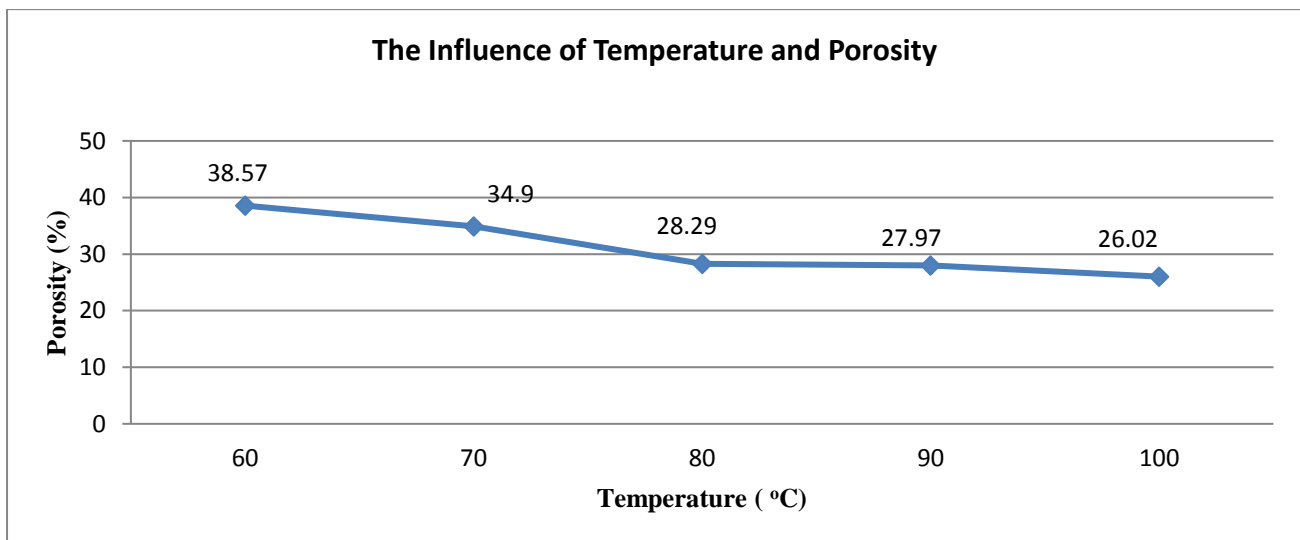
cellulose fibers began to lose the ability to form cavities because the amount of mass decreases, so that the cavity formed in this sample is only small.

## 2. Porosity

Porosity are the ratio between the volume of pores to the total volume of the membrane. In this cellulose fiber separator membrane empty palm oil-bunches fiber glass that happens is some porosity in the sample is still open in the middle to the surface of the membrane where water still has access during Characterization.

**Table 1.** Characterization Cellulose Fiber Membrane Porosity Empty Fruit Bunch Palm Oil-Fiber glass Separator as H<sub>2</sub>O

No.	Sample Heating Temperature(°C)	MassDry (grams)	WetMassa (grams)	Volume Sample (cm <sup>3</sup> )	Porosity (%)
1	Sample 60 0.435	1	0.715	0.726	38.57
2	sample 2 70	0.505	0.742	0.679	34.90
3	sample 80 0.572	0.416	3	0.540	28.29
4	sample 4 90	0.455	0.627	0.615	27.97
5	sample 5 100	0.50	0.698	0.761	26.02



**Figure 2.** Graph of the Porosity and Heating Temperature

Based on Table 1 and Figure 2 above, it shows that the higher the temperature of the separation, the lower the porosity value of the separator. The maximum porosity value obtained is 38.57% in the composition of sample 1 with a heating temperature of 60°C, while for the minimum porosity value obtained is 26.02% in sample 6 which is with a heating temperature of 100°C.

### 3. Characterization of Electrical Properties of Membrane Cellulose Fiber Empty Palm Oil Bunches Fiber glass as Separator H<sub>2</sub>O

The electrical properties of cellulose fiber separator membrane empty palm oil bunches -fiber glass is done by measuring the resistivity of the material to determine the conductivity value of the material, where the material resistivity is influenced by the structure of atoms and molecules who moves<sup>[4]</sup>. So that it can be calculated the value of the conductivity of the material which can affect and help the breakdown process H<sub>2</sub>O, the results of Characterization the electrical properties with the conductivity value of materials as in Table 2.

