Study of Morphological, Optical and Electrical Properties of Graphene Oxide Thin Film Relative to the Reaction Time of Synthesis

E.Jaafar[1], M. Kashif[1], SK. Sahari[1] and Z.Ngaini[2]
[1]*Faculty of Engineering, Universiti Malaysia Sarawak (UNIMAS), 94300 Kota Samarahan, Sarawak, Malaysia.*
[2]*Faculty of Resources Science & Technology, Universiti Malaysia Sarawak (UNIMAS), 94300 Kota Samarahan, Sarawak, Malaysia*
erdajaafar91@gmail.com

***Abstract*—In this work, graphene oxide (GO) was synthesized by treating graphite powder with potassium permanganate ($KMnO_4$) and a mixture of concentrated sulphuric acid (H_2SO_4)/ phosphoric acid (H_3PO_4) at various reaction time. The GO thin film is coated on a glass substrate by using drop casting method. The morphological, optical and electrical properties of GO thin film were carried out by using scanning electron microscopy (SEM), UV-Vis spectroscopy (UV-Vis), Fourier Transform Infrared Spectroscopy (FTIR), and current-voltage (I-V) characteristic. The morphological study of GO shows that more oxygen functional groups were observed as the reaction time increases from 24h to 96h and is justified from the optical properties of GO thin films. The optical and morphological properties of GO thin film affects the electrical properties as the resistivity increase from 9.33 x 10^6Ω.cm to 26.15 x 10^6Ω.cm. Morphological and optical data confirms that 48h is the optimized reaction time having a resistivity of 12.30 x 10^6Ω.cm.**

***Index Terms*—Graphene Oxide; Reaction Time; Synthesis; Thin Film.**

I. INTRODUCTION

Carbon-based nano-materials have undergone an explosion of interest due to their unique combination of chemical and physical properties [1]. Unusual and exotic properties make the graphene, graphene oxide (GO), reduced graphene oxide (rGO) appeared as the hot topic among all the carbon-based [2]. In every field of technology [3], carbon-based nanomaterials have shown their importance including in energy sources [4]. Graphene oxide (GO) consists of a 2D network of sp^2 and sp^3 bonded atoms, while graphene sheet consist 100% sp^2 hybridized carbon atoms [5]. Furthermore, GO is a wide band gap two dimensional (2D) material with graphene sheets occupied by epoxy and hydroxyl groups at its basal plane, and carboxylic acid groups at the edges call as graphene oxide (GO) [6]. In certain aspects, GO is comparable to graphene with oxygen moieties and holds a remarkable position independent of graphene in the research field [7].

Graphene oxide (GO) is the result of the oxidizing graphite powder with oxidation agents which function as adding oxygenated functionalities to the graphite structure and exfoliate the layers [8]. There are various methods used for its synthesis which are Brodie's [9], Staudenmaier [10], Hoffman [11], Hummer's [12], Modified Hummer's and Improved Methods. In this work, graphene oxide was prepared by an improved method in order to obtain greater yield, and environmentally friendly method [13]. Graphene oxide was prepared by easy, cost-effective and convenient method via treating graphite powder with potassium permanganate ($KMnO_4$) and a mixture 9:1 mixture of concentrated H_2SO_4/H_3PO_4.

GO thin film is made up from deposition process which is process deposited the GO solution on the substrate to form a thin film by using spin coating, drop casting [14] and spray pyrolysis [15]. By using drop casting to deposit thin film, it can avoid wastage of solution during deposition and it is the simplest method. More recently with intense scientific investigations, GO thin film can be used as electron-accepting material in organic solar cells due to its unique structural [16], electronic properties [17], active electrochemical materials [18], cellular imaging and drug delivery applications [19]-[20].

Synthesis condition also influences the properties of graphene oxide including the reaction time, reaction temperature, stirring speed and synthetic route [21]. Reaction time is the condition that was explored in this study. Properties of GO are highly associated with its morphological, optical, electrical properties which are strongly dependent upon the synthesis condition. Graphene oxide was characterized by UV-Visible spectroscopy, FT-IR spectroscopy, Scanning Electron Microscopy and I-V characteristic.

II. EXPERIMENTAL METHOD

Graphene oxide (GO) was prepared by the oxidation of natural graphite powder using improved method as shown in Figure 1. Firstly, 0.75g of graphite powder was added to 4.5g of potassium permanganate ($KMnO_4$). Then the mixture of sulphuric acid (H_2SO_4)/ phosphoric acid (H_3PO_4) (90 ml: 10 ml) was slowly added. Equation (1) and (2) took place in the reaction between potassium permanganate ($KMnO_4$) and sulphuric acid (H_3PO_4) which produce diamanganese heptoxide (Mn_2O_7) to oxidize the graphite [21].

$$KMnO_4 + 3H_2SO_4 \rightarrow K^+ + MnO_3^+ + H_3O^+ + 3HSO_4^- \quad (1)$$

$$MnO_3^+ + MnO_4^- \rightarrow Mn_2O_7 \quad (2)$$