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CHARACTERISTICS OF PEAT WATER AND COCONUT WATER MOLECULES IN THE ELECTROLYSIS PROCESS TO PRODUCE HYDROGEN GAS

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Abstract. Hydrogen energy is one of the alternative energy sources that will help overcome the scarcity of fossil fuels. One of the steps to produce hydrogen energy is by the electrolysis method. In this study, the electrolysis process was carried out with a combination of peat water and coconut water. Given that there are extensive areas of peat land and also many coconut trees in South Kalimantan, a combination of peat and coconut water is used for the electrolysis to promote a sustainable process. In addition, the presence of metallic compounds containing Na, Mg, Al, Fe, Ca, K, and others in peat water may also be beneficial in the electrolysis process. These mineral compounds help in accelerating the formation of hydrogen gas by indirectly producing electrolyte properties and acting as a catalyst. From the results of the research conducted, as much as 155 ml of hydrogen was produced. Hydrogen gas production, 0.6 A of electric current, and 7.3 Watts of electric power in the 30-minute electrolysis process were found in sample F (1.5 L of pure coconut water). In the electrolysis process, peat water and coconut water, the voltage used during the electrolysis process was 12 V, which flowed through the cathode and anode.

Keywords: Coconut Water, Electrolysis, Hydrogen, Mineral, Peat Water

1. INTRODUCTION

The electrolysis process is a technique for separating water (H_2O) into hydrogen gas (H_2) and oxygen (O_2) using an electric current through electrodes in an electrolyte liquid medium [1]. This technology is being increasingly developed as an environmentally friendly method for hydrogen production, supporting the transition to renewable energy [2]. Recent studies have shown that the choice of electrolyte fluid greatly affects the efficiency and success of the electrolysis process [3]. Conventional electrolytes such as acid solutions (H_2SO_4) [4], bases (KOH), or salt (NaCl) have high conductivity but hurt the environment [5]. As an alternative, researchers have begun to develop natural electrolyte fluids such as coconut water and peat water [6]. Coconut water has a high mineral content, such as potassium, sodium, and magnesium, which can increase electrical conductivity and support the formation of hydrogen gas bubbles on the cathode [7]. Meanwhile, peat water contains complex organic compounds such as humic and fulvic acids, which can act as current-conducting ions although their efficiency is lower [8]. With additional processing, such as filtration or the addition of external electrolytes, peat water still has the potential to be used as a cheap and abundant local electrolyte in tropical regions. Therefore, the use of coconut water and peat water as electrolysis fluids is part of a green technology innovation to produce clean hydrogen sustainably [9].

Energy has become an essential component of all activities and plays a vital role in the economic development of any country. The demand for energy in all sectors is continuously increasing due to increasing consumption, population growth, changing lifestyles, and technological advancements [10]. Almost every industry relies on energy, most of which comes from fossil fuels. Renewable energy plays a vital role in addressing all these issues. For this reason, the world and governments are developing new policies, especially in major industrialized countries, seeking to reduce their dependence on fossil fuels [11]. In an effort to boost the share of energy generated from renewable sources, researchers and scientists have proposed "hydrogen" for its advantageous properties. Hydrogen's density is lower than that of air. The gravimetric density of hydrogen is roughly double that of fossil fuels [12]. Hydrogen serves as a fuel that can act as an alternative to conventional fossil fuels like natural gas. Hydrogen is an encouraging energy carrier as it has the ability to store and provide energy in a usable format [13]. The energy density of hydrogen varies from 120 MJ/kg (LHV) to 142 MJ/kg (HHV) [14]. Depending on the method of production, hydrogen exhibits a fairly high power density and low carbon emissions throughout its life cycle. Hydrogen can additionally be mixed with natural gas to satisfy the fuel requirements of different energy systems [15]. However, hydrogen production must be environmentally and economically competitive, which has triggered significant research and development efforts. As an important part of the energy system, fossil fuels not only meet human demand but also cause ecological damage and pollution [16].

The development and use of alternative fuels are becoming increasingly important in global efforts to reduce greenhouse gas emissions [18], improve energy security, and promote environmental sustainability [19]. Although there are still challenges in terms of cost, infrastructure, and technology, progress continues to expand the use of alternative fuels in various economic sectors.

To produce hydrogen gas as a need for self-sufficiency in new renewable energy, a method is needed to produce hydrogen gas in the long term [20], and an electrolyte solution that is environmentally friendly and easy to obtain is needed. Of the many electrolyte fluids that use chemical additives, in the research that we developed, the use of natural electrolyte fluids that are easy to obtain in tropical areas, namely, coconut water, as a substitute for the electrolyte fluid used to produce hydrogen gas. There are several studies in producing hydrogen gas that still use chemical additives, namely research on the productivity of hydrogen gas with a catalyst in the form of KOH, then with a baking soda catalyst, NaCl, and so on.

