The Effect Of NAOH Catalyst On Hydrogen Production Produced Through The Electrolysis Process Of Seawater From Mangrove Area

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Abstract

This research was conducted to examine the volume of hydrogen, hydrogen production rate and hydrogen yield produced through the electrolysis process of seawater from mangrove area with 0.5 M ,1 M, and 1.5 M of NaOH as catalyst. The process was carried out using copper electrodes at a voltage difference of 12 V and an interval of 20 minutes for each measurement of hydrogen volume which was determined using the water displacement method. The lifetime of the copper electrode was also analyzed to determine the resistance of the electrodes to corrosion caused by chlorine. The results showed that an addition of NaOH catalyst can increased the hydrogen production by the electrolysis process of seawater around mangrove areas and the optimal catalyst is NaOH 1 M, which produced 671.8 ml of total hydrogen gas in 1700 minutes. The use of seawater from mangrove areas in producing hydrogen through the electrolysis process in addition with NaOH as catalyst, provided an opportunity to extend the electrode lifetime, prevent corrosion, and also to produce more hydrogen as a source of clean and environmentally friendly energy, as well as to promote conservation and rehabilitation of mangrove.

Keywords: catalyst, hydrogen, mangrove, seawater

Introduction

Utilization of abundant seawater in producing hydrogen through the electrolysis process provides a significant advantage over using fresh water which is one of the main sources of human needs [1]. However, the use of seawater also has a weakness, namely the possibiity of corrosion problems on the electrodes due to the chlorine in the seawater. According to Anggaretno et. al. in Ref. [2] that the chlorine content in seawater can corrode electrodes in the electrolysis process, and it make the electrode will exprience a decrease in its effectiveness, so that the production of hydrogen resulted from the process of electrolysis will also decrease. As it is known that corrosion not only causes oxidation destruction of metal materials, but also degradation of non-metallic materials and affects the function's loss of those materials due to chemical interactions with the environment [3]. While research conducted by Kuang et.al in Ref. [4] shown that seawater electrolysis process with solar cell and without negatively charged coating on anode can sustain for 12 hour.

Meanwhile, research conducted by Tanasale in Ref. [5] and Aprilia et al. in Ref. [6] described that seawater can be desalinated naturally through mangroves. The natural desalination process by mangrove plants is much cheaper and conservative when compared to other seawater desalination methods. As it is known that mangroves need seawater content of Na and Cl for the photosynthesis process, so that the mangroves can be able to grow [7]. Also, research conducted by Rustana et.al in Ref. [8] shown that electrolysis process with seawater originated from mangrove areas could slow down the corrosion of electrodes by chlorine, but unfortunately the volume of hydrogen produced was very small compared to those produced by the electrolysis process of the seawater from non mangrove area. While, according to research conducted by Bow et. al in [9] shown that NaOH catalyst with lower concentration can increase hydrogen production by the electrolysis process of seawater.

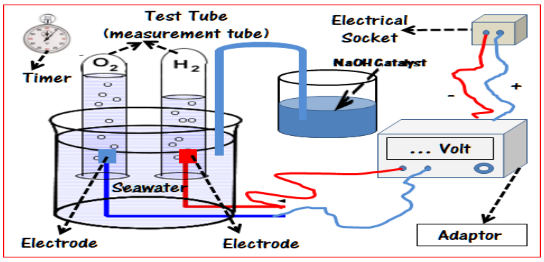
Departing from various research studies as described above, this research was developed to combine the use of seawater taken from mangrove area and the catalyst addition in order to develope a method in producing hydrogen through the electrolysis process that are more effective and efficiency. In this study, the productivity of hydrogen produced would be analyzed by comparing the total volume, production rate, and production time of hydrogen resulted through the electrolysis process of seawater originated from mangroves area with addition of various concentration of NaOH as catalyst. Furthermore, the lifetime of the electrode was also analyzed to determine the resistance of such electrode due to corrosion caused by chlorine contained by seawater..

Thus, through this research, we hope be able to optimally produce hydrogen through the electrolysis process of seawater more effective and efficient in order to provide alternatif energy which are not causing negative impacts on the environment and especially to the human. It can be understood because hydrogen is a renewable energy source that is clean and environmentally friendly (green energy)[10]. Meanwhile, the use of seawater from the mangrove plant area can simultaneously to promote the conservation and to protect the damage to the mangrove plantation area which has the potential to make organisms that live in such plant area be able adapt well [11] since mangrove areas is a habitat for flora and fauna, a place to live of various living things, as well as water storage, lungs of the world and disaster control. As stated by Nurhadi in Ref. [12] that launched from the Ministry of Maritime Affairs and Fisheries website, Republic of Indonesia concluded that mangrove plants have benefits such as preventing abrasion of seawater and the entry of soil into the sea: fishery habitats which have a broad impact in economic: preventing global warming and maintaining water and air quality: development of tourism area and sciences.

