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The Increase Voltage Effect of The Interface Bipolar Plate to Increase H_2/O_2 Production Volume as Alternative Fuel

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ABSTRACT

Renewable fuels hold the key to the increasing energy demand and environmental issues. In recent years, the installed capacity of renewable energy sources has experienced rapid growth based on limited remaining oil reserves. Applying hydrogen/oxygen as fuel in combustion engines is possible. Hydrogen (H_2) which burns with Oxygen (O_2) in the combustion chamber, will produce H_2O compounds that are environmentally friendly. In this study, we wanted to see the effect of increasing the voltage of the interface bipolar plate to increase the H_2 and O_2 gas molecules volume. The experimental results show that the breaking of bonds in water compounds which utilize the interaction force between fields and charges, has been affected by an increase in voltage. The time to convert the H_2O compound into H_2/O_2 gas molecules decreases with the increasing voltage between interfacing electrodes. The voltage increase affects the *Volumetric Flow Rate* (VFR) of H_2 dan O_2 gas molecules. This study also shows that when a voltage of 10 Volts is applied at the electrode interface, charge transport occurs optimally.

Keywords: *Hydrogen/Oxygen, Fuel, Voltage, Volume.*

INTRODUCTION

Renewable fuels are vital to environmental issues parallel with the increasing energy demand. The fossil of conventional fuels crisis and the rapid development of society and industrialization aggravate the shortage of resources such as oil, coal, and natural gas [1,2]. Humans' lives have been threatened by irreversible environmental effects caused by the combustion of conventional fossil fuels, including air pollution, global warming, and climate change [3–5].

The installed capacity of renewable energy sources in recent years has experienced rapid growth compare on remaining limited oil reserves [6]. Fuel cells have a wide application, including vehicles, stationary power generation, and portable equipment. Fuel cells are a promising clean energy device due to their high-energy efficiency [7–9]. There is no other Hydrogen/Oxygen combustion byproduct except the water as the only [10].

Using fuel cells for electric vehicles provides an excellent opportunity to obtain a hybrid source of electrical energy. Electrical energy can be supplied from a charging battery embedded in the vehicle and from a portable fuel cell dispenser application [11]. However, using fuel cells for motorized vehicles provides a slight solution but raises new, more significant problems. Vehicles based on internal combustion engines, which have the majority of the world's population, ranging from cars, motorcycles, trucks, buses, and trains, to factory machines, must be converted to electric motors so they can use fuel cells. The costs that must be incurred to convert these machines are the same as those that must be incurred to overcome the environmental impact due to the waste they generate [12]. For this reason, making Hydrogen/Oxygen as fuel for internal combustion engines is the best solution that makes more sense to overcome the current fossil energy crisis [13].

Using Hydrogen/Oxygen as fuel in combustion engines is possible. Hydrogen (H_2) which burns with oxygen (O_2) through the ignition process in the combustion chamber, will follow the following chemical reaction equation:

$$2H_2 + O_2 \rightarrow (combustion) \rightarrow 2H_2O \qquad (1)$$

From the results of this combustion, environmentally friendly water will be obtained without carbon emissions.

Using commercial hydrogen as a fuel source is not very economical, even though oxygen can be obtained directly from the environment, because the price of hydrogen is high, and the handling costs are not cheap [14].

Water is a polar compound of two hydrogen atoms covalently bonded to one oxygen atom (Figure 1). The two hydrogen atoms are charged positively, and the oxygen atom is charged negatively, forming some dipole moments [15,16]. Due to this dipole, the attractive force between water atoms makes each molecule close to the other.

