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Electrical Performances of Lithium-Ion Coin Cell Based on Reduced Graphene Oxide (RGO)

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Abstract— **Recently many portable devices need electrical energy which instant and high capacity. Lithium-ion battery is one of very popular as mobile electrical energy source for them. This study focused to elaborate the electrical performances of reduced graphene. They were electrical conductivity, cycle performance of charge-discharge, and specific capacity. Doctor blade technique was used to produce the anode. Vacuum technique was used to assembly Lithium-Ion Coin Cell. Electrochemical Impedance Spectroscopy and Cyclic Voltammetry were used to measure the electrical performances of coin cell. The results showed that electrical conductivity value was 8×10^{-5} S/cm, and the specific capacity value was 400 mAHr/g. So, this study has shown a prospective application in the future to produced commercially lithium-ion coin cells.**

Keywords—Reduced Graphene Oxide (rGO), Anode, Lithium-Ion Coin Cell, and Doctor Blade Technique

I. INTRODUCTION

Recently many devices need mobile electrical energy sources for supporting and help our life easily. They are calculator, mobile phone, smart watch, digital camera, laptop, and immediately electric vehicles and hybrid vehicles. The main problem is to get electrical energy sources which properties high energy density, higher output power, fast charging, support green environmental principle, small and lightweight in size, and durable [1]. For this reason, Lithium Ion Battery (LIB) is the promising electrical energy sources for suppoting mobile compact energy.

One of the important prototype of LIB is coin cell. It can be assembled from reduced Graphene Oxide/Copper (rGO/Cu) anode, lithium foil cathode, polypropylene separator, and PF_6 electrolyte [2]. They have many advantages to develop Lithium-Ion (LI)-Coin Cell because it has good conductivity, higher energy capacity, easy and cheaper in fabricating, and durable.

Various popular methods are used to prepare battery anode, i.e. solid state method, hydrothermal route, solvothermal process, electrospinning deposition, microwave-hydrothermal method, and sol gel method have been proposed by many researchers [3-7]. In this work solvothermal route was used to prepare slury material for anode. Doctor blade technique and solid state rection method were employed to prepare rGO/Cu composite. Moreover, the effect of rGO to the electrical performances of LI-Coin Cell are also carefully investigated.

II. EXPERIMENTAL AND MEASUREMENTS

LI-Coin Cell formation contained three stages, i.e. preparation of components, assembly process, and measurement of electrical performance. For detailing each stage is explained as follows.

A. Preparation Components LI-Coin Cell

Main Components of LI-Coin consist of anode, cathode, separator, electrolyte, and coin jacket. Anode rGO/Cu was prepared through three stages, i.e. formation of: (1) rGO powder, (2) slurry, and (3) anode composite. It was prepared from coconut shell using the special treatment [8]. Slurry was prepared from rGO powder, polyvinylidene difluoride (PVDF), and acetylene black (AB) with percentage ratio 85:10:5. They were dissolved and Stirred (100 rpm and 80^{o}C) in N,N-Dimethylacetamide (N,N-DMAC). The slurry was superimposed to copper foil using doctor blade equipment with tape casting method. Then it was dried and cut which diameter 16 mm. Standard Lithium foil was used as cathode material (diameter 16 mm) and polypropylene as separator material with diameter size in 199 mm. Further, electrolyte commercial PF_6-EC:DEC was completed as LI-Coin Cell components.

B. Assembly Process of LI-Coin Cell

All of components above were assembled to be a coin cell in a glove box with argon environment with the structure: anode-separator-electrolyte-anode. These components were protected by metal jacket.

C. Mesurement of Electrical Performance

Electrochemical Impedance Spectroscopic (EIS) measurements were carried out with the frequency range 0.5 Hz to 20 kHz using the across voltage 0.1 volt. Cyclic Voltammetry (CV) was used to measure the redox cyclic of the process of intercalation/deintercalation of Lithium ion. Cyclic voltammogram curves were recorded from 0.0 to 3.0 V with a scan rate of 0.1 mV/s. Automatic Battery Cycler WBCS3000 Version 3.2 was used to measure Charge-Discharge (CD) with 0.1C rate.

