

# Characterization of Cellulosa Coconut Fiber-Fiber Glass Membrane as a Separator in Water Electrolizer

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## ABSTRACT

Characterizations of membranes made from cellulose coconut fiber-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 coconut fibers with NaOH immersion process. Cellulose fiber mixed with fiber glass in the composition of 50:0, 40:10, 30:20, 20:30, 10:40, 0:50 (%wt) to get hybrid composite. The results of testing the ability of the membrane as a separator produce H<sub>2</sub> gas concentrations that are more increased than without using a separator. The optimum value produced is 300 ppm in sample 1 which is 50:0:50 %wt, while the H<sub>2</sub> gas production without using a separator which is 51 ppm. For physical properties testing, the addition of mass percent of cellulose coconut fiber affects the physical and electrical properties of membrane where the optimum value of % porosity of the material obtained is 73 %, swelling value is 77,5 % and the conductivity value of the material amounting to  $1,572 \times 10^{-7}$  S/cm.

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

## I. INTRODUCTION

Energy use is one of the serious problems in Indonesia. This problem develops day by day, because almost all activities of human life are very dependent on the availability of energy and the rapid growth of population, urbanization and industrialization. Today most of the 80% energy consumption is generated from non-renewable energy such as coal, natural gas and petroleum. 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 [1]. Therefore research is needed to produce alternative energy sources, one form of alternative energy that can overcome the problem that occurs is hydrogen gas. Storage of renewable energy, especially hydrogen, is very interesting because of its abundance of elements, long-term resilience, low potential costs and also the

ability to transfer electricity to other energy sectors [2].

Hydrogen can be produced from renewable energy sources namely hydropower through the electrolysis process of water. Water electrolysis is a simple electrochemical device that separates H<sub>2</sub>O into oxygen (O<sub>2</sub>) and hydrogen (H<sub>2</sub>) using electric current [1]. Electrolysis Polymer Electrolyte Membrane (PEM) is electrolysis of water in cells equipped with polymer membranes which act as proton conduction, gas separator, and electrode electrical isolation. Gas separators are generally made of micropore polymer membranes, which are usually made from inorganic, organic and natural ingredients. One of the efforts made to maximize the process of separating hydrogen and oxygen gas is by making a separator membrane. Glass fiber is the type of synthetic fiber that is most widely used because it is economical, one of which is

as a filler in thermoset polymer materials which can increase the strength of a material [3].

The use of coconut fibers is widely used because coconut fibers have long-lasting properties, are very resilient, strong against friction, are not easily broken, are resistant to water, do not rot easily, are resistant to fungi and pests and are not inhabited by termites and rats. For this reason, coconut fiber is a composite development alternative, because in addition to being cheap, easy to obtain is also very abundant. Coconut fibers consist of fiber and cork that connects one fiber

to another fiber which is a valuable part of the material [4]

II. METHODS AND MATERIAL

Characterization of cellulose fiber membranes coconut fibers - glass fiber as a separator in the electrolysis process of water begins with determining the percentage weight of each material and its comparison can be seen in table 1.

**Table 1.** Materials used in the manufacture of Coconut-Fiber Glass Cellulose Fiber Membrane Membrane as Separator

No	Membranes	Coconut fiber (%wt)	Fiber Glass (%wt)	Epoxy Resin (%wt)
1	Sampel 1	50	-	50
2	Sampel 2	40	10	50
3	Sampel 3	30	20	50
4	Sampel 4	20	30	50
5	Sampel 5	10	40	50
6	Sampel 6	-	50	50

