The performance conductivity of Mg/Graphene nanosheet as anode of battery

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Abstract. Research on performance conductivity of magnesium (Mg)/graphene nanosheet (GNS) as anode of batteries was carried out. This research is an experimental laboratory research. The purposes of this research are to synthesize anode material on battery and to evaluate performance of GNS and Mg/GNS as a supporting material and a candidate of electrode on battery anode, respectively. First, GNS was synthesized by using graphite as a raw material (modified Hummer’s method) and electrode of Mg/GNS was prepared with impregnation method. The characterization of GNS and Mg/GNS was carried out by using XRD and conductometer, respectively. The XRD data shows a weak and broad peak on GNS (2θ = 26.0°) indicating GNS was synthesized well and on 2θ = 43.79° indicating that the Mg was deposited inside of the graphene nanosheet. The conductivity data showed that Mg 2.02%/GNS has the highest electric conductivity of Mg (63.6945µS/cm) among to graphite and commercial battery anodes. Mg 1.91%/GNS has the lowest electric conductivity. Based on those data, GNS and Mg/GNS are potentially be used as an anode on battery.

1. Introduction
The convenient source of power for portable electric and electronic devices already many used in our daily activities, such as battery. Batteries carry chemical energy whenever needed and can convert chemical energy during the process of exchanging electrons between the anode and cathode [1]. Ideal batteries should be have high power density [2], resistance to interference [3], specific energy [4], low cost [5] and good life cycle [6]. In order to develop commercially battery, the price is very important. For instance Li is very expensive and it will be solid waste. The order problem is the number of density and energy capacity of battery is quite low [7] and the interaction between electrode and electron is still weak [8]. In addition the electrode of battery may be lost the electric during the extend usage [9]. Graphene is prospect to solve the main problem of battery.

Graphene is a carbon two-dimensional which it demonstrates the unique properties of electronic and transport. Graphene has attracted a lot of attention from the different physics and chemistry fields due to it has ambipolar electric field effect, integer and half-integer quantum Hall effects for electrons and holes, and very high electron and hole mobilities, etc. [10,11] The graphene is very special because it is composed of two equivalent sub-lattices of carbon atoms bonded together with σ bonds. Notice, each of carbon atom in the lattice has a π orbital that
is be able to contribute delocalized network of electrons [12]. Graphene has a high intrinsic mobility (200,000 cm²v⁻¹s⁻¹), large theoretical surface area (2,630 m²g⁻¹) [13,14], high thermal conductivity ~5000 Wm⁻¹K⁻¹ [15], high Young’s modulus (~1.0 Tpa) [16] and good optical transmittance (~97.7%) and electrical conductivity merit attention for applications such as for transparent conductive electrodes [17,18] among many other potential applications. In this study we develop our concepts, those are i) using graphene, it may be expected to increase energy storage; ii) to use magnesium, magnesium is a special metal base on the storing properties. That is why it can be used in order to increase the specific energy and energy capacity of the battery [19]. Modification of carbon material combined with magnesium has been proposed [20] and could be used as a supporting material as an electrode in the battery cell.

2. Methodology
2.1. General
This research uses an experimental method which was carried out in the Laboratory of Analytical Chemistry, Chemistry Department, Universitas Sumatera Utara for the preparation of materials. Characterization of samples with XRD instrument was carried out in the Laboratory of Physics, Universitas Negeri Medan. Electrical conductivity test was carried out in the Laboratory of Basic Physics Sciences, Universitas Sumatera Utara.

2.2. Materials Preparation
In this experiment research, we use chemicals supporting by Merck and Sigma-Aldrich (Singapore). GNS was synthesized by using many chemicals. Those are graphite (carbon 98 wt% and ash wt 15%); sulfuric acid (H₂SO₄, 98 wt%); potassium permanganate (KMnO₄, 99.5 wt%); hydrogen peroxide (H₂O₂, 30 wt%); ammonia (NH₃, 25 wt%); sodium nitrate (NaNO₃, 99 wt%) and Magnesium chloride (MgCl₂, 99 wt%).

2.3. Synthesis of graphene oxide
First of all, graphite was oxidized to produce graphene oxide (Hummers and Offenman’s method) [21]. Briefly, 0.2 g of graphite mixed with 0.2 g NaNO₃ and 15 ml H₂SO₄, then the graphite solution was stirred for 1 hour in an ice bath condition. The end of 1 hour, KMnO₄ (1 g) was gradually added into the graphite solution and stirred for 24 hours. Subsequently, graphite solution was added 20 mL of H₂SO₄ 5% and 1 mL H₂O₂ 30%, stirred for 1 hour, respectively to produce graphite oxide. Then, graphite oxide was centrifuged at 6,500 rpm for 20 minutes in piranha solution and ultrasonicated for 6 hours, producing a solution of graphene oxide.

2.4. Synthesis of graphene
Graphene oxide then was reduced by using 5 mL NH₃ 10 M and it was stirred for 72 hours, filtered and dried at 100°C to produce graphene powder. Then, graphene powder was characterized by XRD.

2.5. Preparation of Mg/GNS
As much as 1.0 g of graphene is put into the beaker glass which contains 1.0 ppm standard magnesium series solution. Then, put the magnetic bar into the beaker glass and stirred them for 2 hours. Then filtered using Whatmann filter paper no. 42, and there will be become filtrate and sediment. The filtrate was not given any treatment. While the sediment was dried at 100°C to produce Mg/GNS powder. Then, weigh the precipitate obtained. The same treatment will be done for the 2.0; 3.0; 4.0; 5.0 and 10 ppm of standard magnesium series solution, then Mg/GNS powder was characterized by XRD.

