

Electrochemical Cell of Pure Cu Anode/Al Cathode using NaCl+DI Water Electrolyte

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Abstract: Primary Cu anode/Al cathode cell (non-Lead; Pb) was expected to promote importance for environmentally electrolytic cells and electrolyzed an aqueous solution of Sodium Chloride 2 moldm^{-3} +dionized (DI) water (non-Sulfuric acid; H_2SO_4). The Cu anode and Al cathode metals were prepared by hotpress method from pure metal powders. The crystal structure, microstructure, density, microhardness, resistance, potential of electrochemical cells and discharging are investigated for enhanced electrolytic cells performance. The electrochemical cell Cu anode/Al cathode was discharged by the electrical power increase with increasing time and can be good discharging in NaCl+DI water by nonspontaneous redox reaction.

Keywords: Cu/Al primary cells, electrolytic cells, galvanic cells, cathode and anode metals, electrolysis

1. Introduction

The basic electrochemical unit being referred to is the “cell”. A battery consists of one or more of these cells, connected in series or parallel, or both, depending on the desired output voltage and capacity [1]. Batteries are an important source of energy storage, most of which are used as backup power sources, to supply electric power to electrical equipment. In the modern, electrical energy is normally converted from mechanical energy, solar energy, and chemical energy etc. A battery is a device that converts chemical energy to electrical energy. The first battery was developed by Alessandro Volta in the year of 1800 [2]. In the year 1836, John Frederic Daniell a British chemist developed the Daniell cell as an improved version of the voltaic cell. From that time until today, the battery has been the most popular source of electricity in many daily life applications. In our daily life, we generally use two types of battery, one of them is which can be used once before it gets totally discharged. Another type of battery is rechargeable which means it can be used multiple times by recharging it externally. The former is called primary battery and later is called secondary battery [3]. Batteries can be found in different sizes and may be as small as a shirt button or may be so big in size that a whole room will be required to install a battery bank with this variation of sizes. The battery is used anywhere from small wrist watches to a large ship [3]. There are two types of batteries: primary and secondary such as primary include Zinc-Carbon, Alkaline and Lithium-Iron and secondary batteries include Lead acid, Nickel-Cadmium, Nickel-Melton-Hydride and Lithium-Ion [3]. But most commonly used lead acid battery because of its long life and high discharge capacity [4]. Lead-Acid battery consists of anode, lead powder, peroxide, PbO_2 , cathode, pure lead or porous lead, and electrolyte solution are sulfuric acid (H_2SO_4). Lead-Acid Battery is highly toxic from lead to human and environment. Lead is the most commonly encountered toxic metal pollutant in the environment as a result of its current and previous use in, for example, batteries, gasoline, plumbing, and paints. Considerable effort is, therefore, being directed toward solving this environmental problem. In this regard, the toxicological properties of lead are associated with its interactions with proteins and, in particular, 5-aminolevulinic acid dehydratase (ALAD). The influence of lead on the latter enzyme is particularly harmful because ALAD is responsible for the asymmetric dimerization of 5-aminolevulinic acid (ALA) to porphobilinogen, a monopyrrole which is essential for synthesis [5].

In this paper, we present of non Lead and non sulfuric acid used only pure Cu and Al and investigates the discharging of electrochemical cell. This work has objectives: to prepare Cu anode and Al cathode by hot press method, to measure characteristic, crystal structure, microstructure, resistance and to discharge of Cu anode and Al cathode and to study possibility of electrochemical cells of Cu anode and Al cathode in NaCl+DI water.