III. RESULTS AND DISCUSSION

A. Results of EIS Measurement

First, impedance confirmed through EIS measurement. It measured values of real (Z) and imaginary (Z') impedance as displayed at Fig.1. Semi-circle curve represented the electrolyte resistance (R_e) that arise as consequence of electrochemical reaction between electrolyte and surface of active material. Straight line represented diffusion process of lithium ion into bulk electrode material. It as a reference for electrode's performance to save lithium ion.

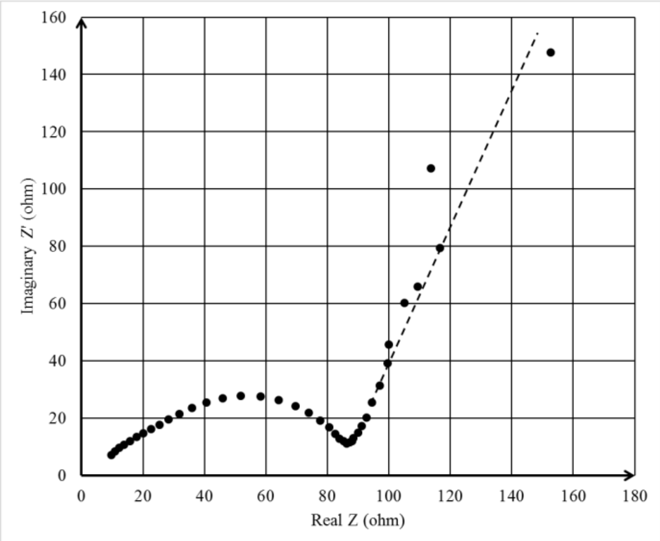

Fig. 1. Nyquist Plot of Coin Cell

Figure 1 and 2 show the profile of impedance of coin cell which electrical conductivity (σ) value is 8.2×10^{-5} S/cm. It is enough to meet the requirement as coin cell [9].

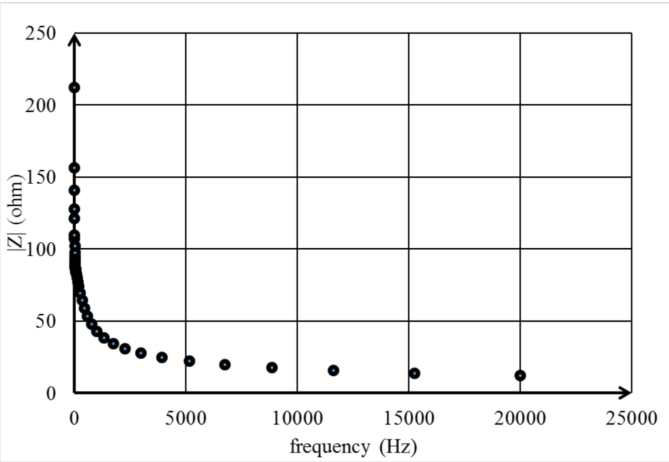

Fig. 2. Bode Plot of Coin Cell

B. Results of CV Measurement

Figure 3 shows the voltammogram of CV measurement that describe the peak value of anode and cathode voltage. In this measurement the both peaks did not appear sharply. In the first cycle measurement has the different voltage 1.0 volt and 0.8 volt for next cycle. It is meant the electrode have bad intercalation process due to its crystallinity problem [10]. Furthermore, the electrode quality can be affect the inserting process of lithium ion and number cycles of reversible process of this coin cell. Based on the CV measurement results are needed further improvement in anode fabrication.