1. Making Isolation of Cellulose Fiber Coconut fibers

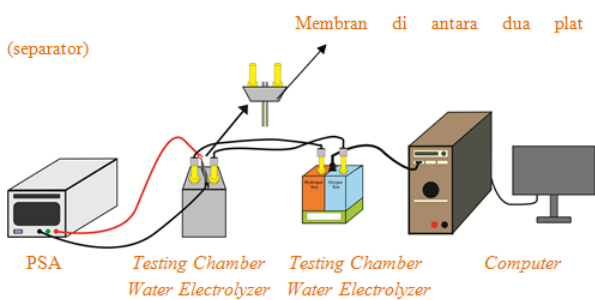
Fiber coconut fibers that have been chopped cleaned and soaked with water for one night and then dried. After drying, cut into pieces with a size of 2-3 cm. Soaked with 2% (v/v) NaOH for one night. Washed to neutral pH. Then bleached using NaOH 17.5% (w/v), acetic acid 7.4% (v /v), NaOCl 10% (v /v) and H<sub>2</sub>O<sub>2</sub> 15% (v /v). Then filtered and washed with water. Dry in an oven at 60°C. After that, the dried fibers are smoothed using a commercial blender. Then filtered using a 200 mesh screen.

2. Manufacture of Coconut-Fiber Glass Cellulose Fiber Membrane Membrane as Separator

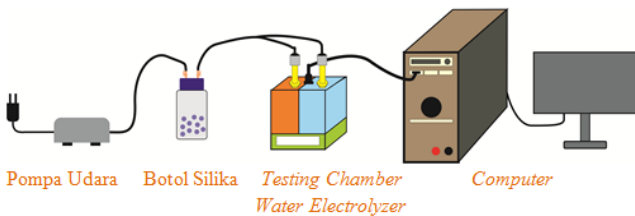
The first thing that was done in the process of making membranes in this study was weighing coconut fiber fiber powder and small pieces of glass fiber with variations in mass fractions 50: 0, 40:10, 30:20, 20:30, 10:40 and 0:50% (wt). Then coconut fiber fiber powder and small glass fiber pieces are inserted into the beaker glass, then mixed with epoxy resin with a ratio of 50:50% (w/v). After that stirred until homogeneous and placed on the mold that has been coated with aluminum foil so that the membrane is not sticky to the mold. Dry in an oven at 80°C for 12 hours.

3. Testing the ability of membrane fibers of coconut fiber glass cellulose as H<sub>2</sub> and O<sub>2</sub> separators

Testing the ability of cellulose fiber membranes coconut fibers - glass fiber as separator H<sub>2</sub> and O<sub>2</sub> made from filler and epoxy resin as a matrix is done 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 Testing Chamber Water.



**Figure 1.** Illustration of testing the ability of coconut fiber cellulose fiber membranes - glass fiber as a hydrogen-oxygen gas separator.



**Figure 2.** Illustration of the recovery process of Hydrogen & Oxygen Chamber with silica gel.

Testing the ability of cellulose fiber membranes coconut fibers - glass fiber as a separator by placing a membrane between two iron plates into an Electrolyzer Testing 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

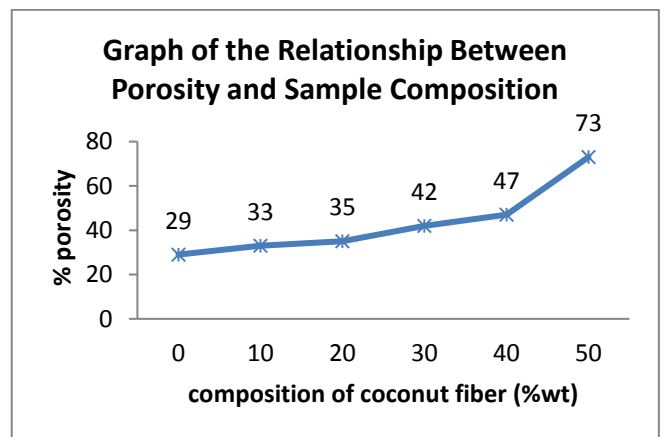
the test data will be recorded and displayed on the laptop screen using the PLX-DAQ data acquisition system.