Research Method

The experiment equipment was set up as shown in Figure 1 (adapted from Rustana et. al., in Ref.[13], while the data of hydrogen production was determined by measuring the change of water level in the measuring tube before and after the electrolysis process with taken place various concentration of NaOH and within a certain time span. The difference in such water level in the measurement tube was then used to determine the volume of seawater before and after the electrolysis process that indicated the volume of hydrogen produced by the electrolysis process [14]. Furthermore, this data of hydrogen volume was then utilised to calculate the production rate and yield of hydrogen as well as the yield of hydrogen produced through the electrolysis process of seawater taken from area of mangrove plantation with various concentration of NaOH as catalyst. Quantitative descriptive analysis was applied to process and discuss the research results.

Figure 1 Electrolysis equipment arrangement schematic



NaOH catalyst which was added to the electrolysis process of seawater originated from mangrove area was in the form of a solution as described by Knozinger and Kochloefl in [15]. NaOH solution with a certain concentrationis was made up by dissolving a solid material of NaOH with distilled water with composition following the molarity formula stated by Saputro and Rangkuti in[16] on (1):

$$M = \frac{g}{Mr} \times \frac{1000}{mL} \qquad (1)$$

M = Concentration (mol/L atau M)

g = solid mass (gr)

mL = volume of distilled water

Mr = Molecule relative

The production rate of hydrogen resulted through the electrolysis process of seawater originated from mangrove area with addition of each concentration of NaOH was calculated using the following formula on (2)[17].

$$\text{Hydrogen Production Rate (ml/min)} = \frac{\text{Volume of hydrogen(ml)}}{\text{Measurement Time(t)}} \qquad (2)$$

Meanwhile, hydrogen yield which is the percentage of resulted hydrogen was calculated by comparing the volume different of hydrogen produced at the begining and at the end of the electrolysis process divided by the total volume of hydrogen produced during the electrolysis process, as follows on (3):

$$\frac{\text{measured gas volume} - \text{previous gas volume}}{\text{total volume}} \times 100\,\% \qquad (3)$$

Furthermore, the lifetime of electrode that shown the resistance of such electrode to corrosion of chlorine can be observed by totalling the time of the electrolysis process of seawater taken from the mangrove area with a certain concentration of NaOH from beginning to the end the electrolysis process when such process was stopped or no more hydrogen was produced.

Results and Discussion

Figure 2 shown the total volume of hydrogen produced at a certain time span of the electrolysis process of seawater taken from mangrove plant areas with various concentration of NaOH (0.5 M, 1 M and 1.5 M). The result indicated that the total volume of hydrogen (335.7 ml) was resulted through the electrolysis process with an addition 0.5 M of NaOH as a catalystvof for duration time of 1300 minutes. However, the addition of 1 M of NaOH to such electrolysis process produced a total volume of hydrogen of 671.8 ml for 1700 minutes of the process . while, a total volume of hydrogen (650 ml) was resulted by adding 1.5 M of NaOH when the process of electrolysis in progressing for 1000 minutes. These results shown that addition of NaOH as catalys to the electrolysis process of seawater taken from mangrove areas would increased total volume of produced hydrogen was higher compared to those total volume of hydrogen as resulted using ordinary seawater which was not from mangrove areas [8]. While, the addition of NaOH with 1 M concentration produced a total volume of hydrogen was higher compared to those other concentration of NaOH as mentioned in researched conducted by Yingpu Bi & Gongxuan Lu in [18] that NaOH catalyst with concentration 1 M can produce more hydrogen than other concentration and more longer time of the use of electrodes as shown by figure 4.

Fig. 2 Graph of total volume of produced hydrogen versus time

of the electrolysis process for each variation concentration of NaOH

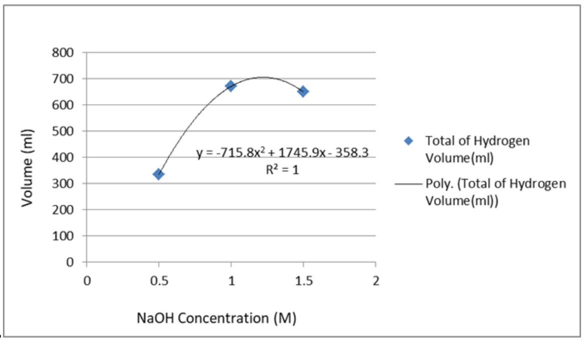


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Fig.3 Graph of hydrogen volumeversus measurement timeof the electrolysis process for each concentration of NaOH.