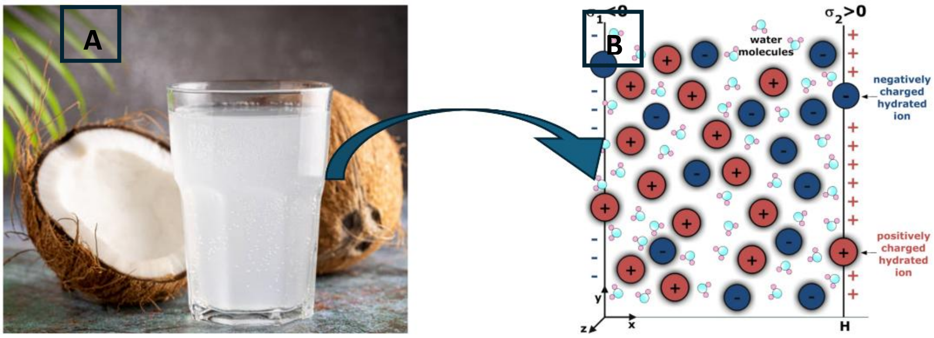


Figure 1. a. Coconut water, b. electrolyte properties of coconut water [21]

Pure coconut water without additional chemicals contains mineral compounds. These mineral compounds consist of Mg, Na, Cl, Al, K, Ca, and so on. These mineral compounds found in coconut water have electrolyte properties; in the world of health, this electrolyte fluid functions to replace sweat fluid after exercise. However, the electrolyte fluid contained in coconut water can function as a conductor of electric current. In addition to coconut water, which is used as an electrolyte medium, in this study, coconut water is also combined with peat water as a combination of electrolyte fluid because peat water found in swamp land has electrolyte properties. In research on swamp water in the laboratory, peat water also has a mineral composition including Mg, K, Na, Ca, Al, Fe, and fulvic acid. Fulvic acid found in peat water has a magnetic field found in the aromatic ring. Aromatic rings that are magnetic can interfere with hydrogen bonds in water, so that they can facilitate the reduction of H_2O bonds.

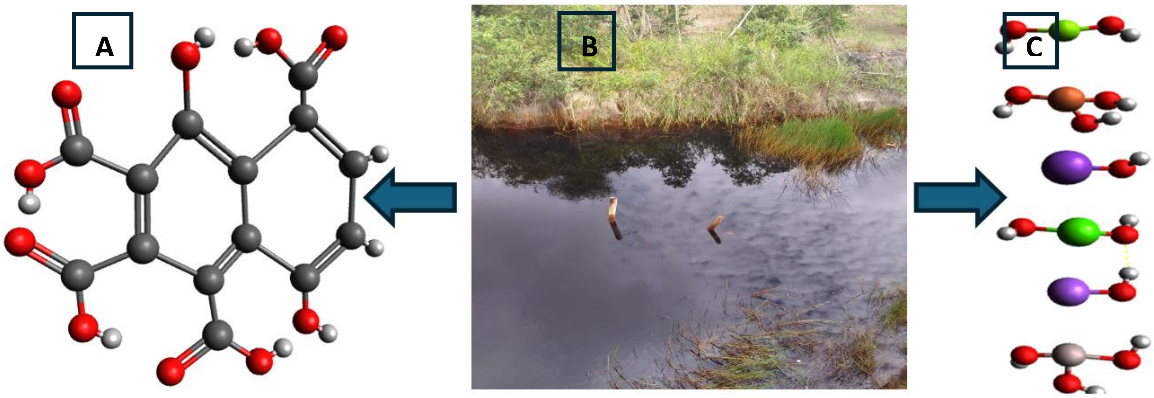


Figure 2. a. Peat fulvic acid structure, b Peat water, c. Peat mineral compounds structure

Thus, the combination of electrolyte fluid from coconut water and electrolyte fluid from peat water can provide a positive impact to obtain maximum results through hydrogen gas production by the electrolysis method. Electrolysis of hydrogen gas requires electrolyte fluid to carry out the separation reaction between hydrogen gas at the cathode and oxygen at the anode through water media that has electrolyte properties. Water that has electrolyte properties can easily reduce H_2O to produce hydrogen gas.

2. METHODS

2.1. Research Variables

Thus, this research process uses an experimental method to obtain hydrogen gas from coconut water and peat water. There are 6 sets of samples listed in Table 2.1. The results of the analysis of the content of peat water with a coconut water catalyst and pure coconut water were obtained by testing at the Balitra Banjarbaru Laboratory, South Kalimantan and are shown in Table 2.2.