2. Materials and Method

The Cu cylinder anode (2.0 cm diameter, 1 cm thickness) was prepared by hotpress method at 900 °C, 1.0 MPa for 1 h in Ar gas from grinded Cu metal powders for 3 h in air. The anode of 0.1 cm thickness was cut and polished by saw low speed and polisher using sandpaper No.100 (30 min) and No.2400 (30 min). The Al cylinder cathode (2.0 cm diameter, 1 cm thickness) was prepared by hotpress method (vacuum heated pressing furnace;OTF-1200X-VHP-4) at 670 °C, 1.0 MPa for 1 h in Ar gas from grinded Al metal powders for 3 h in air. The cathode of 0.2 cm thickness was cut and polished by saw low speed (Isomet Low Speed Saw) and polisher (Metaseve 3000) using sandpaper No.100 (30 min) and No.2400 (30 min). The Cu anode and Al cathode were analyzed crystal structure by X-ray diffractometer (XRD; Shimadzu 6100), before and after drift in NaCl solution 2mol dm^{-3} for 1 h (annealing at 60°C for 1 h) observed microstructure by scanning electron microscope (SEM; SU8230, 5000X-10000X), density measured by Density Kit (MS204), Vicker hardness measured by micro hardness tester (HNV-2T), resistance measured by Picotest(M3500A, 6½ digit multimeter) and electrical chemistry properties measured by cyclic voltammetry technique(balance weight of and Cu anode and Al cathode). The anode Cu and cathode Al were connected Potentiostat-446 by anode Cu connected working electrode and Al connected reference electrode and counter electrode Al to show results on computer monitor. The program in Echem v2.2.2 was run by cyclic voltammetry technique using initial of -300 mV, final of -300 mV, upper of 300 mV, lower -300 mV, rate of 50 mV s⁻¹, Number of Cycle 100 for 24s and get data for plot voltage applied with current graph as shown in Fig. 1. The electrochemical cell of Cu/Al was discharged by dip in NaCl+DI water for 40 min ($R_{\text{load}} = 1 \Omega$) and then measured voltage and current by Picotest, model M3500A, 6 ½ digit multimeter, M35XX Excel Add-In program to evaluate the electrical power.



Figure 1: Cyclic voltammetry technique (a) Cu anode, (b) Al cathode, (c) dipping in NaCl+DI water, (d) connecting computer and (e) Staircase cyclic voltammetry

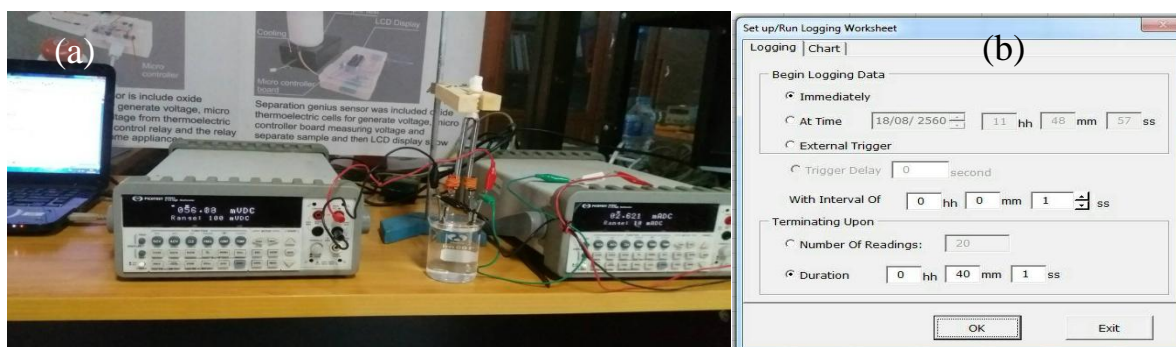


Figure 2: Discharging measurement (a) measured voltage and current of Cu anode/Al cathode dip in NaCl+DI water for 40 min by Picotest digital multimeter (b) program setup/run logging worksheet by M35XX Excel Add-In program to evaluate the electrical power

3. Results and Discussion

The crystal structure of Cu anode was obtained face center cubic structure, lattice parameters $a = b = c = 3.6193 \pm 0.0657 \text{ \AA}$, the plane composed of (111), (200) and (220) correspond with PDF#00-004-0836, are show in Fig. 3.