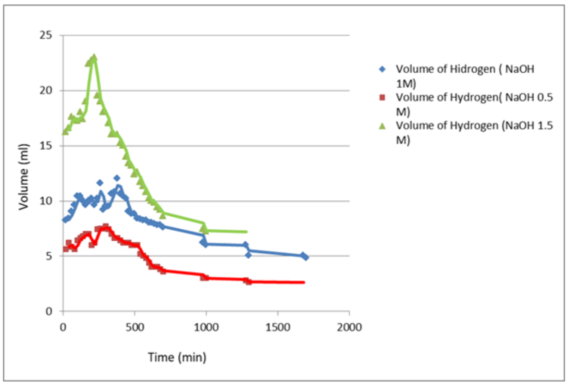
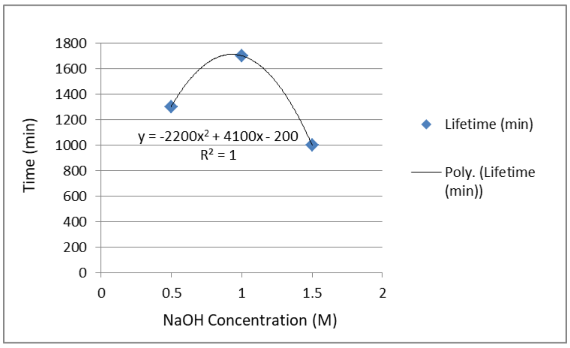


Figure 3 shown that the highest volume of hydrogen produced through the electrolysis process of seawater from around the mangrove area with 1.5 M of NaOH were faster achieved than to the electrolysis process with other NaOH concentration such as 0,5 M and 1 M. Furthermore, the figure 3 also indicated that the hydrogen volume was rapidly decreased till no more hydrogen was resulted or the process was stopped when the electrolysis process with 1,5 M of NaOH reaching 1000 minutes. This result was different compared to the trend of increasing and decreasing of hydrogen volume produced by the electrolysis process with 0.5 and 1 M of NaOH. The total volume of hydrogen (650 ml) was resulted by the electrolysis process with 1.5 M of NaOH for a total time of 1000 minutes. It was less compared to the total volume (671.8 ml) but higher than the total volume of hydrogen (335.7 ml) produced respectively by the electrolysis process with 1 M of NaOH for a total time of 1700 minutes and 0.5 M of NaOH for a total time of 1300 minutes.

A quadratic tendency with R^2=1 as shown in figure 4 described the effect of different concentration of NaOH versus the lifetime of electrodes which indicated the resistance of the electrodes to corrosion caused by chlorine. The shortest lifetime (1000 minutes) for using the electrode occurs in the electrolysis process with concentration of NaOH (1.5 M). It was less than the lifetime of electrodes used in the electrolysis process with respectively 0.5 of NaOH (1300 minutes) and 1 M of NaOH (1700 minute). It meant that the addition of NaOH with 1 M was the best to slow down the corrosion process of electrodes by chlorine in the electrolysis process of seawater taken from area of mangrove plant and more better than research conducted by Slama in [19] and Kuang et.al in [4] which only 17 hours or 1020 minutes and 12 hour sustain from corrosion effect with copper electrode.

Fig. 4 The effect of different concentration of NaOH versus the lifetime of electrodes



The production rates of hydrogen generated through the electrolysis process of seawater originated from mangrove plants area with a certain concentration of NaOH and for each time of measurement were shown in Figure 5. A lowest hydrogen production rate of 0.26 ml/minutes was generated from electrolysis process of seawater that was originated from mangrove areas with 0.5 M of NaOH for 1300 minutes. While, the highest hydrogen production rate (0.65 ml/minute) was produced by the electrolysis process with 1.5 M of NaOH for 1000 minutes. It was higher than the production rate of hydrogen resulted from the electrolysis process with 1 M of NaOH such as 0.40 ml/minutes for 1700 minutes. Combination of the seawater taken from magrove plants area and NaOH as catalyst was be able to increase the total production rate of hydrogen in the electrolysis process. It was in agreement with Frydendal in Ref.[20] who stated that a reaction including electrolysis could run faster by adding more catalyst. However, the addition of catalyst could possibly to decrease the total volume of hydrogen and the lifetime of electrodes as shown in both Figure 1 and 3. Figure 6 indicated the graph of hydrogen production rate for every 20 minutes of measurement. The highest hydrogen production rate was achieved through the electrolysis process with 1.5 M of NaOH prior to rapidly decreasing as shown in Figure 6. It could be understood that more catalyst was added to the electrolysis process of seawater, it would made more difficult for the ions in electrolyte solution for moving and causing the hydrogen production was stopped since the electrodes was corroded by chlorine contained in the seawater [21].

Fig.5 Graph of the total production rate of hydrogen for various concentration of NaOH.