**Table 2.** Characterization the Electrical Properties of Cellulose Fiber Membranes Empty Bunches of Palm Oil Fiber glass as Separator H<sub>2</sub>O

Sample	V in (V)	V <sub>R</sub> (V)	d (cm)	$\rho_{\text{sample}} 10^{10}$ ( $\Omega$ cm)	$\sigma_{\text{sample}} 10^{-10}$ (S/cm)
1	10	0,0009	0,17	0,725	1,38
2	10	0,0009	0,163	0,752	1,33
3	10	0,0011	0,111	0,909	1,10
4	10	0,0081	0,19	0,071	0,91
5	10	0,0006	0,147	1,266	0,79

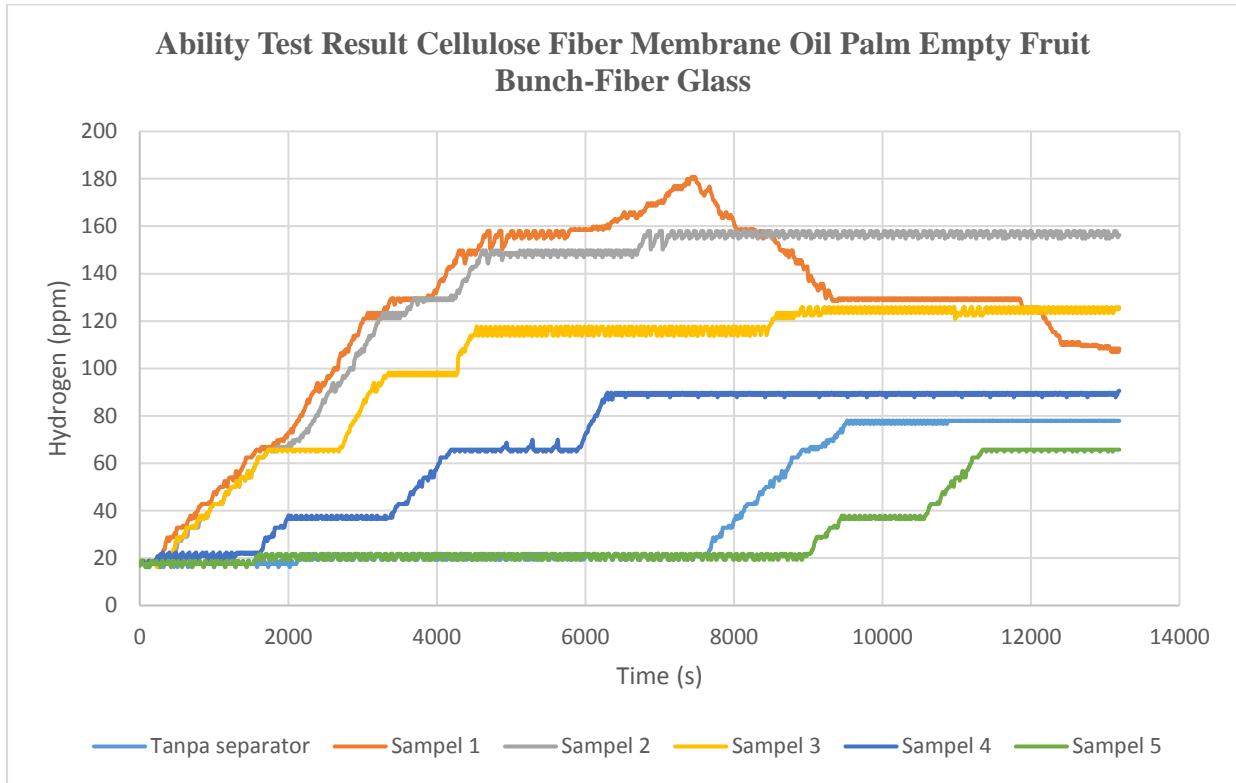
Based on Table 2 above shows that as temperature increases effect on conductivity value separator. When the temperature is increased, the conductivity value of the membrane also decreases. This is due to the resin or matrix undergoing a depolymerization process at high temperatures<sup>[5]</sup>. The maximum conductivity of oil palm empty cellulose membrane separator fiber glass is  $1.38 \times 10^{-10}$  S/cm in sample 4 which is at a heating temperature of 60°C and for a minimum conductivity value is  $0.79 \times 10^{-10}$  S/cm the sample 5 is at a heating temperature of 100°C. The results of this conductivity when compared with the Nafion 117 type commercial separator membrane are still very small, but can still help the process of transferring protons from the anode to the cathode in the water electrolysis process.

