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EFFECT OF pH TOWARDS HYDROGEN GAS OUTPUT OF A SMALL AND PORTABLE ALKALINE ELECTROLYSER

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Graphical abstract

Abstract

Experiments have been conducted to test the hydrogen gas output of a small and portable alkaline electrolyser, a device which converts electricity into hydrogen and oxygen gases via electrolysis process. This cell will be mounted on a vehicle with 12VDC electricity system to supply hydrogen gas to the air intake which will react as a fuel catalyst to enhance combustion and emission while the oxygen will be released back to the atmosphere. The small cell is made of 16 stainless steel plates type SS316 with size of 15 cm x 10 cm x 0.06 cm and the electrolyte is made of distilled water mixed with potassium hydroxide. The aim of this study was to obtain optimal pH level for the electrolyte. Result showed that the hydrogen gas output started to increase when the pH of the electrolyte approached pH14. Almost zero gas production wasrecorded at pH below 13.5. However, by increasing the amount of potassium hydroxide even when the pH was already 14 showed increased amount of gas released. The same result was recorded for distilled water and reverse osmosis water (RO for drinking).

Keywords: Hydrogen output, pH, DC voltage, alkaline electrolyser

1.0 INTRODUCTION

Effort has been taken to reduce the harmful gases and particles released by the transportation sector, which creates serious smog in major cities. Combustion of fossil fuel either petrol, diesel or even natural gas by the vehicles releases abundant carbon monoxide, carbon dioxide, NOx and particulate matter into the air, threatening the environment and also the health, thus lowering the quality of life of the living population in the vicinity.

Hydrogen has long been researched by many researchers as the future power carrier [1]. It contains clean energy and the reaction with oxygen releases only heat and water. The cycle is perfect as water is abundant and the reaction will release the water back means it is a renewable source. The production of the hydrogen gas is already available and economical [2]. Hydrogen can be processed either from petroleum refining, electrolysis or even from algae. But the hydrogen used today is mostly processed from petroleum refining [3].

To replace fossil fuel fully with hydrogen will take a lot of effort, time and cost. The hydrogen filling station must firstly built, which is very costly [1], [4], [5]. All engines must be replaced with hydrogen engine which leads to another problem. Petroleum-based fuel will lose the transportation market resulting major economic downturn infavorable to the oil producers. Due to all these reasons, an alkaline electrolyser had been built which produced hydrogen on board of the vehicle. The output gas is not to replace the fossil fuel but to be added with the fuel during combustion to reduce consumption as it boost the burning quality leads to a better emission [6].

2.0 METHODOLOGY

The small alkaline electrolyser was built of 16 SS316 plates with polyester monofilament in the middle to split the hydrogen and oxygen gases from mixing in the chamber. The neoprene gasket of 3 mm thick was then placed between the plate to seal the compartment as well as to keep the plates at a fixed position.