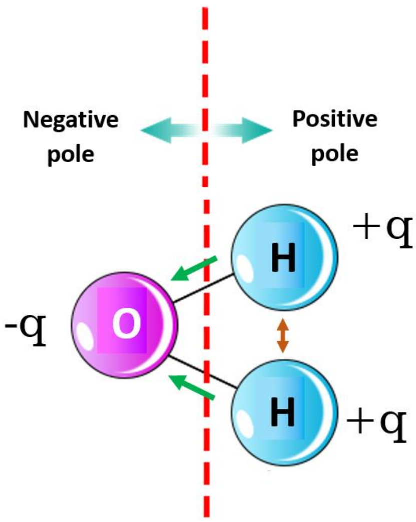

Figure 1. Water is a polar compound of two hydrogen atoms and one oxygen atom.

This compound can be used as an alternative hydrogen source by breaking the bonds between hydrogen and oxygen atoms. The most common way to break them apart into separate molecules is through electrolysis (Figure 2) [17].

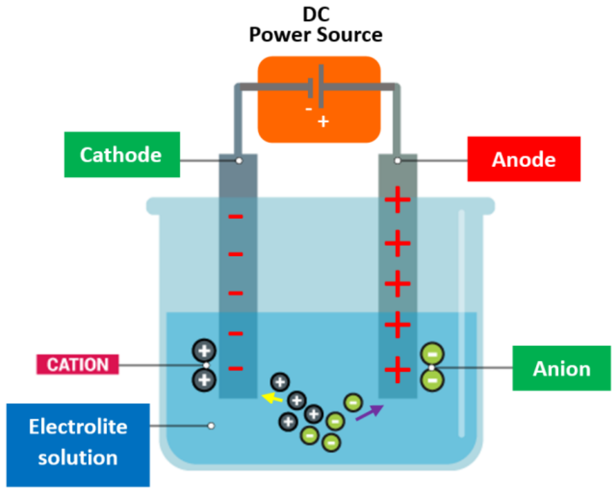

Figure 2. Electrolysis Process.

This electrolysis process uses two electrodes connected to a *Direct Current* (DC) electric power source [18,19]. The two interface electrodes are immersed in a container filled with water (H_2O) and then connected to a source of electric voltage. At the cathode (positive electrode) are formed O_2 molecules, and at the anode (negative electrode) are formed H_2 molecules, accompanied by a current flowing between the two electrodes. This reaction follows the chemical equation:

$$2H_2O \rightarrow (electrolysis) \rightarrow 2H_2 + O_2 \qquad (2)$$

These Hydrogen/Oxygen molecules form a gas phase on the electrode surface. So that it appears the bubbles that gather and enlarge, then rise to the surface [20].

The electrolysis process is considered inefficient for producing Hydrogen/Oxygen gas. The gas produced is not proportional to the electrical power used. To produce one kg of hydrogen, which stores 33.6 kWh of energy, approximately 53 kWh of electricity is required [21]. In addition, the value of the electrical resistance water possesses will cause energy loss. It causes the temperature to increase at both the electrodes and the water medium.

The interfaced plate polarization method is believed to be more efficient and effective in breaking Hydrogen/Oxygen bonds in water compounds [22–25]. The electric field will produce a pulling force and a pushing force against the charges of the H and O atoms simultaneously. So, it is expected that the production of H_2 can be more. In this study, we wanted to see the effect of increasing the voltage on the rapidity of breaking H_2O bonds into H_2 and O_2 gas molecules.

1. METHODOLOGY

2.1. Water source

The water used in this study comes from groundwater. The water contains minerals that are carried from water sources in the ground. The water is not filtered to separate the minerals contained.

2.2. Hydrogen/Oxygen Generator

Separation of hydrogen and oxygen from the bonding of water compounds is carried out using a Hydrogen-Oxygen Generator (Hydro-Oxy Generator), which works by breaking the bond with the polarization method on two interfaced plates to area A, which are separated by a distance d, with given a voltage difference V between both of them (Figure 3).

