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By Department of Chemistry, Sriwijaya University

IJFAC (Indonesian Journal of Fundamental and Applied Chemistry)

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IJFAC (Indonesian Journal of Fundamental and Applied Chemistry) is an international peer-reviewed scholarly journal in the field of chemistry. Commenced in February 2016 by Department of Chemistry, Faculty of Mathematics and Natural Sciences, Sriwijaya University, Indonesia, IJFAC publishes three times annually (February, June, October).

IJFAC aims to publish refereed, high-quality scientific papers in form of original research papers, reviews, and short communications for the dissemination of knowledge and advancement of chemistry as a branch of science. The journal welcomes the submission of articles in **biochemistry, inorganic chemistry, physical chemistry, organic chemistry, analytical chemistry, and applied chemistry**. Articles which describe a novel theory and its application are welcome, as are those which illustrate the transfer of techniques from other disciplines.

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Focus and Scope

Indonesian Journal of Fundamental and Applied Chemistry (IJFAC) is an an international research journal and invites contributions of original research articles as well as review articles in several areas of chemistry. The journal aims to publish refereed, high-quality research papers with significant novelty and short communications in all branches of chemistry. Papers which describe novel theory and its application to practice are welcome, as are those which illustrate the transfer of techniques from other disciplines.

IJFAC calls for papers that cover the following fields:

Inorganic Chemistry field received articles in the area of fundamental studies in all phases of inorganic chemistry. Coverage includes experimental and theoretical reports on quantitative studies of structure and thermodynamics, kinetics, mechanisms of inorganic reactions, bioinorganic chemistry, and relevant aspects of organometallic chemistry, solid-state phenomena, and chemical bonding theory.

Organic chemistry field received articles from the entire spectrum of synthetic organic, bioorganic, physical-organic chemistry, and natural products.

Biochemistry field received articles in a range of scientific disciplines, including genetics, microbiology, forensics, plant science and medicine which was studying components like proteins, lipids and organelles.

Physical chemistry received articles in a broad scope which includes spectroscopy, dynamics, kinetics, statistical mechanics, thermodynamics, electrochemistry, catalysis, surface science, quantum mechanics and theoretical developments. Interdisciplinary research areas related with physical chemistry are welcomed.

Analytical chemistry received articles new and original knowledge in all branches of analytical chemistry. Articles may be entirely theoretical with regard to analysis, or they may report experimental results. They may contribute to any phase of analytical operations, including sampling, bioanalysis, electrochemistry, mass spectrometry, microscale and nanoscale systems and structures, environmental analysis, separations, spectroscopy, chemical reactions and selectivity, instrumentation, imaging, surface analysis, and data processing. In this term, environmental chemistry is included.

Applied chemistry area received articles inter-disciplinary chemistry and related field with the application of scientific discoveries and advancements in chemical and biological technology that aim towards economically and environmentally sustainable industrial processes.

Section Policies

Articles

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Peer Review Process

All manuscripts are subject to peer review and are expected to meet standards of academic excellence. If approved by the editor, submissions will be considered by double-blind peer-reviewers, whose identities will remain anonymous to the authors. If your article is based on a conference article which may have been published elsewhere, it is important that you observe the following:

The submitted article must have been substantially revised, expanded and rewritten so that it is significantly different from the conference paper or presentation on which it is based. The article must be sufficiently different to make it a new, original work. As a guide, you should aim to have more than 50% new material. This is a matter of judgment and will be based on a comparison of the submitted article with the original conference paper.

The original conference article should be supplied by the author of the expanded article for the purpose of comparison. All such articles will be subject to the same review process as any other submitted article. Please include the statement '*This article is a revised and expanded version of an article entitled [title] presented at [name location and date of conference]*' in the online system when you submit your article, using the "Notes for the Editor" field.

If the original conference article on which the extended article is based has been published elsewhere, or the copyright has been assigned to the conference organizers or another party, authors should ensure that they have cleared any necessary permissions with the copyright owners. Articles will not be accepted, post-review, for publication unless such written permissions have been provided along with author copyright forms.