### III. RESULTS AND DISCUSSION

#### 1. Porosity

Porosity is the ratio of the volume of pores to the total volume of the membrane. In the coconut fiber membrane, glass fiber is what happens is some porosity in the sample is still open in the middle to the surface of the membrane so that the water still has access during testing.

**Table 2.** Testing Porosity of Cellulose Fiber Membranes Coconut-fiber glass As a Hydrogen and Oxygen Separator



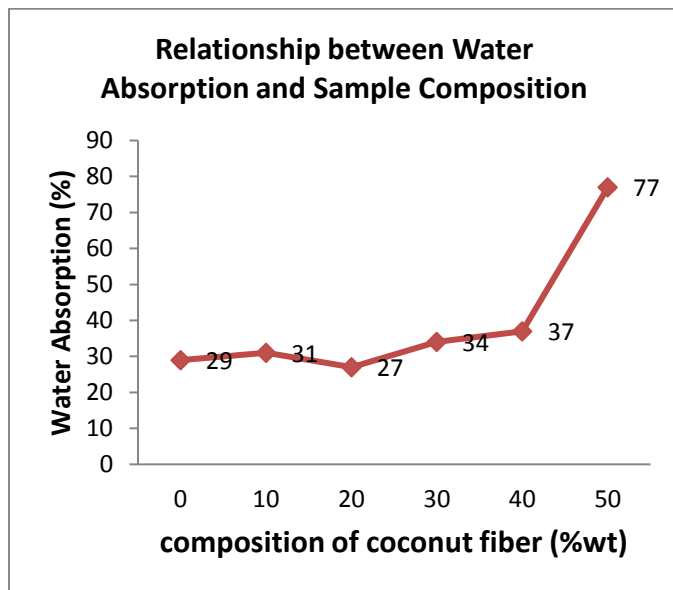
**Figure 3.** Graph of the Relationship Between Porosity and Sample Composition

Based on table 4.1 and figure 4.3 above, it shows that the more the composition of the percent mass of coconut fiber fibers increases, the greater the % porosity of the separator. The maximum porosity value obtained is 73% in the composition of sample 1 which is 50: 0: 50% wt, while the minimum porosity value obtained is 29% in the composition of sample 6 which is 0:50:50 %wt for the comparison of coconut fiber cellulose fiber: glass fiber: epoxy resin. The effect of variations in mass percentages of coconut fiber cellulose fibers in % porosity is caused by

coconut fiber cellulose fibers which make the amount of air increase so that porosity becomes large during the heating process with a temperature of 80 °C [5].

## 2. Water Absorption

The purpose of this water absorption test (swelling) is to determine the ability of fiber glass fiber cellulose membrane samples to absorb distilled water for 24 hours, with a sample size of 2 cm x 2 cm at room temperature.



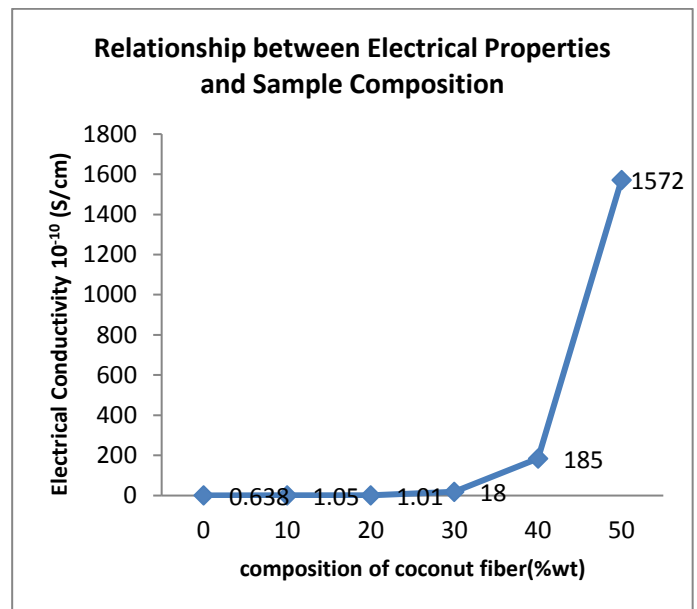
**Figure 4** Graph of the Relationship between Water Absorption and Sample Composition