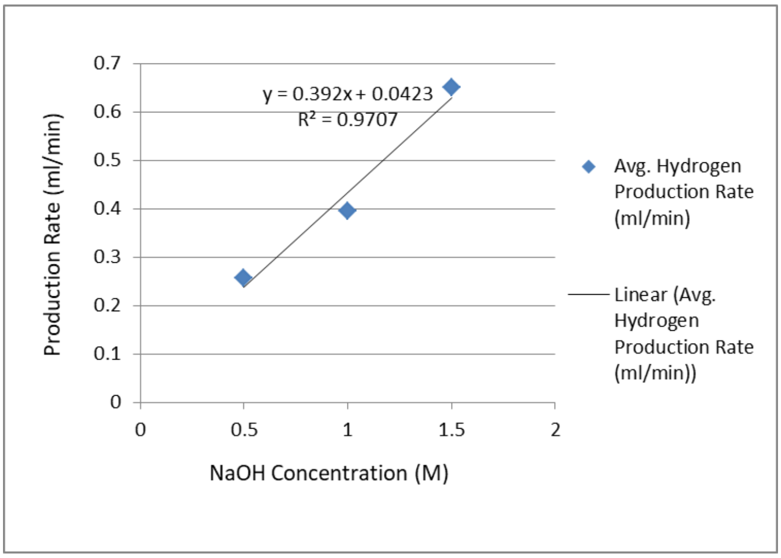


Fig.6 Graph of hydrogen production rate versus time measurement for various concentration of NaOH

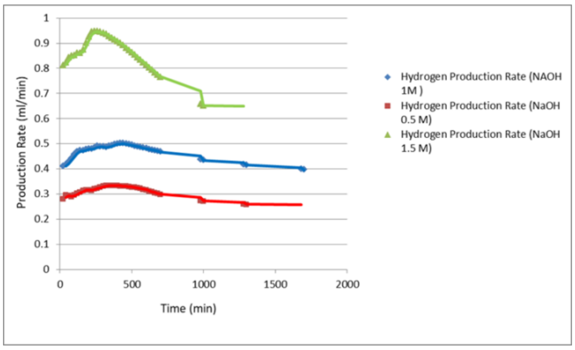


Figure 7 and 8 shown respectively the effect of NaOH concentration and the correlation of time for each 20 minutes measurement to the total yield of hydrogen . The electrolysis process of seawater taken from mangrove plants area with an addition of 0.5 M of NaOH produced 2.29 % of hydrogen yield. While, the lowest of hydrogen yield (1.78 %) was resulted through the electrolysis process with 1 M of NaOH. It was less than total yield of hydrogen (3.54 %) achieveing through the electrolysis process with 0.5 and 1.5 M of NaOH. The electrolysis process with 1.5 M of NaOH reached the highest hydrogen yield faster compared to the use of other NaOH concentration. However, the hydrogen yield of the electrolysis process with 1.5 M of NaOH decreased rapidly after reaching such highest value compared to those other concentration of catalyst and the hydrogen production was also stop faster than the electrolysis process with both other concentration.

Fig.7 Graph of the total hydrogen yield versus various concentration of NaOH

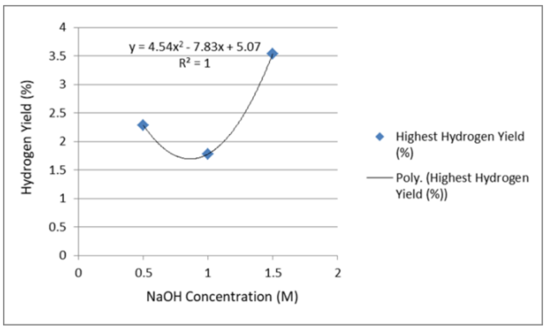
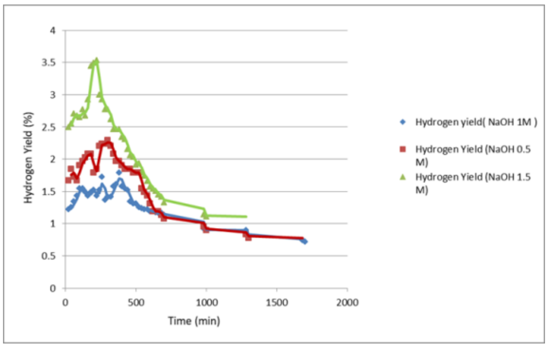


Fig.8 Graph of Hydrogen Yield versus time measurement for various concentration of NaOH



Conclusion

Based on analysis result of the data obtained in this study, it was concluded that the use of various concentration of NaOH as catalyst be able to increase the total volume of hydrogen generated through the electrolysis process of seawater taken from the area ofmangrove plants. The highest total volume of hydrogen andthe longer lifetime of electrolysis were achieved through the electrolysis process with 1 M of NaOH, Although it does have the lowest yield and production rate of hydrogen compared to 0.5 M and 1.5 M of NaOH, but the use of 1 M NaOH was be able to slow down corrosion of electrodes because of chlorine contained in the seawater.

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