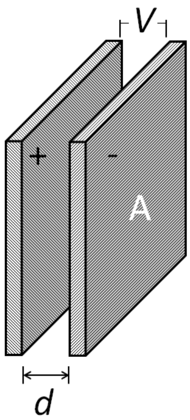

Figure 3. *Hydrogen/Oxygen breaker bond.*

Then the two plates are given a *Direct Current* (DC) voltage difference of 8 Volts, 9 Volts, 10 Volts, 11 Volts, and 12 Volts. The cross-sectional areas of interfaced plates and the distance between them are fixed. The parallel plates are placed in a sealed container to collect the formed Hydrogen/Oxygen gas. Furthermore, the production gas is measured by volume and time of collection.

At the same time, the electric current flowing between the two interfaced plates is also measured. The DC power source uses the MDB POWER SUPPLY 305DM, which has a display to display the current flowing. Voltage measurements were carried out using a DIGITAL MULTIMETER SANWA CD 800a. The volume of gas produced was measured using a gas bag filled with water, and the water that came out was measured using a 100 ml measuring cup (Figure 4).

Figure 4. Setup of experimental Instrumentation.

The volume limit of 90 ml is used to measure the time needed to produce Hydrogen/Oxygen gas. The DC electric current is also measured to identify the relationship between charge mobilization and the volume of gas produced. At each increase in voltage, do ten repetitions. The flow of this experimental activity is shown in Figure 5.

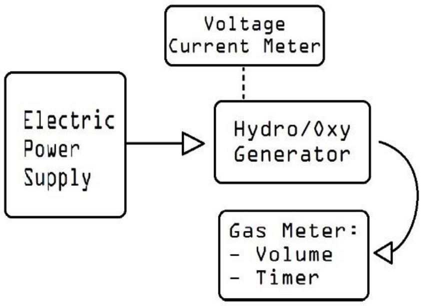

Figure 5. Experimental diagram.

RESULTS AND DISCUSSION

3.1. Termination of the H_2O Bond in the Hydro-Oxy Generator

Hydro-Oxy Generator consists of parallel plates placed in a closed reactor tube. Inside the tube is given water which soaks most of the surface of the two plates. So that water fills the space between the two parallel plates (Figure 6). When the two parallel plates are given a potential difference of V, a field E will be formed between the two interfaced plates at a distance d, following the equation:

$$\boldsymbol{E} = \frac{\boldsymbol{V}}{\boldsymbol{d}} \quad (3)$$

The water compound that is between the interfaced plates will experience a pulling force and a repulsive force F due to the E field that is formed between the two interfaced plates [26], following the equation:

$$F_{H^+} = E \cdot 2q_{H^+} \text{ (Repulsive force)} \quad (4)$$

$$F_{O^-} = E \cdot q_{O^-} \text{ (Attractive force)} \quad (5)$$

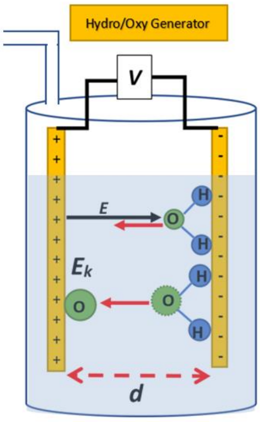

Figure 6. Interfaced plates are placed in a closed reactor chamber.

The bond between the O atom and the two H atoms occurs due to the forces acting between those three atoms in a state of equilibrium. In this condition, the H–O–H bonds form an angle of 104.5°, forming polarization [27]. Under the influence of the electric field, the polarization orientation of the atomic compound of water will follow the field direction. The magnitude of the binding force between H-O follows the equation:

$$F_{H_2O} = k\frac{q_{H^+} \cdot q_{O^-}}{{r_{O-H}}^2} \quad (6)$$

The breaking of the H_2O bond occurs when the attractive force between the O atoms (q_{o^-}) and the H atoms (q_{H^+}) is smaller than the attractive force between the O atoms and the electric field that attracts the O atoms, following the equation:

$$F_{O^-} > F_{H_2O} \quad (7)$$

The addition of voltage between the two interfaced plates will increase the magnitude of the formed electric field. The magnitude will increase the attractive force on the O atom in the H_2O Compound. The breaking of the H_2O followed by the movement of O- ions towards the positive electrode and H+ towards the negative electrode, causes an electric current [28,29].