Figure 4 shows that the more the composition of the percent mass of coconut fiber fibers increases, the greater the absorption rate of water from the separator membrane. The maximum absorbency value obtained is 77% in the composition of sample 1 which is 50: 0: 50% wt for comparison of coconut fiber cellulose fiber: glass fiber: epoxy resin and for the minimum absorption value obtained is 29% in sample composition 6 which is 0 : 50: 50% wt for comparison of coconut fiber cellulose fiber: glass fiber: epoxy resin. The effect of variations in mass percentages of coconut fiber cellulose fibers on% of water absorbency is caused by the nature of coconut fiber cellulose fibers which are hydrophilic to water. So that when the mass percent of cellulose fiber of

coconut fiber is added, it automatically enlarges the percent water absorbency value of the membrane.

## 3. Conductivity

The electrical properties of the cellulose fiber separator membrane coconut fiber glass fiber is done by measuring the resistivity of the material to determine the conductivity value of the material, where the resistivity of the material is influenced by the structure of the moving atoms and molecules [6]. So that it can be calculated the value of the conductivity of the material which can affect and help the H<sub>2</sub>O breakdown process.



**Figure 5.** Graph of the Relationship between Electrical Properties and Sample Composition

From Figure 5, the addition of coconut fiber cellulose fibers increases the conductivity value of the separator membrane. It is seen that there is a significant increase in conductivity value along with the addition of coconut fiber cellulose fibers. In Figure 3, it can be seen in sample 1 that it also has the highest porosity value. This is in line with the increased conductivity value because water canals in sample 1 can increase ion mobility so that the conductivity value is high. Membrane separator with composition of coconut fiber cellulose fiber glass fiber

50:50% wt that is in sample 1 has the greatest conductivity response with a conductivity value of  $1,572 \times 10^{-7} \text{ S / cm}$ . But in the other samples when glass fiber was added, the conductivity value of the membrane decreased significantly. This is related to the nature of glass fiber itself which is an insulating material. Based on the conductivity value, membrane samples can be categorized into semiconductor materials where the range of conductivity values for semiconductor materials is  $10^3\text{-}10^8 \text{ S/cm}$  [7].

4. Testing the ability of membrane fibers of coconut-fiber glass cellulose fibers as H<sub>2</sub>O separators

Testing the ability of cellulose fiber membranes Coconut fibers as glass separators H<sub>2</sub>O are carried out by looking at the increase in performance during the electrolysis process of water. Tests carried out related to the ability of the membrane as H<sub>2</sub>O separator seen from the electrolysis process of water in Electrolyze Testing Chamber Water. Testing the ability of

cellulose fiber separator membrane coconut fiber glass fiber is placed between two types of stainless steel iron plates into an Electrolyzer Testing Chamber Water where it will be connected to the cathode pole and the 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 - fiber glass palm fibers 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 experience neutralization with OH<sup>-</sup> ions, where neutralization can reshape water molecules. The gas output of the H<sub>2</sub> produced and the neutralized water molecules will flow into the Hydrogen Chamber through the 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 is obtained by testing results as shown in Figure 6.