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Design of Dry Cell HHO Generator using NaCl Solution for Hydrogen Production

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Abstract

Excessive use of electricity produces emissions, as well as carbon will have impact on global warming because electricity mostly still using fossil-based energy. Usage of other alternative energy is beneficial to reduce dependence on the use of fossil fuels. Researchers are currently working to reduce the use of fossil energy by using renewable energy. Among the most common alternative energies found is water, so this research focuses on designing dry cell type HHO (Hydrogen Hydrogen Oxygen) Generator technology with hydrogen gas water electrolysis. The HHO generator functions to break water (H_2O) into hydrogen atoms and oxygen atoms, known as HHO. Electrolysis testing using NaCl and a storage tube to see the rise and fall of water from the gas produced. NaCl used weighing 20 grams, 50 grams, 75 grams, and 100 grams dissolved in 500 cc of water. The results of the data obtained, many uses of NaCl produce hydrogen gas faster, the data shows 100 grams of NaCl at 180-210 seconds produces a gas volume of 175 CC compared to 20 grams produces a gas volume of 75 CC, 50 grams produces 125 CC, and 75 grams produces 150 CC.

Keywords: Renewable Energy, HHO Generator, Dry Cell, Hydrolysis, Oxyhydrogen

Abstrak (Indonesian)

Peningkatan penggunaan listrik yang berlebihan dapat menghasilkan emisi, dan juga karbon akan berdampak pada pemanasan global karena listrik sebagian besar masih menggunakan energi berbasis fosil untuk itu penggunaan energi alternatif lain bermanfaat untuk mengurangi ketergantungan terhadap penggunaan bahan bakar fosil. Para peneliti saat ini sedang berupaya untuk mengurangi penggunaan energi fosil dengan menggunakan energi terbarukan. Di antara energi alternatif yang paling banyak ditemukan adalah air, maka penelitian ini berfokus pada perancangan teknologi Generator HHO (Hidrogen Hidrogen Oksigen) tipe sel kering dengan elektrolisis air gas hidrogen. Generator HHO berfungsi untuk memecah air (H_2O) menjadi atom hidrogen dan atom oksigen yang dikenal dengan HHO. Pengujian elektrolisis menggunakan NaCl dan tabung penyimpan untuk melihat naik turunnya air dari gas yang dihasilkan. NaCl yang digunakan seberat 20 gram, 50 gram, 75 gram, dan 100 gram dilarutkan dalam 500 cc air. Hasil data yang didapat, banyak penggunaan NaCl menghasilkan gas hidrogen lebih cepat, data menunjukkan 100 gram NaCl pada 180-210 detik menghasilkan volume gas 175 CC dibandingkan dengan 20 gram menghasilkan volume gas 75 CC, 50 gram menghasilkan 125 CC, dan 75 gram menghasilkan 150 CC.

Kata Kunci: Energi Terbarukan, Generator HHO, Dry Cell, Hydrolisis, Oxyhidrogen

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INTRODUCTION

Energy has become a basic human need in everyday life and researchers continue to strive to produce energy conversion methods that are more efficient and environmentally friendly. Most of the electricity still uses fossil-based energy such as oil, gas, and coal, negatively impact such as air pollution, greenhouse gas. Therefore, the use of other alternative energy is very helpful to reduce the adverse effects of using fossil fuels [1-4]. Therefore, scientists must continue to conduct research to find renewable energy sources to overcome the problem. This new energy is called renewable energy. Among these alternative energies are solar energy, air potential energy, biomass

energy and wind energy. One of the energy sources that can be used and most abundantly available is water [5-8].

Water can be used as a hydroelectric power plant (PLTA) and can also be used to produce hydrogen gas through the electrolysis of water [9]. Hydrogen is the most abundant element found on earth even though it is in the form of a compound because hydrogen has the advantage that it can be easily applied to replace hydrocarbon fuels without changing the structure, generates high heat, is environmentally friendly and does not produce toxic emissions [10-12]. However, the use of hydrogen also has a weakness, namely hydrogen is difficult to store safely, so in this study using safety equipment such as a hydrogen flashback arroster and a one-way valve.

