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Volumetric Study of Zinc in Various Concentration of Potassium Hydroxide

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ABSTRACT. Zinc (Zn) was immersed in different concentration of potassium hydroxide (KOH) aiming at the preparation of volumetric measurement of Zn in KOH, which led by producing the hydrogen evolution gas. Zn that been used in this study was 99.9% pure Zn. In this study, the characterization of Zn was studied, this is including hydrogen evolution gas and structural analysis. In this experiment, instruments that used is X-ray diffraction (XRD). The analysis from XRD for the metal of Zn showed that the immersion of KOH electrolyte into Zn gives some effect where the surface of Zn showed white patch. This is due to oxide presence at Zn surface.

Keywords: *ZnO, KOH, Volumetric, Hydrogen gas;*

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1. INTRODUCTION

Zn is one of the most metals in electroplating and it is favourable anode in primary batteries due to its properties high discharge efficiency and high safety features associated with its manufacturing process and use [1]. While, regarding another researcher Zn metal is a favourable anode in primary batteries because of its high capacity (0.82 Ah/g) [2]. Furthermore, Zn is a material that can be an electrode that has a large surface area, fairly dense, volume consumption is about three times lower than for magnesium and dimension of the Zn anode are correspondingly smaller [3]. This criteria of Zn makes it more preferable as anode in primary batteries due to its properties high discharge efficiency and high safety features associated with its manufacturing process and use [1]. While, regarding another researcher Zn metal is a favourable anode in primary batteries because of its high capacity (0.82 Ah/g) and has a superior performance at the higher current drains and low temperatures and its better shelf life [2]. Besides that, Zn is chosen because properties of the Zn that make it valuable corrosion resistance is its ability to form a protective layer that consist of zinc oxide (ZnO) and hydroxide (OH^-) or various basic salts, depending on the nature of the environment. The function of the protective layers is to cover the surface of the metal, the corrosion proceeds at a greatly reduced rate [4].

However, in the alkaline battery electrolyte is important as it is functioning as a catalyst that conducts or promote the movement of ions from cathode to anode during charge or in reverse on discharge. There are several types of electrolyte that can be used such as sodium hydroxide (NaOH), sodium chloride (NaCl) and potassium hydroxide (KOH). Moreover, for the electrolyte that currently used in battery needed a strong base. Strong base is a substance that increasing the concentration of OH^- where hydrolyses completely can accept proton and donate a pair of electrons. Strong base usually used as electrolyte. Electrolyte is a substance that containing a free ion which are carrying electric current in the electrolyte [5]. Potassium hydroxide (KOH) is chosen as an electrolyte because of it character as a strong base that allow the current to flow, do not gas off and remain in the cell. Besides, it contained loosely bound semi-solid jelly granules and limited amount of free KOH electrolyte available to the Zn electrode due to the high water retentively of the gel.

The usage of KOH in different concentration in different application will determine the limitations of the free charge carrier when the concentration increased. The free ions would tend to come closer to each other's. On the other hand, KOH solution with a concentration of 30 wt.% shows the highest ionic conductivity, a good solubility of ZnO and relatively low viscosity, which is beneficial for high power density flow battery applications [6,7]. In addition, the battery can give some effect where it can undergo the leakage. The battery leaks because of the discharge of batteries (chemistry of the battery changes and some hydrogen gas is generated) [8]. This out-gassing process increases pressure in the battery. Eventually, the excess pressure either ruptures the insulating seals at the end of the battery, or the outer metal canister [8]. The disadvantages of corrosion to the materials will make the materials facing serious problem which tend to damage internal and external of the material such as cracking [9]. In the alkaline battery, the problem with Zn frequently facing corrosion because of the electrolyte. For this reason, the behavior of the Zn is depending on the concentration of KOH is being used. Where, basically in corrosion understanding towards of metal behavior, corrosion is happen when the metal reacts to the environment such as the presence of O_2, reaction toward acidity and alkaline level of environment and the moisture content of surrounding [10,11].