Table 2.1 Formulation of Electrolyte Mixture in Experiments

Water Mixture Formulation		
Variable	Peat Water (mL)	Coconut Water (mL)
Sample A	1300	200
Sample B	1200	300
Sample C	1100	400
Sample D	1000	500
Sample E	900	600
Sample F	0	1500

Table 2.2 Results of Peat Water + Coconut Water Composition Analysis

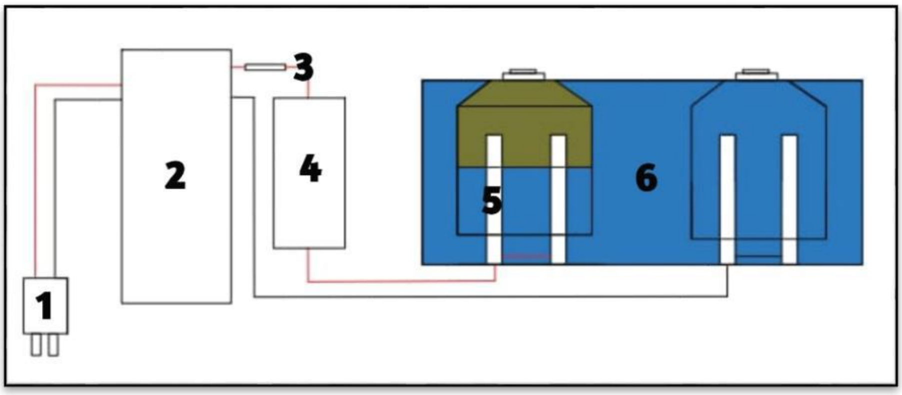
Number	Parameters	Unit	Variable					
			Sample A	Sample B	Sample C	Sample D	Sample E	Sample F
	Code		1	2	3	4	5	6
1	K	m.e L^{-1}	3,49	4,86	5,66	7,17	8,58	24,41
2	Na	m.e L^{-1}	0,94	0,87	0,95	1,11	1,22	4,21
3	Ca	m.e L^{-1}	2,53	2,34	2,50	3,37	3,82	12,93
4	Mg	m.e L^{-1}	2,64	2,01	2,53	3,21	3,50	6,91
5	Fe	m.e L^{-1}	0,06	0,06	0,07	0,04	0,09	0,02
6	Al	m.e L^{-1}	0,06	0,08	0,07	0,04	0,06	0,06

The results of laboratory tests on the sample solution between peat water and coconut water showed that the higher the concentration of coconut water, the higher the overall mineral content produced at the solution concentration, such as K, Na, Ca, and Mg found in sample F compared to other sample concentrations. However, the values of Fe and Al are still relatively the same, and the smallest value is in Fe. Overall, from the results of laboratory tests, sample F can be categorized as the best electrolyte for the electrolysis process and can contribute the most to producing hydrogen gas through the electrolysis process.

Table 2.1 shows the composition of the peat water and coconut water mixture used as the electrolyte variable in the electrolysis process for hydrogen gas production. In each sample, the total volume of the electrolyte fluid was maintained at 1,500 mL, but with different mixture proportions between peat water and coconut water. By increasing the proportion of coconut water, it is expected to increase the conductivity of the solution and the efficiency of hydrogen production. Sample F (100% coconut water) likely demonstrated the highest performance in terms of gas productivity and energy efficiency.

2.2. Research Mechanism

In the research process using water electrolysis, the main thing to do is to determine the concentration of mineral content in coconut water and peat samples. This is done in order to find out the variables used to collect data accurately. After knowing the concentration of mineral content, then one by one the samples are electrolyzed by flowing 12 V DC electric current through the cathode and anode electrodes. From the electrolysis process, hydrogen and oxygen gases are obtained, which are collected in the tube. The method for measuring the volume of hydrogen gas is by observing the decrease in the water level in the tube, which has previously been marked with a measuring instrument in the form of milliliters. The decrease in water pressure is caused by the pressure of the hydrogen gas produced. The amount of water reduction is interpreted as the amount of hydrogen gas produced in mL units. In addition to measuring hydrogen gas productivity, this study also measured the pH of the solution before and after the electrolysis process and changes in current and power during the electrolysis process.