Electrolysis of water is a process of decomposition of water compounds (H_2O) into oxygen O_2 and hydrogen gas (H_2) by using an electric current flowing through the water [13]. The factors that affect the electrolysis of water are the use of a catalyst, the quality of the electrolyte, temperature, pressure, and the material of the HHO generator used [14-16].

The rate of chemical reactions in the electrolysis of water, a catalyst is needed. from previous studies used various types of catalysts containing elements of acid and base compounds, such as the catalyst used in this study, namely NaCl (Sodium Chloride) which is another name for salt which belongs to the strong electrolyte group. [17]. The electrolytic process also requires electrodes that function as a medium for conducting electric current from an energy source (battery) with a DC current to the electrolyte solution. The electrode has an anode pole (positive) and a cathode pole (negative) which is arranged in the HHO Generator circuit [18]. The electrode flow equation is shown below:

Anode : $2\ OH^- \rightarrow \frac{1}{2}\ O_2 + H_2O + 2\ e^-$ (1)

Cathode : $2\ H_2O + 2\ e^- \rightarrow H_2 + 2\ OH^-$ (2)

Total reaction : $H_2O \rightarrow H_2 + \frac{1}{2}\ O_2$ (3)

This tube serves as a separator between water and gas, where the gas produced will go to the bottom of the tube surface and produce air bubbles filled with *Oxyhydrogen* gas.

In this article, we will discuss the effect of variations in the weight of NaCl solution of 20, 50, 75 and 100 grams on the amount of gas produced using a dry cell type HHO generator made of stainless steel and to determine the effect of variations in the size of NaCl solution on the time of production of oxyhydrogen gas in the form of air bubbles at reservoir tube.

Dry Cell Type HHO Generator

HHO Generator (Hydrogen Hydrogen Oxygen) is a tool that functions to produce HHO gas using a water electrolysis system. The gas produced from the electrolysis of water is hydrogen and oxygen gas, with a composition of 2 hydrogen and 1 oxygen [19], [20]. The equation for the flow of these water compounds can be seen below:

$$2H_2O \rightarrow 2H_2 + O_2 \quad (4)$$

The advantages of using a dry cell type HHO generator are [21]:

1. The water in electrolysis is only necessary, that is, only water is trapped between the cell plates.
2. That heat generated is relatively small, because there is always circulation between hot and cold water in the reservoir.
3. The electric current used is relatively smaller, because less power is converted into heat.

In this study, water will be mixed with NaCl (as a catalyst) and charged with positive (+) and negative (-) electricity.

MATERIALS AND METHODS

Materials

The manufacture of HHO generators in this study are:

1. Stainless steel plate (2mm thick)
2. Acrylic seat (10mm thick)
3. Seal seat (2mm thick)
4. M10 and bolts the nut
5. Hose Connector
6. Pneumatic hose

The size of the cathode plate, anode and neutral plate is 100 mm x 100 mm for 2 pieces of cathode plate and 1 piece of anode. The top left is as the anode plate, and on the right side that is not cut, a hole of 10 mm is made as a place for the entry of the bolt to drain the positive current from the battery. Next, cut the upper right side as a cathode plate, make a hole on the left side that is not cut by 10 mm as a place for the entry of the bolt to drain the negative current from the battery.

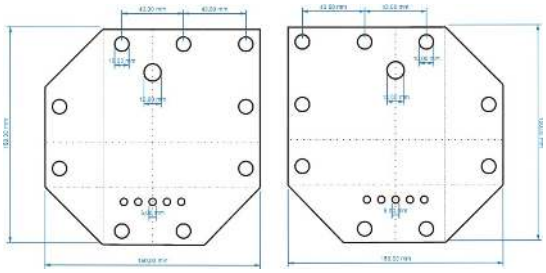

Figure 1. Design of anode and cathode plates

Making 8 neutral plates. The size of the plate and the size of the holes on the neutral plate are the same as the anode and cathode plates, what distinguishes the neutral plate is that the top of the left and right sides of the plate are cut. Cutting both sides aims to avoid a direct connection of the neutral plate with the anode and cathode plates.