2.6. Measurement of electrical conductivity
Put 0.25 g of graphite powder into the fuse (glass), compacted, and covered with a fuse cover. The crocodile clamp cable is connected to the negative and positive poles of the Digital multimeter and
Regulated DC Power Supply. Measured electrical conductivity with variations in voltage 5, 10, 15, 20, 25, and 30 volts and recorded the current. The same treatment will be done for the GNS powder; commercial battery anode, and Mg 1.0; 2.0; 3.0; 4.0; 5.0; 10 ppm/GNS powder.

3. Results and Discussions

3.1. Analysis of XRD

The patterns X-ray diffraction (XRD) of graphite, GNS and Mg/GNS may be seen in Figure 1.

![XRD patterns of (a) graphite, GNS, commercial battery anode and (b) Mg/GNS with any percentage variations](image)

**Figure 1.** XRD patterns of (a) graphite, GNS, commercial battery anode and (b) Mg/GNS with any percentage variations

The sharp peak at 26.56° appear for graphite. It indicates C (002) is there. This data is well confirmed by JCPDS No. 75-1621 [22] (Figure 1). The graphite XRD peak is totally different with GNS. GNS has weak and broad peak at 2θ = 26.0°, indicating GNS is formed.

The pattern XRD of Mg/GNS shows a weak peak and width at 2θ = 43.79°, indicating magnesium (102) are deposited (JCPDS Number 78-0430). At 2θ = 64.16° shows the peak of magnesium (112) (JCPDS Number 035-0821). This shows that zero-frequency Mg has been deposited in GNS (Figure 1.b). The Mg peak (102) has a different peak intensity and width, meaning that the particle size of Mg in GNS varies every concentration in Mg/GNS.

3.2. Electrical properties analysis (electrical conductivity)

Graph of electrical conductivity of graphite, graphene nanosheet (GNS), commercial battery anode and Mg/GNS with with any percentage variations for voltage variations were showed in the following figure.
Figure 2. Comparison of (a) electrical conductivity and (b) current strength of graphite, graphene nanosheet, commercial battery anode, and Mg/GNS with any percentage variations

Graphs of electrical conductivity (Figure 2.a) and current strength (Figure 2.b) variation of Mg/GNS above show that the combination of GNS with metal can increase electrical conductivity and current strength. Graphene with a combination of Mg metal is higher than that of graphite, GNS and commercial battery anodes. At Mg 2.02%/GNS has the highest electrical conductivity, but at Mg 1.91%/GNS has the lowest electrical conductivity. This is because of the combination of 1.91% Mg/GNS concentration affects the electron mobility slower to move to conduct electricity.

The data above shows that graphite shows that electrical conductivity at 5-25 V has increased significantly, but at 30 V the electrical conductivity decreases, and for GNS data shows that the electrical conductivity at 5-20 V has increased significantly, but at a voltage of 25-30 V the electrical conductivity decreases. This is due to the mobility of graphite and graphene electrons having difficulty in delivering electric current. While the electrical conductivity data for commercial batteries at 5-30 V voltage has increased significantly. This is due to the presence of metal alloys so that the mobility of electrons at commercial battery anodes is able to conduct electrical currents quite well.

From the graph of electrical conductivity variation (Figure 2.a) and the graph of current variation (Figure 2.b) above can also show that the conductivity in graphene nanosheet has an electrical conductivity and strong electric current that is higher than graphite and battery anode commercial. This is because graphene has a higher surface area and thermal conductivity than graphite and carbon [23].

Graphs of electrical conductivity variation of Mg/GNS (Figure 2.a) and current strength variation of Mg/GNS (Figure 2.b) above show that the combination of GNS with metal can increase electrical conductivity and strong current. Graphene with a combination of Mg metal is higher than that of Graphite, GNS and commercial battery anodes. At Mg 2.02%/GNS has the highest electrical conductivity, but at Mg 1.91%/GNS has the lowest electrical conductivity. This is because the combination of 1.91% Mg/GNS concentration affects the electron mobility slower to move to conduct electricity.

3.3. Current Measurement of Mg 2.02%/GNS with time variations at a voltage of 30 volts
To know the stability of strong current Mg 2.02%/GNS, the measurement of current strength at a voltage of 30 volts at a time variation of 10-60 minutes.
The graph above shows that Mg 2.02%/GNS loses electrons per relatively little extra time, meaning that the use of Mg 2.02%/GNS at the battery anode can last a long time. This is because Mg has the ability to store electrons and release electrons gradually. The stability of the conductivity of graphene made of metal conduct electricity and the lifetime of the graphene-based battery is influenced by the stability of the conductivity modification of metal concentrations. The density of metals in graphene also affects the mobility of electrons in graphene [24]. Magnesium has excellent electrical properties, which can store large amounts of electrons compared to current commercial battery anodes, such as lithium. But magnesium reduction power is small, if the cathode in the battery is graphite (electron capture occurs) and the anode is used Mg metal (electron discharge occurs) then the kinetics between the anode and cathode become unbalanced, where the cathode is ready to capture electrons while the anode has not released electron. By combining Mg and GNS into Mg/GNS metals, it is expected to increase the reduction of Mg metals. In addition, the chemical interaction between Mg and GNS is also a factor affecting the activity of the battery anode electrode.

4. Conclusions
Preparation of electrodes on battery anodes is by conducting graphite synthesis into graphene (Hummer’s method) with magnesium reducing agent. And continued with the impregnation method to deposit metal in graphite and graphene. Modification of the battery anode gets good results. Mg/graphene nanosheet can be used as an alternative battery anode because of its higher conductivity (63.6945 μS/cm) compared to the commercial battery anode (26 μS/cm).

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