1. Socket
2. Power supply
3. Wiring
4. Multimeter
5. Electrode
6. Reactor

Figure 3. Research installations

3. RESULTS AND DISCUSSION

3.1. Hydrogen Production

The results of hydrogen gas production tests from six different samples, tested at different times, are as follows:

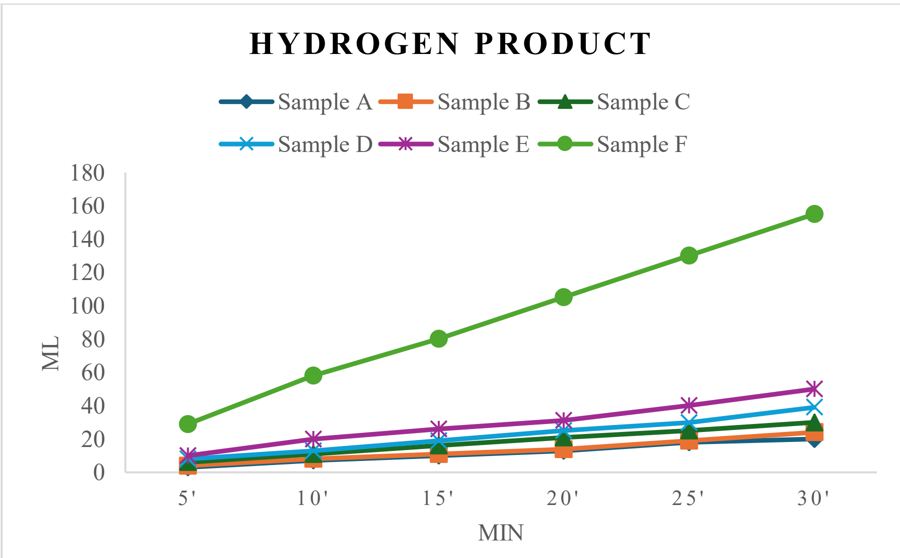


Figure 4. Hydrogen gas production results

Figure 4 shows the highest hydrogen gas production results in sample F with 155 ml of hydrogen gas production in a 30-minute electrolysis process, compared to sample A, which produces 20 ml of hydrogen gas; sample B, which produces 24 ml of hydrogen gas; sample C, which produces 30 ml of hydrogen gas; sample D, which produces 39 ml of hydrogen gas; and sample E, which produces 50 ml of hydrogen gas using peat water with the addition of a coconut water catalyst. The difference in the ability of pure coconut water with peat water with the addition of a coconut water catalyst to produce hydrogen gas is influenced by the electrolyte content in it, thus affecting the productivity of hydrogen gas. Pure coconut water naturally contains potassium, sodium, chloride, magnesium, and so on, while peat water, with the addition of a catalyst, contains lower electrolytes compared to pure coconut water. When coconut water is electrolyzed, the dissolved ions increase the electrical conductivity, allowing electric current to flow more easily [22]. This results in a more efficient electrolysis process where more ions can react and produce more hydrogen and oxygen gas. In contrast, samples A, B, C, D, and E, containing peat water with the addition of a coconut water catalyst, have lower electrolyte content than sample F, which is only pure coconut water, so the electrical conductivity is lower and the electrolysis process is less efficient, resulting in less hydrogen gas. Therefore, pure coconut water tends to produce more hydrogen gas because of its ability to carry an electric current better due to its higher electrolyte content [23].

3.2. Electric Current

The flowing current varies in each sample. In sample A, the flowing current is 0.11 A after electrolysis for 30 minutes; in sample B, the flowing current is 0.14 A after electrolysis for 30 minutes; in sample C, the flowing current is 0.21 A after electrolysis for 30 minutes; in sample D, the flowing current is 0.23 A after electrolysis for 30 minutes; in sample E, the flowing current is 0.25 A after electrolysis for 30 minutes; and in sample F, the flowing current is 0.60 A after electrolysis for 30 minutes. This difference is due to the content of electrolyte concentration in it. Sample F only uses pure coconut water without any mixture, while the other samples use a mixture of peat water and coconut water. It can be seen in the graph above that the more coconut water is mixed, the higher the current flows. This is due to the high concentration of natural electrolytes in coconut water, such as potassium, sodium, and chloride [24]. These electrolytes can increase the conductivity of the solution, allowing electric current to flow more easily through the solution. This makes coconut water usable as a natural catalyst or directly electrolyzable to produce hydrogen gas. During electrolysis, the current flowing for 5 minutes, 10 minutes, 15 minutes, 20 minutes, 25 minutes, and 30 minutes varies due to the influence of the solution reaction.