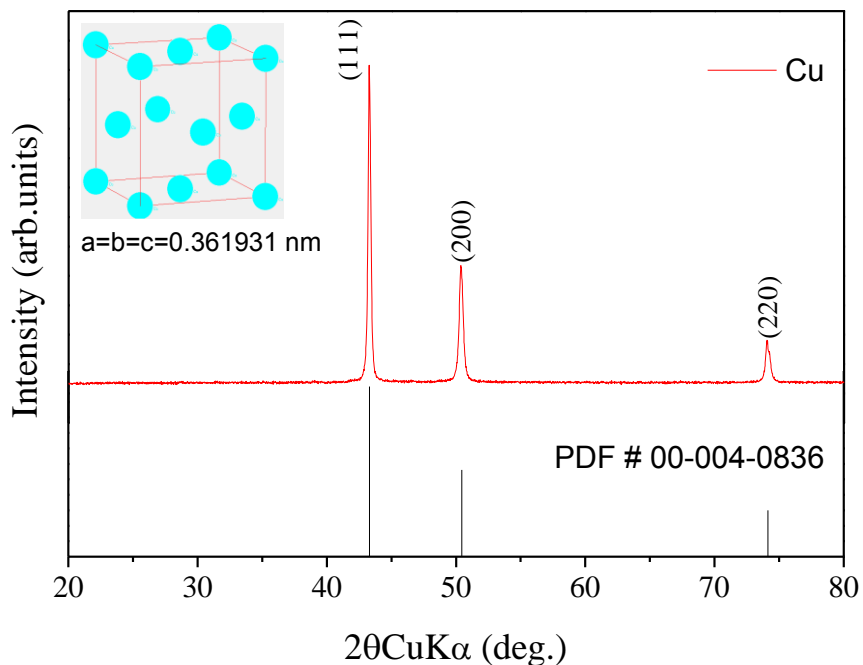


Figure 3: X-ray diffraction patterns of Cu anode together with PDF#00-004-0836

The crystal structure of Al cathode was obtained cubic structure, lattice parameters $a = b = c = 4.0623 \pm 0.0072 \text{ \AA}$, the plane composed of (111), (200), (220) and (311) corresponded with PDF#00-004-0787, are show in Fig. 4.

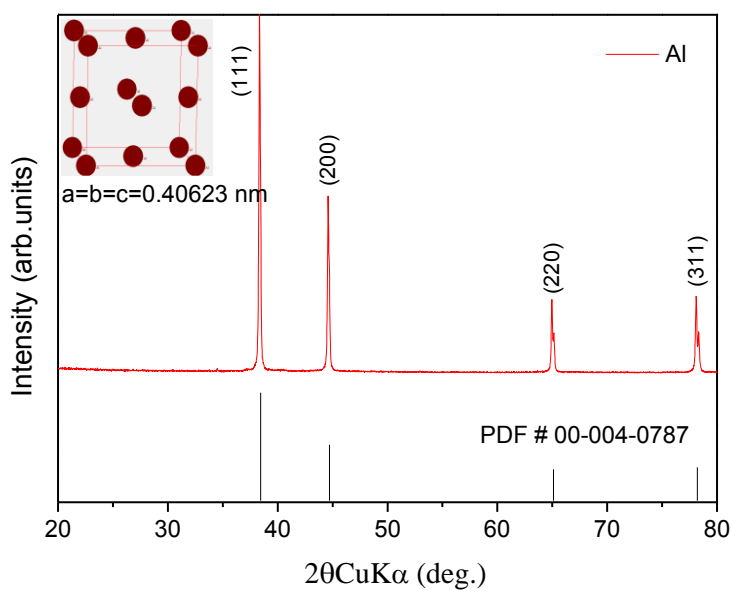


Figure 4: X-ray diffraction patterns of Al cathode

Figure 3 and 4 were confirmed single phase of Cu anode and Al cathode indicate that the successfully preparation of high purity of metal by hotpress method.

The morphology and microstructure of prepared pure Cu and Al metals were showed flash surface, only Cu as shown in Fig. 5(a) and (b) and Al metals (non impurity) as shown in Fig. 5 (c) and (d), which correspond with XRD results.