Inherently, at low concentration of KOH, few charge carriers existed so that ionic conductivity correspondingly kept low in value so that the corrosion towards the Zn is least [12]. The addition of higher concentrations of KOH increased the ionic conductivity due to an increase in the number of OH^- ions available in the electrolyte [13]. The volume of hydrogen evolution gas expected to increase as a function of KOH concentrations. It is because 6 M of KOH give maximum impact on corrosion behaviour as stated in the previous study [14]. In the previous study, there are many researchers that study on the concentration of 2, 4 and 6 M of KOH with Zn to reveal their characterization and conductivity [15-17]. But, no researcher that doing towards concentration of KOH in 2, 4, 6 and 8 M with Zn by revealing the volume hydrogen evaluation gas of Zn plate.

2. MATERIALS AND METHODS

In this research, the materials will be used are Zn plate with dimension 2 cm x 1 cm (99.9% purity, Merck), KOH (Merck), commercial Zn plate and diesel oil. Measurement of production hydrogen gas was carried out by immersion of Zn in the different concentration of KOH (2, 4, 6 and 8 M) and connected a tube to the burette inside of the beaker that contain tap water as showed in Fig. 1.

The container is contained of Zn plate that immersed in the KOH concentration. Top of the KOH solution is oil. The function of the oil is to collect or prevent the bubbles produce from moving randomly. The bubbles were directly flow to the rubber tube. This procedure was taken for calculate and compare between the volume of hydrogen gas that released by the Zn to concentration of KOH.

XRD (Bruker) was used to observe the composition of the Zn plate. The crystalline phase was identified using the International Centre of Diffraction Data (ICDD) powder diffraction database. The angle of 2θ at the range of 10° to 90°.

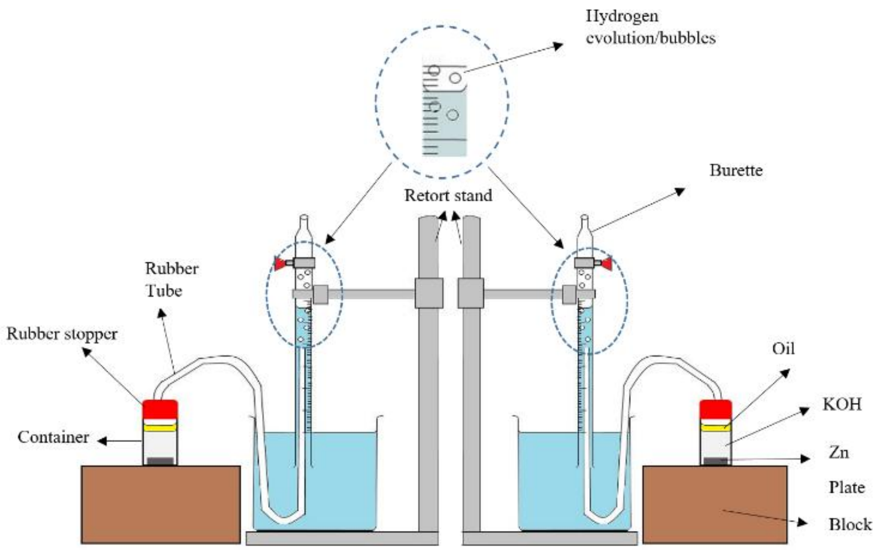

Fig. 1 Schematic diagram of volumetric measurement setup

3. RESULTS AND DISCUSSION

Fig. 2 shows the hydrogen consumption of Zn commercial that immersed in KOH. In 2 M of KOH showed that gradually decline for 170 hours. 0.1 mL of water was decreased every eight hours due to the low of KOH concentration. This will slow the movement of ion to attack the surface of Zn and unproductive air bubble is produced.

The pattern lines for 4 M KOH showed that lines are drawn through most of the data points. However, surprisingly at 110 hours there is small difference that there is indicates a lower volume of water at the increasing of time. Every four hours the volume of water decreasing by 0.1 mL.

Compared to 6 M that slightly decrease in pattern until at the 17 hours, but, then steeply dropped up to 45 hours and steadily until 170 hours. The water constantly decreases by 1.0 ml every hour. While at 8 M of KOH, showed data that decrease steadily for 82 hours and volume of water remain constant from 82 hours until 170 hours. The water keep diminished by 0.6 ml for every hour.