3.2. Effect of Voltage on Transformation Time

The magnitude of the electric voltage (*V*) affects the interaction of the force between the field and H_2O atoms that are bonded to each other. The applied voltage affects the time it takes to convert the H_2O compound into H_2/O_2 gas molecules. The relationship is shown in Figure 7

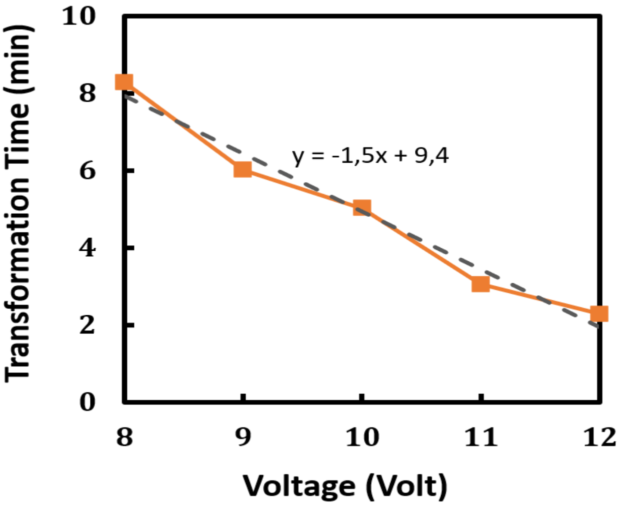

Figure 7. Time transformation H_2O to H_2/O_2 by the increasing voltage.

The time to convert H_2O compounds into H_2/O_2 gas molecules decreases as the voltage between the two electrodes increases. The increase in the voltage applied to the two parallel plates has increased the magnitude of the H_2O bond breaking force.

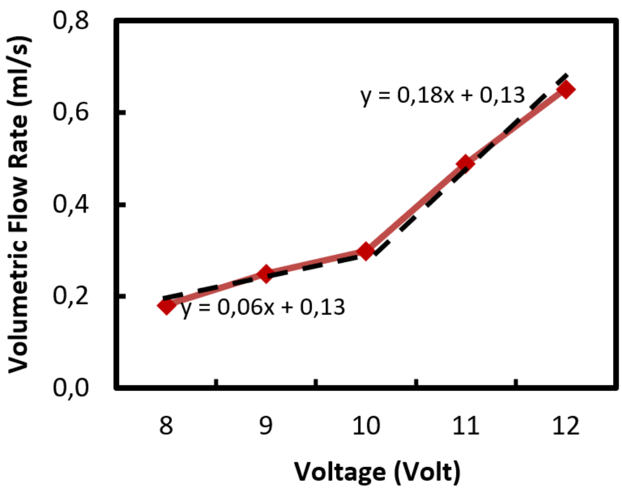

Figure 8. *Volumetric flow rate* (VFR) gas H_2/O_2 by increasing voltage.

3.3. The Voltage Increase Effect Against Increase Gas Volume

The H_2O bond breaking obtained from the Hydro-Oxy Generator consists of H_2 and O_2 molecules gas phase. The two types of gas molecules will collect together in one container. So, the measured volume of gas molecules is the total volume of H_2 and O_2 gases. The relationship between the amount of voltage on the interfacing two plates and the *Volumetric Flow Rate* (VFR) of H_2/O_2 gas is shown in Figure 8. It can be seen that the amount of voltage applied affects the VFR of the production of H_2/O_2 gas molecules. Increasing the voltage from 8 Volts to 12 Volts will increase the VFR of the gas molecule production from 0.18 ml/s to 0.65 ml/s. The two form a linear relationship pattern.