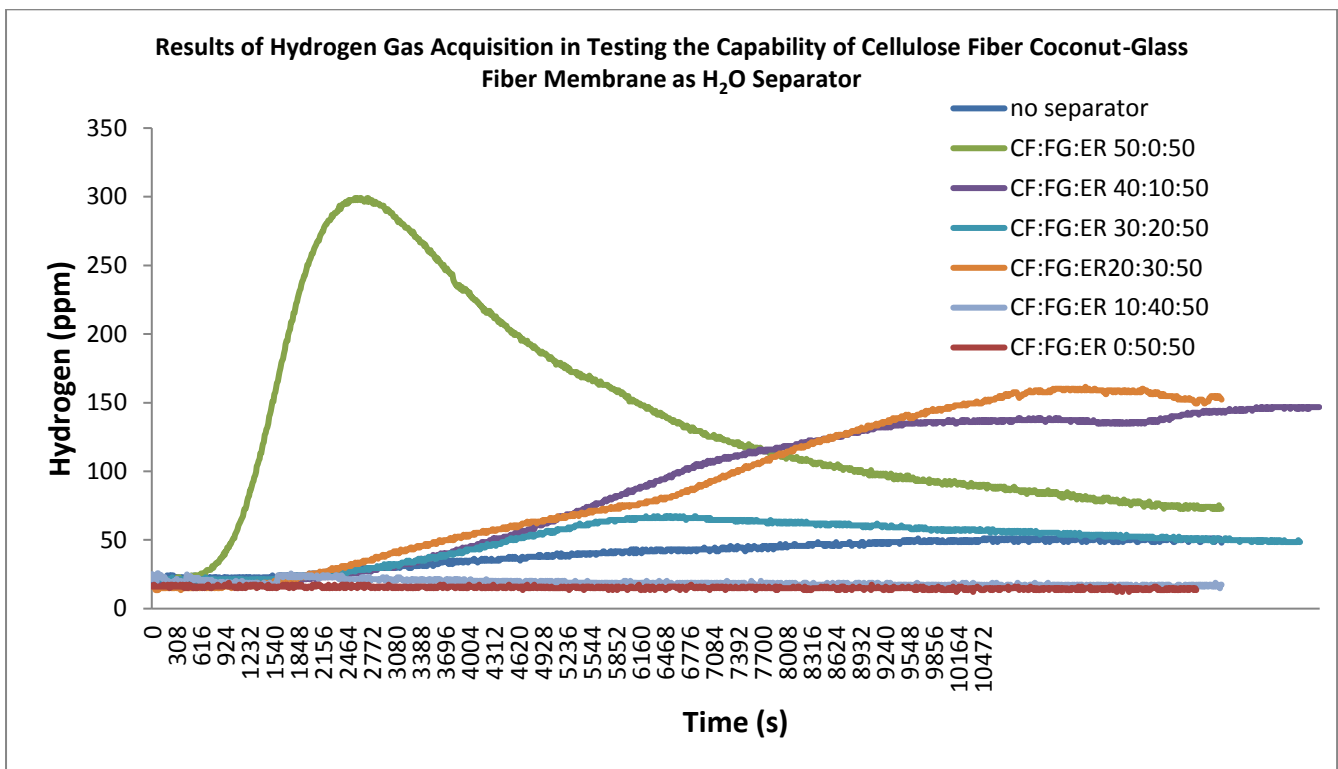


Figure 6 Graph of the Results of Hydrogen Gas Acquisition in Testing the Capability of Cellulose Fiber Coconut-Glass Fiber Membrane as H<sub>2</sub>O Separator

Based on Figure 6 of the testing on the electrolysis process of water for the H<sub>2</sub> gas value that is passed, the results obtained by using cellulose fiber membranes of coconut fibers and glass fiber H<sub>2</sub> gas concentration concentrations are more increased compared to the electrolysis process of water without using a membrane separator. Where the greater the mass of cellulose fiber coconut fibers on the membrane separator, the greater H<sub>2</sub> gas is missed. The optimum value of the H<sub>2</sub> gas concentrated results using cellulose fiber separator membrane coconut fiber glass fiber is 300 ppm in sample 1 which is 50: 0: 50% wt for the comparison of coconut fiber cellulose fiber: glass fiber: epoxy resin. While the results of H<sub>2</sub> gas concentration without using a separator are 51 ppm.