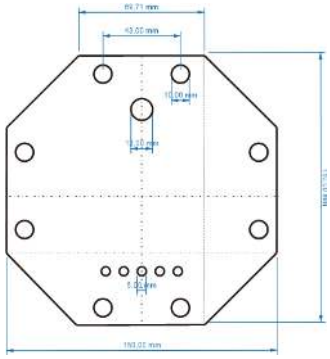

Figure 2. Design of neutral plate

In the manufacture of the casing that functions as a layer of the HHO generator plate using acrylic with a thickness of 10 mm.

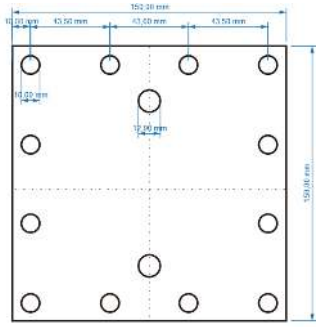

Figure 3. Design of Casing Plate

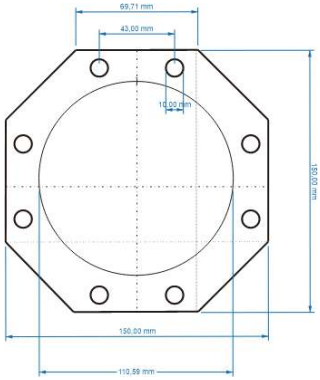

Figure 4. Design of seal rubber

Rubber seals are used on tools to avoid gas leaks in the HHO generator. Install the anode plate on the acrylic, make a hole in the top side with bolts and fasten it using a nut, install the seal by positioning it above the anode plate then install 4 neutral plates, each plate is limited by a rubber seal and so on, install the cathode plate by inserting the bolt holes on the opposite side of the anode plate. After the cathode plate is installed, proceed with the installation of the neutral plate and interspersed with 4 rubber cells on each neutral plate, and ending with the anode plate, tighten the nut 10 on the outer side of the acrylic.

All parts that have been made according to the design, then need to be compiled into a single unit in the form of an HHO generator.

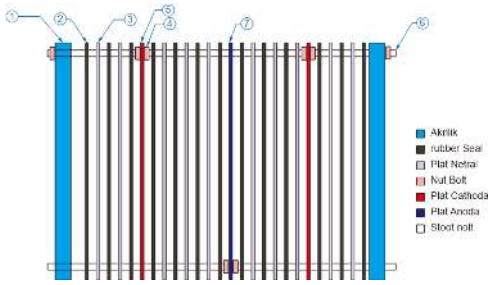

Figure 5. HHO generator

HHO Generator Testing Process

The generator testing process was carried out for 240 seconds in each measurement experiment with the addition of salt as a catalyst to accelerate the reaction with the steps below:

1. Setting up the volume control tube by filling with water.
2. Prepare a battery with a rated voltage of 12 volts 10 amperes.
3. Fill the reservoir with water that has been dissolved in NaCl with various sizes of 20 grams, 50 grams, 75 grams, and 100 grams.
4. Connect the generator to the battery and prepare a stopwatch to see the hydrogen bubble reaction that occurs in the HHO generator in the form of hydrogen gas bubbles at the cathode (-) and mixed with oxygen gas bubbles at the anode (+) carried away from the water circulation process which is electrolyzed in the HHO generator, to the bubble tube which makes Browns gas bubbles. Then the gas in the bubble tube fills the tube space, at that time the browns gas will press in to meet the water volume control tube A which contains water which is pressed by gas to move to the water control volume tube B.
5. Measuring the height of the water compressed by hydrogen gas