The graph also shows the difference in slope between the voltage range of 8 – 10 Volts and the voltage range of 10 – 12 Volts. The slope transition happened at 10 Volts. The two slopes equation is mathematically stated as follows:

$$\boldsymbol{y = 0,06x + 0,13\ ;\ R^2=0{,}99} \tag{8}$$

$$\boldsymbol{y = 0,18x + 0,13\ ;\ R^2=1} \tag{9}$$

In the second equation, with a value of R^2=1, we find a mathematical relationship between VFR (v) and the interfacial bipolar plate voltage (V), are:

$$\boldsymbol{\frac{(v - 0,13)}{0,18} = V}$$

The VFR transformation of gas production occurs when the voltage applied to the two parallel plates has exceeded 10 Volts. The increase in VFR in the voltage range 8 – 10 Volt has a constant value of 0.06 ml/s. After passing the 10 Volt voltage, in the 10 – 12 Volt voltage range, the value of the VFR increase becomes 0.18 ml/s. This incident indicates that at a voltage of 10 Volts, there is a change in the voltage barrier in the process of separating O_2 and H_2 molecules.

3.4. Voltage Increase Effect Against the Movement of Charges

The movement of charge shows the relationship between the formation of electron flow due to the formation of H_2 and O_2 molecules after breaking the bonds of H_2O compounds. This event is expressed in the chemical reaction equation as follows:

$$\boldsymbol{4H^+ + 4e = 2H_2} \tag{10}$$

$$\boldsymbol{2O^- = O_2 + 4e} \tag{11}$$

The magnitude of the moving charge (Q) during the Transformation time (t) is proportional to the magnitude of the current flowing between the electrode plates (I) following the equation [30]:

$$\boldsymbol{Q = I \cdot t} \tag{8}$$

Thus, the number of moving electrons ($\boldsymbol{e = 1,6 \cdot 10^{-19}\ Coulomb}$) between two interfaces plate can be calculated. The graph of the relationship between the movement of charge and the increase in voltage on the two electrode plates is shown in Figure 9.

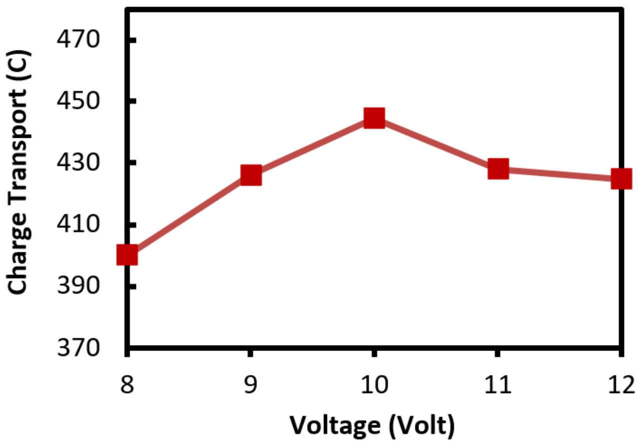

Figure 9. Charge transport between two interface plates.

Fig. 9 shows that the maximum charge movement occurs at a voltage of 10 Volts where the value of Q is 444.54 Coulombs. When the voltage is 11 Volts, the charge transport value decreases gradually. This situation indicates that the optimal bond breaking between O-H atoms in water compounds occurs at a voltage of 10 Volts, where the resistance barriers run into a transition.

4. CONCLUSION

Efforts to use water as environmentally friendly fuel for combustion engines have been made. Bonds in water compounds can be broken using a Hydro-Oxy Generator, which utilizes the interaction force between fields and charges. The voltage increase affects the *Volumetric Flow Rate* (VFR) of H_2 and O_2 gas molecules. The separation rate of the two molecules also increases with increasing voltage. Charge transport occurs optimally at the supply of 10 Volts because the resistance barrier runs into transition.

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