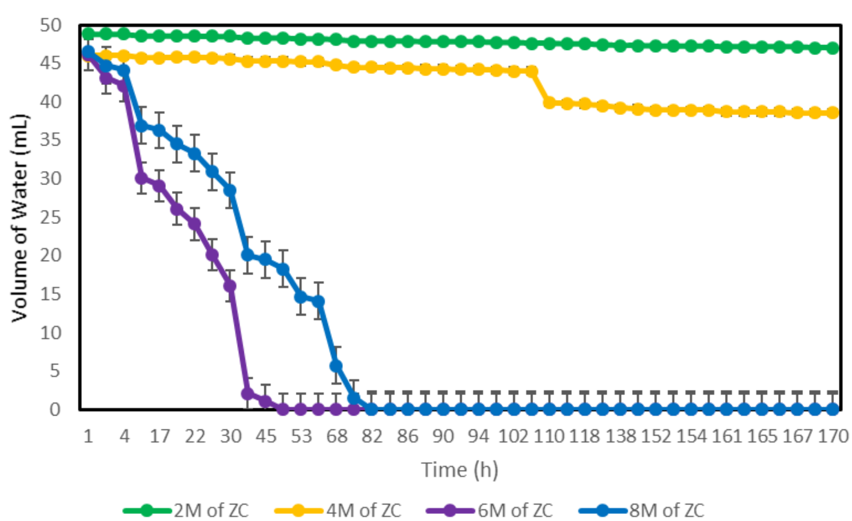

Fig. 2 Rate of hydrogen gas for Zn immersed in different concentration of KOH

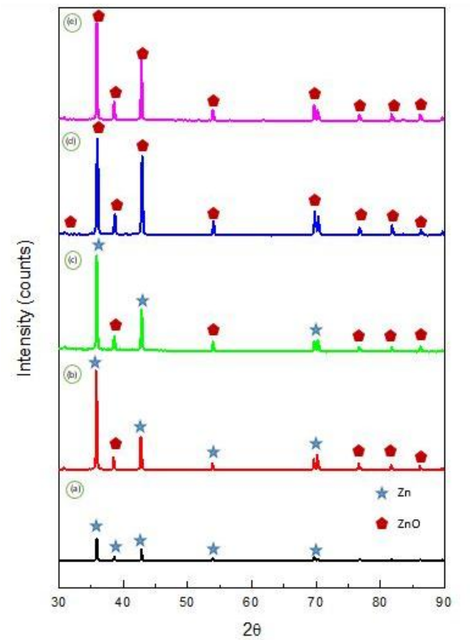

Fig. 3 Comparison peak analysis for XRD of (a) Zn commercial and Zn after reaction with (b) 2, (c) 4, (d) 6 and (e) 8 M of KOH

Fig. 4 shows the illustration of reactions happen in the media. The existing of hydrogen evolution is causing by the corrosion on the reactions of KOH and Zn by reactions of Zn + $2H_2O \rightarrow ZnO + H_2$. Zn is reacted to the KOH and caused the white patch (OH^-) on the surface after the observation at the end of experiment. The higher concentration of KOH, the reactions and corrosion to Zn will be faster.

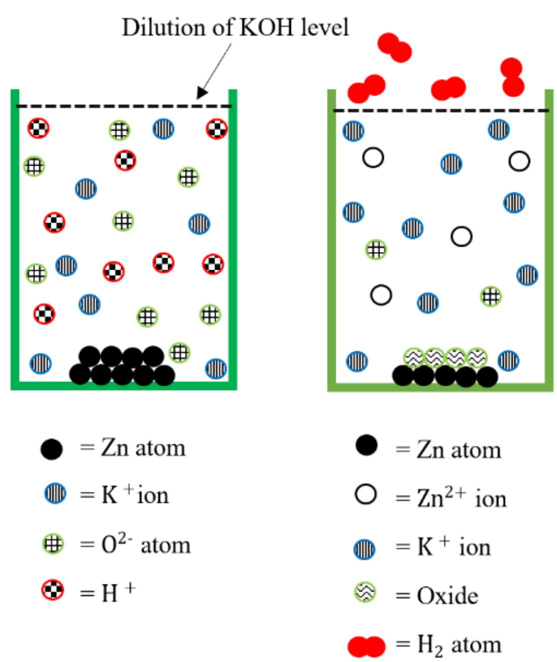

Fig. 4 Illustration of Zn reaction in KOH solution

4. SUMMARY

The volume of hydrogen evolution gas was increasing until it attains the maximum level concentration of KOH, 6 M and the higher concentration of KOH will produce more oxygen that can led the Zn deposited to ZnO. This reaction will have led Zn to corrode due to the appearance of oxygen increasingly.

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