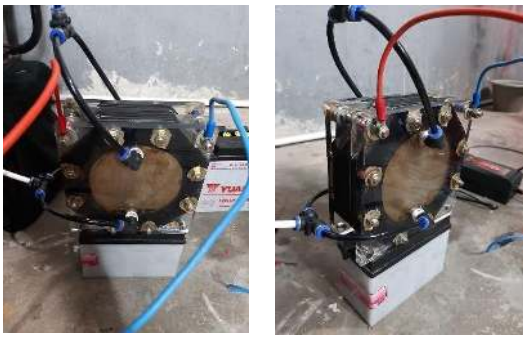

Figure 6. Generator of HHO

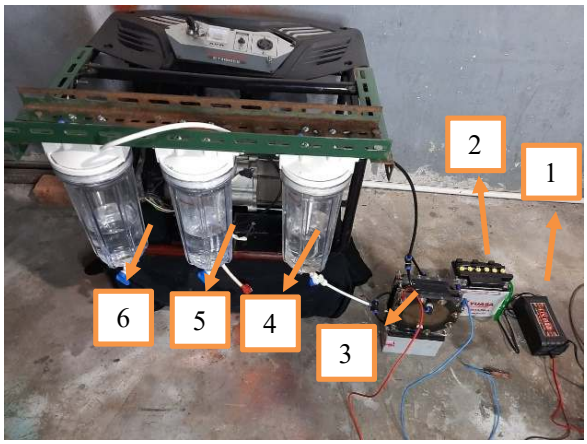

Figure 7. HHO Generator Installation

Caption:
1. Charging battery
2. Battery
3. HHO Generator
4. Bubble Gas Reservoir Tube
5. Water Tube A
6. Water Tube B

RESULT AND DISCUSSION

Electrolysis test 500 cc of water and 20 grams of NaCl

The hydrolysis test uses 500 cc of water and 20 grams of salt with a battery source of 10 Ampere current and 12 Volt voltage. However, using a variety of catalysts using NaCl of 20, 50, 75, and 100 grams. It can be seen in Table 1. This is the result of a hydrolysis test using 20 grams of NaCl, it can be seen that it takes 30-60 seconds to produce bubbles. The bubbles containing HHO gas will press the water in tube A. It can be seen from the fluid flow in tube A that it becomes 475 so that in tube B the fluid pressure is 525 cc. by producing a gas volume of 25 cc. At the time of testing 120-180 seconds produces a gas volume of 75 cc, however, at a time of 180-240 seconds the gas volume does not change.

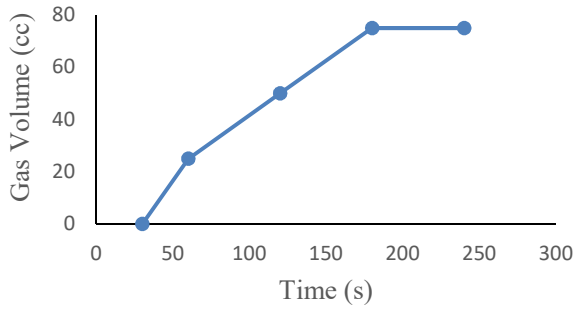

Figure 8. The Result of Hydrolysis Test 500 cc of water and 20 Grams of NaCl

Table 1. Analysis results of hydrolysis tests eith 500 cc of water and 20 grams of NaCl

Tube Control Volume (cc)		Gas Vol (cc)	Current (Amp)	Voltage (V)	Time (s)	Temperature (°C)
A	B					
500	500	0	10	12	0-30	30
475	525	25	10	12	30-60	30
450	550	50	10	12	60-120	31
425	575	75	10	12	120-180	34
425	575	75	10	12	180-240	36

Electrolysis test with 500 cc of water and 50 grams of NaCl

Hydrolysis testing using 500 cc of water and 50 grams of salt with a battery source of 10 Ampere current and 12 Volt voltage at 0-30 seconds has produced bubbles. The bubbles containing HHO gas will press the water in tube A. This can be seen from the fluid flow in tube A to 475 so that in tube B the fluid pressure of 525 cc produces a gas volume of 25 cc. At a time of 30-60 seconds the test produces a gas volume of 50 cc, however, at a time of 120-150 seconds the gas volume

produces a gas volume of 125 cc until a time of 240 seconds the gas volume still produces 125 cc. It can be seen in Table 2.