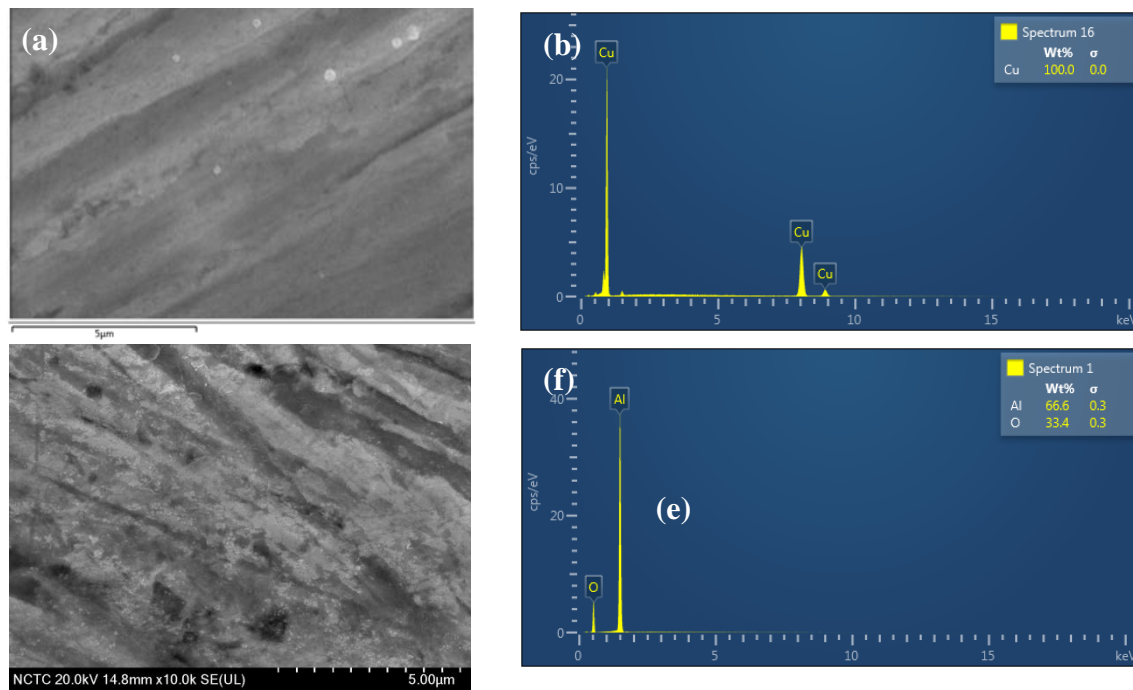


Figure 5: The morphology and chemical composition of pure Cu and Al before dip in NaCl+ DI water solution (a) SEM image of Cu, (b) EDS of Cu, SEM image of Al and (e) EDS of Al

The Cu anode and Al cathode were dipped in NaCl+DI water for 40 min show relationship between applied potentials with current, is seem in Fig.6. The relationship was corresponded to the further reduction of the hydrogen peroxide as following the equations:

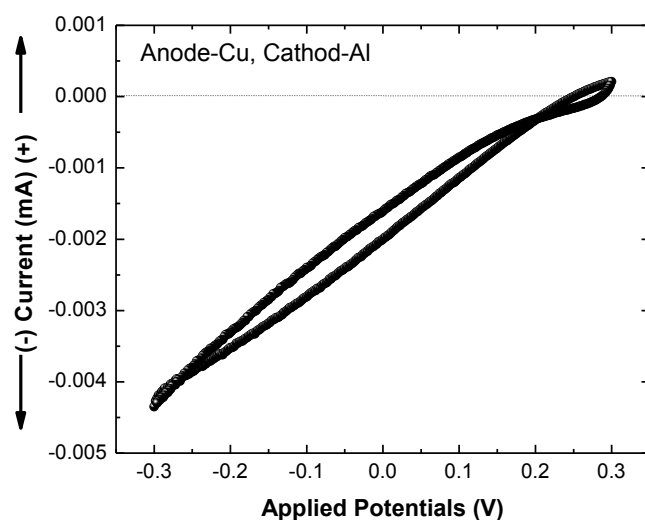


Figure 6: Polarogramsvolammatic behavior of Cu anode and Al cathode for100 Cyclic voltammetry technique