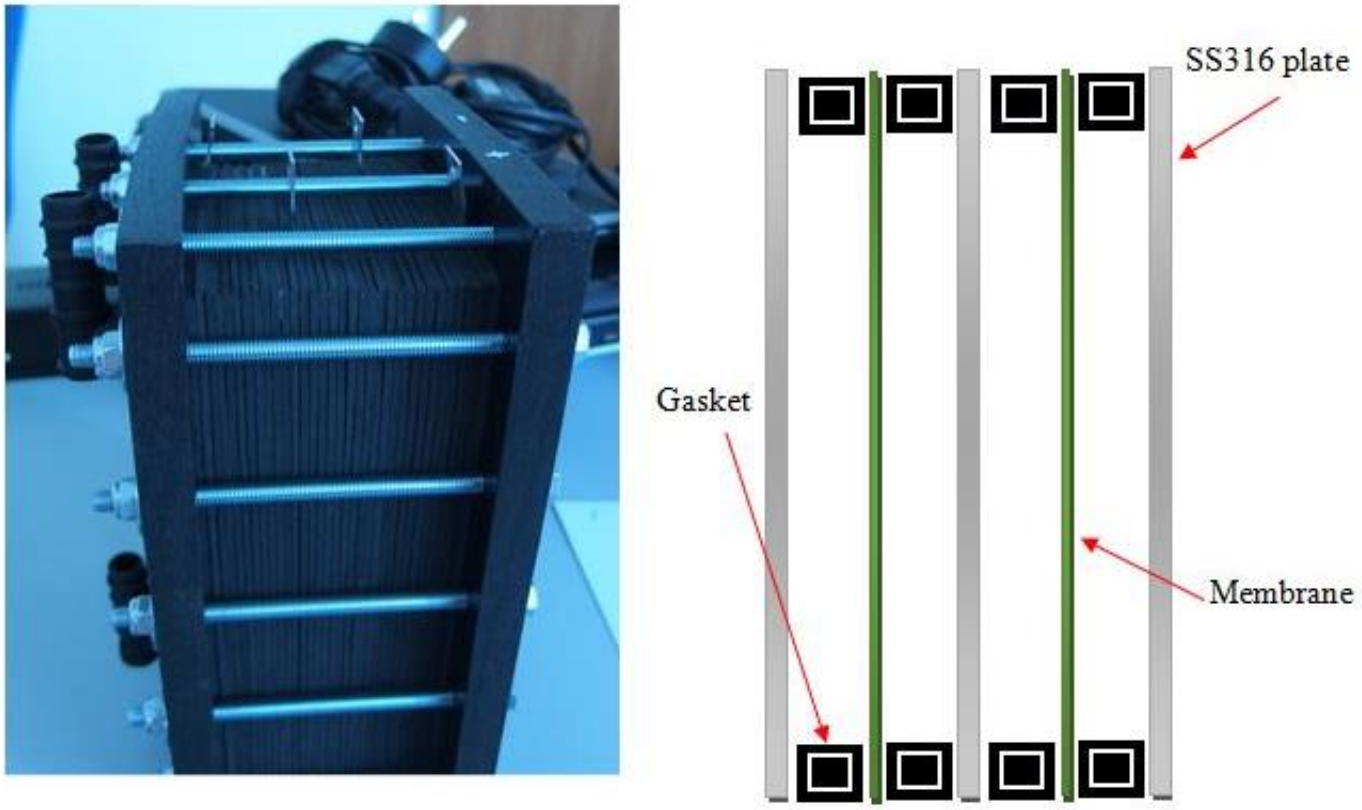

Figure 1 Complete built up of the alkaline electrolyser (left) and schematic diagram of the cell (right)

The stacks were then fixed with long bolts and nuts. The electrolyte input was placed at the bottom of the cell with two output at the top, each for oxygen and hydrogen (refer Figure 1, left side). The generated oxygen gas at the moment was released back to the atmosphere. Only the hydrogen gas output was channeled to the air intake compartment of the vehicle. The electricity required by the alkaline electrolyser was fed from the unused electricity generated by the vehicle's alternator. This wasa done via an electronic controller. When there was a surplus of electricity then these electrons will be fed to the cell otherwise the cell will be in standby mode. By doing this, the engine was not pushed to produce extra power to power up the cell. However modern alternator has been measured to always have a surplus of electricity of up to 10A mostly during daytime, when most of the lighting system was switched off. This finding had been tested and proven in the UTeM's automotive lab. This excessive electricity if not used, will be lost as thermal energy, heating up the cable which was not only useless but lessens the cable lifetime.

The experiments to test the pH was initiated at pH14, where based on many literatures will deliver most gas but will not increase the electrolyte temperature. The same step was then repeated with pH13.9 at an interval of 0.1pH until pH13 to check the effect to the gas output and temperature. The experiment was then repeated for pH beyond pH14

by simply adding the potassium hydroxide at 1 g/liter distilled water to observe any changes in gas production. As the pH meter manages to measure up to pH14, the quantitative value of the pH above pH14 cannot be determined.

3.0 RESULTS AND DISCUSSION

The cell starts to produce a sensible rate of hydrogen at pH13.9. Very little hydrogen gas output observed for pH13.8 and below. At 13.5 there is even no tiny bubble comes out from the hose into the measuring beaker, which means a complete stop of electrolysis process (Figure 2).

The voltagewas set at 14 VDC which was a normal voltage produced by an automobile's alternator. Even though the peak voltage is 14.4 V for a 12 V battery system but this voltage was only available whenever no load was applied to charge the battery and powers the basic engine electricity requirements. 14 V is a typical voltage during normal ride with air-conditioning, entertainment and lighting systems are switched on. The ampere of the supplied electricity is ranging from 0 A to 3 A at pH14+. The power supplied to the cell can be calculated using Equation 1.

$$P = I \times V \quad (1)$$

Where:
P = Electricity power
I = Current
V = Voltage (DC)