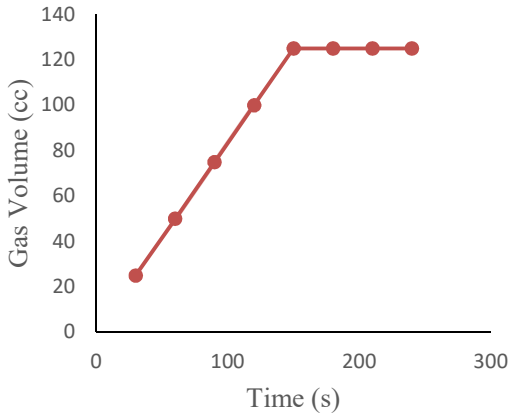

Figure 9. Hydrolysis Test Results With 500 cc of Water and 50 Grams of NaCl

Hydrolysis test with 500 cc of water and 75 grams of NaCl

The results of the hydrolysis test using 500 cc of water and 75 grams of salt with a battery source of 10 Ampere current and 12 Volt voltage at 0-30 seconds have produced bubbles. The bubbles containing HHO gas will press the water in tube A. This can be seen from the fluid flow in tube A to 475 and in tube B the fluid pressure is 525 cc, the largest gas volume is 150 cc. Can be seen in Table 3. At a test time of 30-60 seconds it produces a gas volume of 50 cc, however, at a time of 90-120 seconds a gas volume produces a gas volume of 100 cc up to 120-150 seconds a gas volume produces 125 cc, and at a time of 150-180 seconds a gas volume increased to 150 cc. at 180-240 seconds the volume of gas does not change.

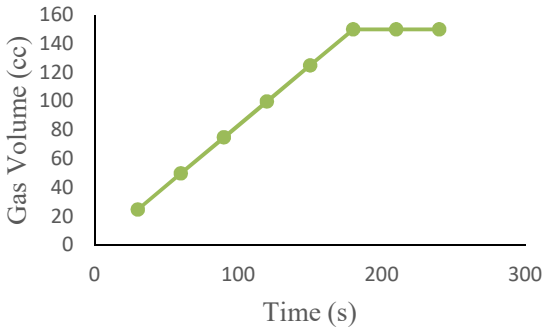

Figure 10. Hydrolysis Test Results With 500 cc of Water and 75 Grams of NaCl

Table 2. Analysis Results of Hydrolysis Tests With 500 cc of Water and 50 Grams of NaCl

Tube Control Volume (cc)		Gas Vol (cc)	Current (Amp)	Voltage (V)	Time (s)	Temperature (°C)
A	B					
475	525	25	10	12	0-30	30
450	550	50	10	12	30-60	30
425	575	75	10	12	60-90	31
400	600	100	10	12	90-120	32
375	625	125	10	12	120-150	34
375	625	125	10	12	150-180	38
375	625	125	10	12	180-210	40
375	625	125	10	12	210-240	41

Table 3. Analysis Results of Hydrolysis Tests With 500 cc of Water and 75 Grams of NaCl

Tube Control Volume (cc)		Gas Vol (cc)	Current (Amp)	Voltage (V)	Time (s)	Temperature (°C)
A	B					
475	525	25	10	12	0-30	30
450	550	50	10	12	30-60	30
425	575	75	10	12	60-90	31
400	600	100	10	12	90-120	32
375	625	125	10	12	120-150	35
350	650	150	10	12	150-180	39
350	650	150	10	12	180-210	42
350	650	150	10	12	210-240	44

Hydrolysis test with 500 cc of water and 100 grams of NaCl

The results of the hydrolysis test using 500 cc of water and 100 grams of salt with a battery source of 10 Ampere current and 12 Volt voltage at 0-30 seconds have produced bubbles or bubbles so that the pressure in the form of hydrogen as seen from the fluid flow in tube A becomes 475 so that at tube B fluid pressure of 525 cc to produce a gas volume of 25. Can be seen in Table 4.