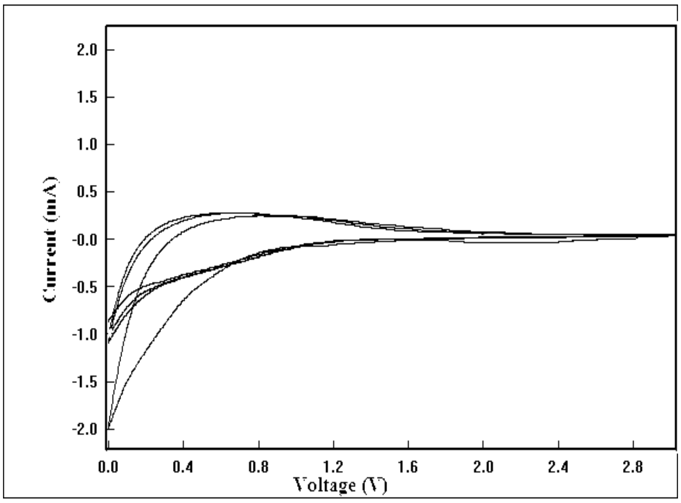

Fig. 3. Voltammogram CV of Coin Cell

C. Results of CD Measurement

The charge-discharge performance had been measured and displayed at figure 4. The first stage of this measurement is to discharge this coin cell. At the end of discharging process, it has specific capacity 200 mAh/g on voltage 0.5 V. The second stage is to do charging process and at the end this process shows it has specific capacity 180 mAh/g on voltage 3.0 V. And the third process is discharging process, it has specific capacity 400 mAh/g on voltage 2.4 V.

This coin cell has specific capacity performance as good as previous finding researchers [10-11]. It had an effective charging but still had a serious problem in the rapid discharging process. So it would need the improvement of electrode's quality in the next research.

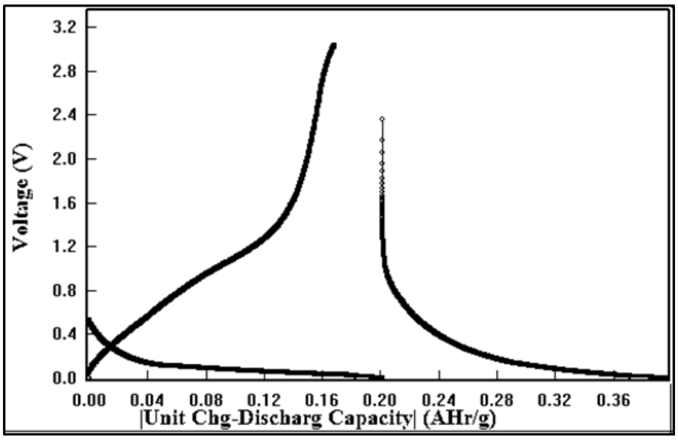

Fig. 4. Charge-Discharge Plot of Coin Cell

The performance of the coin cell is very dependent on the anode materials. As the findings of the researchers [11-14] are summarized in Table I. It can be understood that the anode made of rGO has the highest value specific capacity in the discharging process (400 mAh/g) and has a good capacity in the charging process (180 mAh/g). Specific capacity constraints in charging processes require special treatment in the fabrication of the anode, i.e. using the rGO-graphite composite with certain composition.

TABLE I. SPECIFIC CAPACITY DIFFERENCE OF VARIETY ANODE MATERIAL

Anode	**Specific Capacity (mAh/g)**	
	Charging Process	***Discharging Process***
graphit	301	253
rGO	180	400
graphit coated Na_2CO_3	367	316
rGO coated Na_2CO_3	8	18

IV. CONCLUSION

In this paper, Lithium-Ion coin cell was successfully synthesized and characterized based on rGO/Cu composite. It has electrical performances: (1) electrical conductivity (σ) value is 8.2×10^{-5} S/cm, (2) the different peak value of anode and cathode voltage are 1.0 V for the first cycle and 0.8 V for the next cycle, and (3) specific capacity 180 mA/g (charging) and (discharging).

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