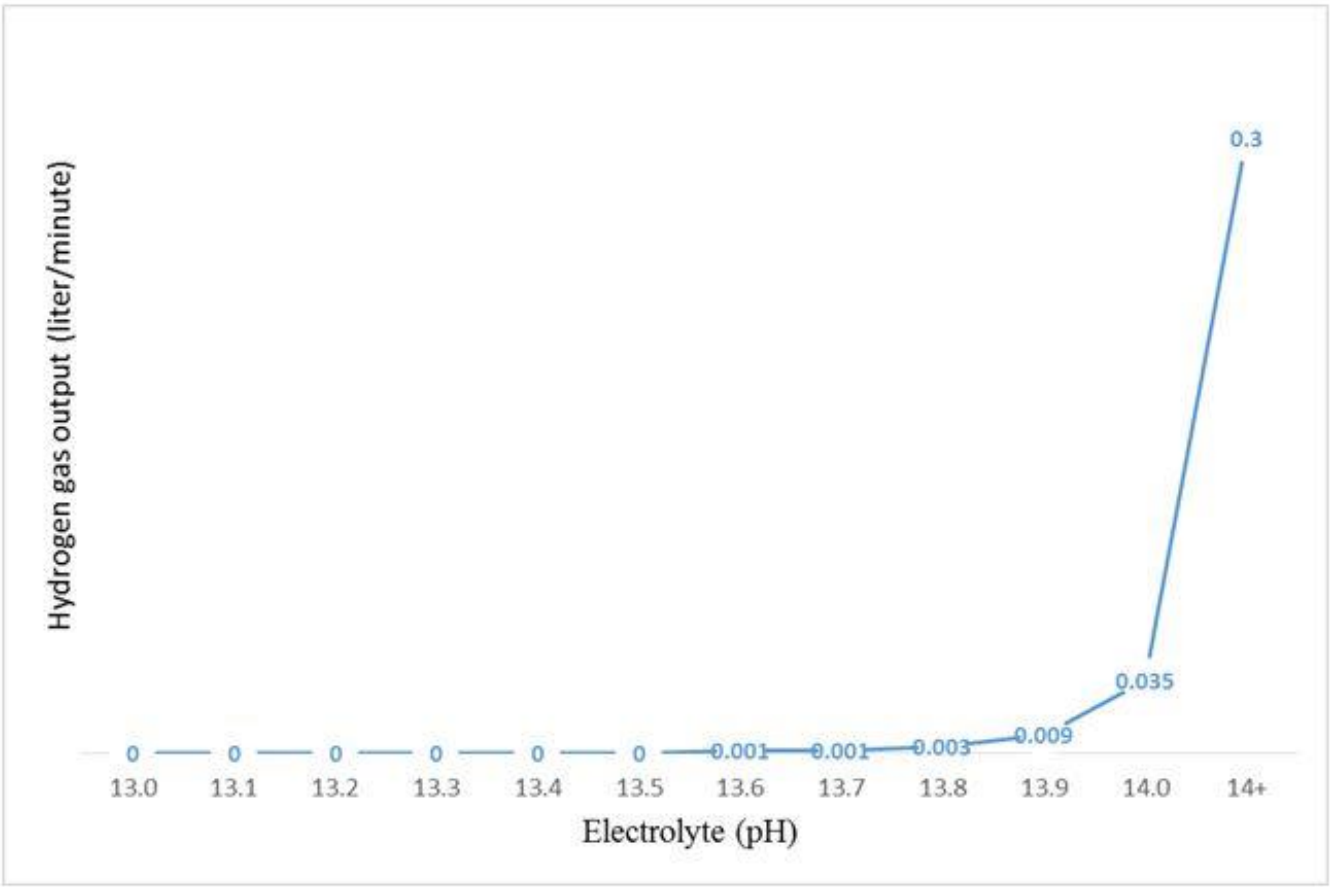

Figure 2 Hydrogen gas output versus pH at $14V_{Dc}$

4.0 SUMMARY

In general electrolysis of water can occur at any pH level. But by making the water acidic or base the reaction can occur faster as there are more free electrons in the water. Base solution is used for an alkaline electrolyser as it is more stable, safer to handle compare to acid and does not corrode the SS316 as fast as in the acidic solution. In addition, the potassium hydroxide (KOH) used in the cell is suitable with the polyester membrane. This membrane is very thin and cannot withstand harsh and acidic environment. Even it can be replaced with nylon which is acid resistant but the SS316 plate with Ferum content cannot withstand the corrosion.

The increasing of gas output in relationship with addition of KOH beyond pH14 is a result of increase of

free OH^+ ions in the electrolyte. The unit of pH therefore should be replaced with a more measurable unit like mol or ratio of KOH:water. Even though mol is more scientific but due to the fact that most KOH available in the market is not 100 percent pure so extra caution must taken to avoid miscalculation.

The water used was for the experiment consist of distilled water and reverse osmosis for drinking. Both delivered the same performance throughout the experiments. No testing of higher level of RO was done but many literatures state that pure water was acidic which means more KOH will be required to make it alkaline. Tap water from the water supply is not done to avoid damaging the membrane or the plate. It is however the best solution if this water can be used inside the cell as it will ease the maintenance of cell. Easier maintenance will increase the interest of the user to buy and apply in their automobiles. Affordable cell and almost free maintenance will boost usage thus a greener and more fuel efficient transportation can be achieved and utilized.

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