### 4. Membrane Capability of Cellulose Fiber Empty Palm Oil Bunches Fiber Glass as Separator H<sub>2</sub>O.

The ability of cellulose fiber membranes of OPEFB fiber glass as separator H<sub>2</sub>O is carried out by looking at the increase in performance during the electrolysis process of water as a separator H<sub>2</sub>O seen from the electrolysis process of water in Electrolyze Characterization Chamber Water. Characterization the ability of cellulose fiber separator membranes TKKS fiber glass is placed between two types of iron plates stainless steel into an Electrolyzer Characterization Chamber Water where it will be connected to the cathode pole and anode on the PSA (Power Supply Atten). At the anode pole there is decomposition of H<sub>2</sub>O into O<sub>2</sub> gas, releasing H<sup>+</sup> ions and electrons which will then move through the cellulose fiber separator membrane OPEFB fiber glass to the cathode pole by capturing two electrons

which are then reduced to H<sub>2</sub> gas. It can be seen the working role of the separator that can pass H<sup>+</sup> ions through the formed shaft so that not many H<sup>+</sup> ions are neutralized with OH<sup>-</sup> ions, where neutralization can reshape water molecules. The output of H<sub>2</sub> gas produced and the neutralized water molecule will

flow into the Hydrogen Chamber via a connected hose. Then the sensor inside will work to read in the form of voltage and will be displayed on the PLX-DAQ data acquisition system. The data obtained by the test results shown in Figure 3 below:



**Figure 3.** Graph Ability Test Result Cellulose Fiber Membrane Oil Palm Empty Fruit Bunch-Fiber Glass as Separator H<sub>2</sub>O

Based on Figure 3 of the test on water electrolysis process for gas value H<sub>2</sub> passed, the results obtained by using cellulose fiber membranes empty oil palm bunches fiber glass H<sub>2</sub> gas concentrating value is more increased compared to the electrolysis process of water without using a membrane separator. Where when the temperature is raised, the greater the gas H<sub>2</sub> is missed. The optimum value from the results of H<sub>2</sub> gas concentration using cellulose fiber separator membrane TKKS-fiber glass is ppm in sample 1 which is at a heating temperature of 60°C for 12 hours but the value of H<sub>2</sub> is not stable. This is due to heating temperature 60°C surface Non-homogeneous samples that cause While sample 2 separator with heating temperature 70°C has a value of H<sub>2</sub> lower than sample 1 but has a stable value. While the result of concentrating H<sub>2</sub> gas without using a separator is 51 ppm.

#### IV.CONCLUSION

The results of Characterization the ability of cellulose TKKS fiber glass as a separator of H<sub>2</sub>O in the electrolysis process of water resulted in a higher concentration of H<sub>2</sub> gas than without using a separator. The optimum value produced is ppm in sample 1 which is at a heating temperature of 90°C for 12 hours but is not stable while the separator of sample 2 produces H<sub>2</sub> which is more stable with a maximum value that is not much different from sample 1. Whereas the result of gas production H<sub>2</sub> without using a separator is 51 ppm.

A good and stable value for cutting as a separator at a heating temperature of 70°C with a percent porosity of the membrane of 34.9%, a percent value of water

absorption (swelling) of 46.93% and a membrane conductivity value of  $1.33 \times 10^{-10}$  S/cm and SEM results show that samples with heating 70°C have high homogeneity.

## V. REFERENCES

- [1]. Chakik F, Kaddami M, Mikou M, 2017. Effect Of Operating Parameters On Hydrogen Production By Electrolysis Of Water. *International Journal Of Energy*, 42: 25550-25557.
- [2]. Deb PC, Rajput LD, Hande VR, Sasane S, Kumar A, 2007. Modification of Sulfonated Poly (Ether Ether Ketone) With Phenolic Resin. *Polymers For Advanced Technologies*, 18: 419-426.
- [3]. Schmidt O, Gambhir A, Staffell I, Hawkes A, Neslon J, Few S, 2017. Future Cost and Performance of Water Electrolysis: An Expert Elicitation Study. *International Journal of Hydrogen Energy*, 42: 30470-30492.
- [4]. Millet P, 2015. Hydrogen Production By Polymer Electrolyte Membrane Water Electrolysis. *Compendium of Hydrogen Energy*, France, pp. 255-286.
- [5]. Santos D, Sequira C, 2013. Hydrogen Production By Alkaline Water Electrolysis. *Journal of Materials Electrochemistry*, 8: 1176 - 1193.

## Cite this article as :

Khairizar Sapwan, K. Sembiring, Tulus Ikhsan Nasution, Mutia Amalia, Rika Rahmayanti, "Characterization of Cellulosa Empty Palm Oil Bunches-Fiber Glass Membrane as Separator in Water Electrolyzer", *International Journal of Scientific Research in Science, Engineering and Technology (IJSRSET)*, Online ISSN : 2394-4099, Print ISSN : 2395-1990, Volume 6 Issue 4, pp. 267-270, July-August 2019. Available at doi : <https://doi.org/10.32628/IJSRSET196425>  
Journal URL : <http://ijsrset.com/IJSRSET196425>