#### 5. Scanning Electron Microscopy (SEM)

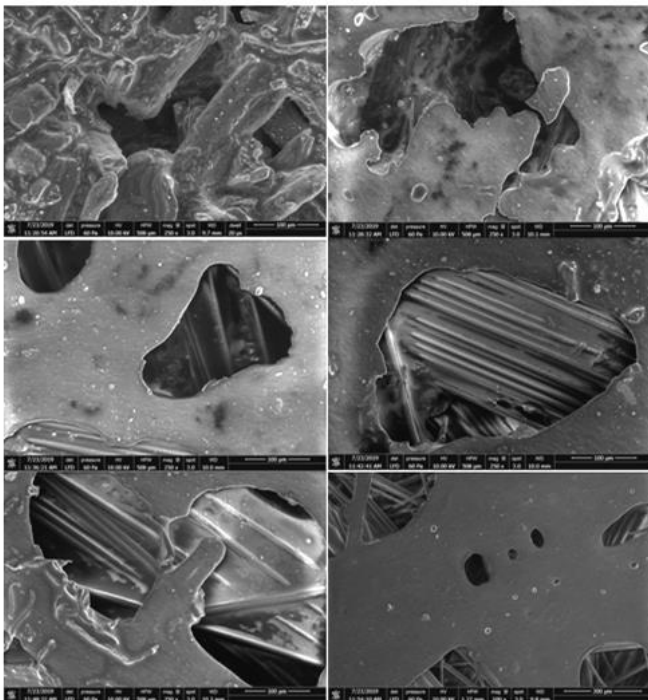


Figure 7. SEM testing results in sample 1 to sample 6

From Figure 7 it can be seen in sample 1 where the composition of coconut fiber cellulose fibers: glass fiber is 50: 0% wt, coconut fiber cellulose fiber dominates with relatively the same size. The brightly

colored part is the cellulose fiber of the coconut fiber itself and the dark one is the formed pore.

#### IV. CONCLUSION

From the results of the research that has been done, it can be concluded that The membrane as an H<sub>2</sub>O separator was successfully made from a mixture of cellulose fiber materials, coconut fibers, glass fiber. The results of testing the ability of cellulose fiber membranes of coconut fibers - glass fiber as separator H<sub>2</sub>O in the electrolysis process of water produce H<sub>2</sub> gas concentrations that are more increased than without using a separator. The optimum value produced is 300 ppm in sample 1 which is 50: 0: 50% wt for comparison of coconut fiber cellulose fiber: glass fiber: epoxy resin, while the yield of H<sub>2</sub> gas production without using a separator is 51 ppm. In testing the physical properties of membranes, the addition of mass percent of coconut fiber cellulose fibers affected the value of the physical properties and electrical properties of the membrane where the optimum value of membrane porosity obtained was 77.5%, swelling was 37.37% and membrane conductivity value of  $1,572 \times 10^{-7}$  S / cm, the three tests were obtained in sample 1, namely 50: 0: 50% wt for comparison of coconut fiber cellulose fiber: glass fiber: epoxy resin.

#### V. ACKNOWLEDGEMENT

The author would like to thank all the teams in the integrated laboratory of the University of North Sumatra, Padang Bulan Medan

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**Cite this article as :**

Mutia Amalia, K. Sembiring, Tulus Ikhsan Nasution, Khairizar Sapwan, Rika Rahmayanti, "Characterization of Cellulosa Coconut Fiber-Fiber Glass Membrane as a Separator in Water Electrolizer", *International Journal of Scientific Research in Science, Engineering and Technology (IJSRSET)*, Online ISSN : 2394-4099, Print ISSN : 2395-1990, Volume 6 Issue 4, pp. 260-266, July-August 2019. Available at doi : <https://doi.org/10.32628/IJSRSET196427>  
Journal URL : <http://ijsrset.com/IJSRSET196427>