It can be seen in Table 4 that the results of the hydrolysis test using 500 cc of water and 100 grams of salt with a battery source of 10 Ampere current and 12 Volt voltage at 0-30 seconds have produced bubbles or bubbles so that the pressure in the form of hydrogen is seen from the fluid flow in tube A. to 475 so that in tube B the fluid pressure is 525 cc and produces a gas volume of 25 cc.

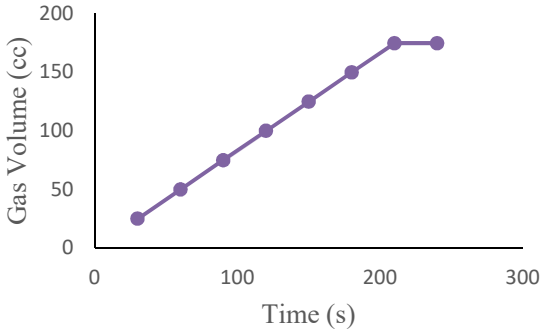

Figure 11. Hydrolysis Test Results With 500 cc of Water and 100 grams of NaCl

Table 4. Result Analysis of Hydrolysis Test Using 500 cc of Water and 100 Grams of NaCl

Tube Control Volume (cc)		Gas Vol (cc)	Current (Amp)	Voltage (V)	Time (s)	Temperature (°C)
A	B					
475	525	25	10	12	0-30	30
450	550	50	10	12	30-60	30
425	575	75	10	12	60-90	32
400	600	100	10	12	90-120	34
375	625	125	10	12	120-150	37
350	650	150	10	12	150-180	40
325	675	175	10	12	180-210	42
325	675	175	10	12	210-240	45

At a test time of 30-60 seconds it produces a gas volume of 50 cc, however, at a time of 90-120 seconds a gas volume produces a gas volume of 100 cc up to 120-150 seconds a gas volume produces 125 cc, and at a time of 150-180 seconds a gas volume increased to 150 cc. at 180-210 the volume of gas produced is 175 cc. At 210-240 seconds the volume of gas does not change. The results of this test can be seen in Figure 10.

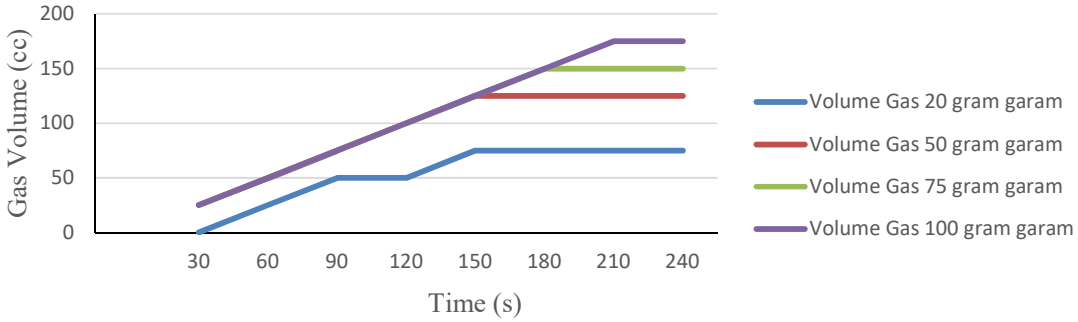

Figure 12. The results of the salt variation test of 20, 50, 75, and 100 grams of the hydrolysis process

CONCLUSION

Based on the research that has been done, there are 33 measurements in 1 day producing measurement data. The resulting measurement results can be concluded that from the level of the catalyst in the form of salt and its variations affect the results of the volume

of gas produced and will stop at the point where the level of Hydrogen is hydrolyzed, it can be seen that the more use of NaCl 100 grams produces hydrogen gas faster than 20 grams of NaCl which used, and the largest temperature in this study was 45 minutes which occurred when conducting experiments using 100 grams of NaCl, it proved the generator temperature would increase rapidly along with the greater number of grams of NaCl mixed in the hydrolysis process.

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