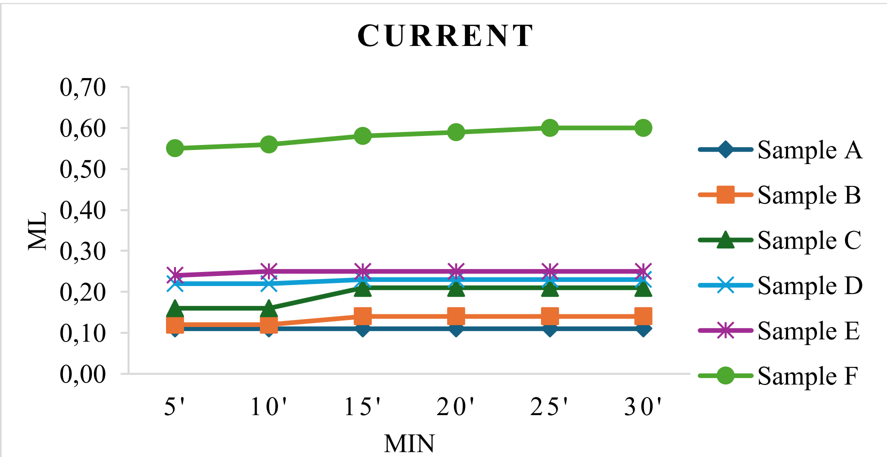


Figure 5. Comparison of electrolysis currents

3.2. Power

Figure 4.2 It can be seen that the power produced varies in each sample. In sample A, the power produced is 1.3 watts after electrolysis for 30 minutes; in sample B, the power produced is 1.7 watts after electrolysis for 30 minutes; in sample C, the power produced is 2.5 watts after electrolysis for 30 minutes; in sample D, the power produced is 2.8 watts after electrolysis for 30 minutes; in sample E, the power produced is 3.0 watts after electrolysis for 30 minutes; and in sample F, the power produced is 7.3 watts after electrolysis for 30 minutes. This difference is due to the content of electrolyte concentration in it. Sample F only uses pure coconut water without any mixture, while the other samples use a mixture of peat water and coconut water. It can be seen in the graph above that the more coconut water is mixed, the higher the power produced. This is due to the high concentration of natural electrolytes in coconut water, such as potassium, sodium, and chloride. These electrolytes can increase the conductivity of the solution, allowing electric current to flow more easily through the solution [25]. This makes coconut water usable as a natural catalyst or directly electrolyzable to produce hydrogen gas. During electrolysis, the power generated from 5 minutes, 10 minutes, 15 minutes, 20 minutes, 25 minutes, and 30 minutes varies due to the influence of the solution reaction.

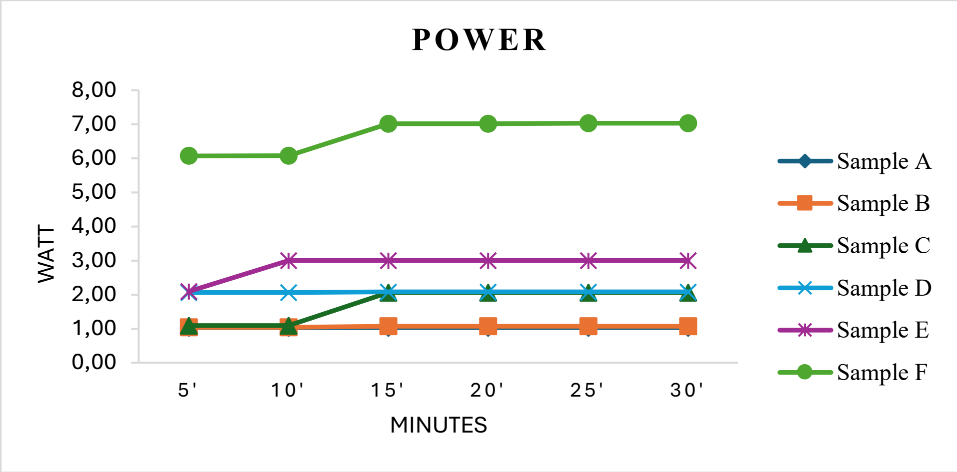


Figure 6. Comparison of electrolysis process power

4. CONCLUSION

Although the electrolysis results showed that coconut water performed better in terms of current, voltage, and gas productivity, the use of peat water still produced measurable electrolysis results. This evidence indicates that peat water has limited electrolyte potential. The organic and mineral content of peat water allows for electrochemical reactions, but not as efficiently as coconut water. Therefore, peat water has the potential to be used as an alternative, inexpensive, and abundant local electrolyte solution. However, further optimization, such as the addition of external electrolytes or pretreatment, is needed to increase its efficiency in the electrolysis process. Therefore, coconut water plays a significant role as an electrolyte supplement to produce hydrogen gas in the electrolysis process when combined with peat water.

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