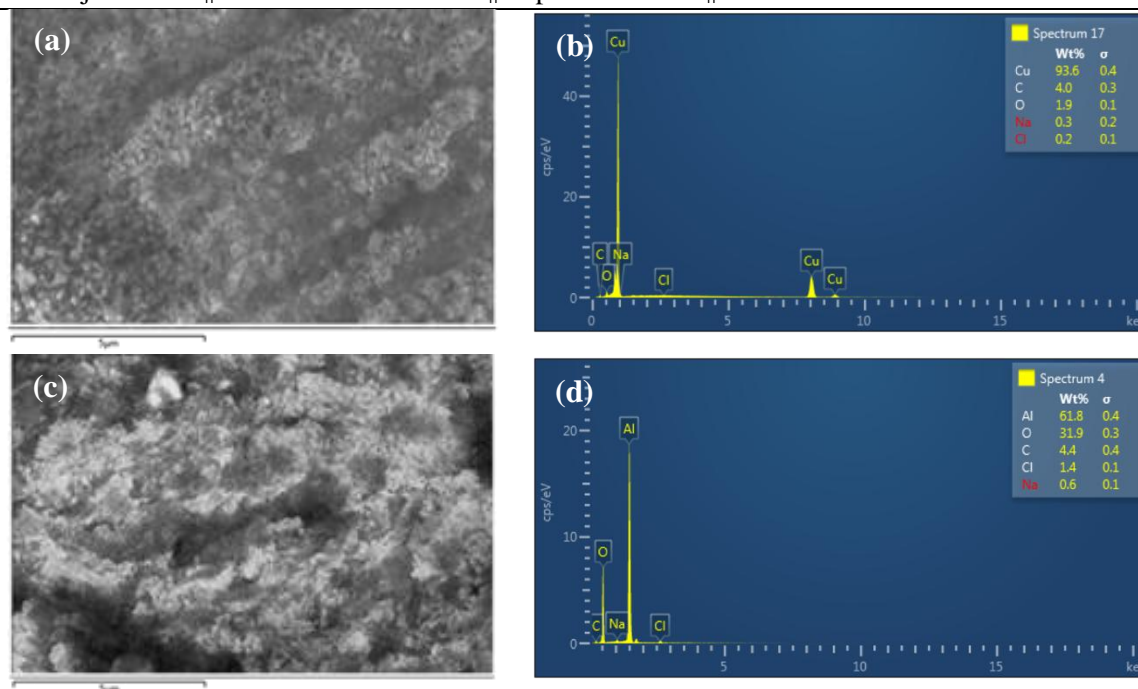


Figure 7: The morphology and chemical composition of pure Cu and Al after dip in NaCl+ DI water solution (a) SEM image of Cu, (b) EDS of Cu, SEM image of Al and (e) EDS of Al

The physical properties of Cu anode and Al cathode were obtained density, microhardness and resistance, are shown in Table 1.

Table 1: Physical properties of Cu anode and Al cathode before and after dip in NaCl+DI water solution

Sample	Density (g m ⁻³)	Microhardness (MPa)	Resistance (Ω)
Cu	7.29	363	0.49
Al	2.02	151	0.63

The mass of Cu anode and Al cathode were dipped in NaCl+DI water, as shown in Table 2.

Table 2: Mass of pure Cu and Al before and after dip in NaCl+DI water solution

Sample	Before(g) dip	After(g) dip	difference (g)
Cu	2.6019	2.6105	0.0086
Al	1.2042	1.1636	-0.0406

The discharge of electrochemical cell Cu anode/Al cathode was obtained relationship of time with electrical power, is seen in Fig. 8. The electrical power was increased with increasing time indicate that the Cu anode/Al cathode can be good discharging of in NaCl+DI water nonspontaneous redox reaction.

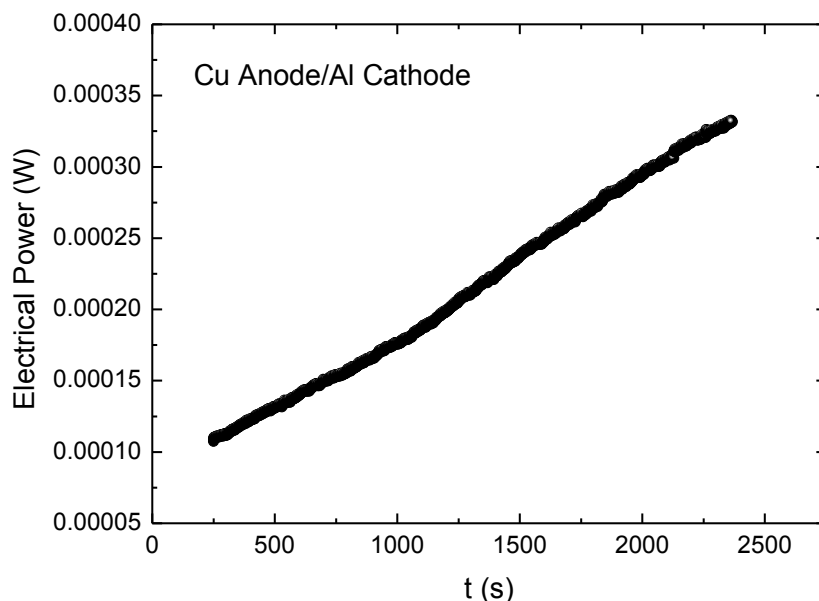


Figure 8: Relationship time with electric power after dip Cu anode and Al Cathode in aqueous NaCl

4. Conclusion

We have investigated Cu anode and Al cathode mechanical properties for fabricate the electrochemical cell by using NaCl+DI water. The electrochemical cell can be generated electrical power in order mW for 40 min in NaCl solution which possibility for base electrolytic sells.

5. Acknowledgements

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