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Study on Graphene Oxide (GO) Supernatant Dilution to the Optical and Electrical Properties of TCF Based-reduced Graphene Oxide (RGO) Films

Dina Rahmawati[1], Akfiny Hasdi Aimon[1*], Ferry Iskandar[1,2], Arie Wibowo[2,3], and Khairurrijal Khairurrijal [4]

[1]Energy and Environmental Laboratory, Departement of Physics, Institut teknologi Bandung, Jl. Ganesa 10 Bandung 40132, Indonesia
[2]Research Center for Nanosciences and Nanotechnology (RCNN), Institut Teknologi Bandung, Jl. Ganesa 10 Bandung 40132, Indonesia
[3]Material Science and Engineering Research Group, Faculty of Mechanical and Aerospace Engineering, Institut Teknologi Bandung, Jl. Ganesha 10, Bandung, Indonesia
[4]Research Center for Biosciences and Biotechnology, Institute for Research and Community Services, Institut Teknologi Bandung, Jalan Ganesa 10, Bandung 40132, Indonesia

*E-mail: akfiny@fi.itb.ac.id

Abstract. Graphene is a potential material to replace indium tin oxide (ITO) and fluorine tin oxide (FTO) as a transparent conductive films (TCF) due to its high conductivity and transparency. In this study, fabrication of graphene-based TCF was carried out by means of the drop-casting method, with graphite oxide as the raw material. The graphene oxide (GO) was diluted by adding 1, 3, 5, and 7 ml of distilled (DI) water. The sample was also heat treated to ensure complete reduction process. The deposited films were characterized using UV-Vis spectroscopy and I-V to investigate their optical and electrical properties. Based on the measurement results, sample with 3 ml DI water addition gives transparency and sheet resistance (Rs) of 41.01 % and 9.43 kΩ/sq, respectively. This material has a great potential to be applied as the optoelectronics material.

1. Introduction

Transparent conducting film (TCF) is a thin layer of material that has high electrical conductivity and excellent optical transparency. To this day, ITO and FTO are two types of material that commonly used as TCF [1,2]. However, these two materials are high expensive due to its rare earth raw material and high production cost [3]. Therefore, graphene, which has electrical conductivity of 6000 S/cm and high transparency of 97 %, is a strong candidate as a substitute material ITO and FTO to be applied as TCF [4,5].

Various synthesis methods have been developed to synthesize graphene including the chemical vapor deposition (CVD) [6], epitaxial growth on the Si-C substrate [7], a mechanical exfoliation of graphite (Scotch-tape) [8], and wet chemical [9]. Wet chemical method is a promising method to synthesize graphene for its low-cost process, large-scale fabrication, efficient and effective synthesis process

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[10,11]. This method is carried out by synthesizing supernatant of graphene oxide (GO) and followed by reduction process, in order to achieve RGO sample.

It is necessary to study the electrical properties and transparency of RGO-based TCF. Dilution of GO supernatant is one of several aspects that needs to be optimized to improve the conductivity and transparency of the film. In this study, GO supernatant was diluted by addition of 1, 3, 5, and 7 ml of distilled (DI) water. The deposited films were characterized to study sheet resistance (Rs) and transparency (Tr) properties of the samples. This study gives new information on preparation and properties of RGO-based TCF.

2. Experimental Setup

Fabrication of RGO films was initiated by synthesize graphite modified using a Marcano [10] and Hummer [11] methods. The graphite oxide exfoliation process was then carried out using an ultrasonic homogenizer for 30 minutes, followed by centrifugation at 4000 rpm. Afterward, 1 ml GO supernatant was by dissolving it in 1, 3, 5, and 7 ml of DI water. Sample was mixed with LAA in a ratio of 5 : 1, and the solution was stirred at 900 rpm in the ice bath for 30 minutes. Then the deposition process is carried out onto a glass substrate by dripped 50 µl / of supernatant. The evaporation process was carried out slowly at room temperature for 12 hours. Furthermore, the thermal reduction treatment by heating in the furnace at 200 °C for 30 minutes. RGO-LAA films were characterized using I-V and UV-Vis spectroscopy to investigate their sheet resistance (Rs) and transparency (Tr). The synthesized GO was tested by FTIR to investigate its chemical composition.

3. Result and discussion

Figure 1. shows FTIR spectra of the synthesized GO. There is a broad peak at wavenumber of 3000-3700 cm^{-1} which indicates stretching vibrations of hydroxyl group [12]. FTIR spectra in figure 1 also shows several sharp peaks correspond to vibration of C-H bond (2917 and 2847 cm^{-1})[10], C=O bond (1739 cm^{-1}) [12,13], C=C bond (1619 cm^{-1}), C-O bond (1224 and 1054 cm^{-1}) [13,14]. The FTIR results indicate that GO supernatant has been successfully synthesized.

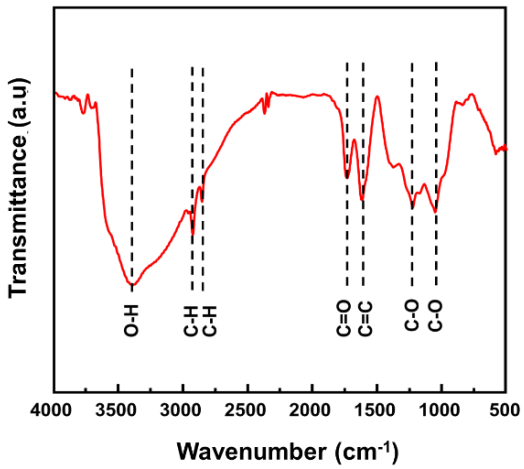

Figure 1. FTIR spectra of the synthesis of GO.

Figure 2 shows appearance of GO supernatant without (a) and with (b) dilution using DI water. It can be seen that the GO supernatant before dilution has a dark brown color. However, after dilution with 1, 3, 5, and 7 ml in the DI water, the supernatant solution turned into brighter color. The results of UV-Vis characterization of GO films is shown in figure 2 (c). Transparency of GO films increases as higher amount of DI water is added. RGO film that was prepared without addition of DI water has Tr value of 1.24 %. Meanwhile, RGO film that were prepared by adding 1, 3, 5, and 7 ml DI water show higher Tr value of 26.07, 41.01, 53.84, and 61.12 % respectively.

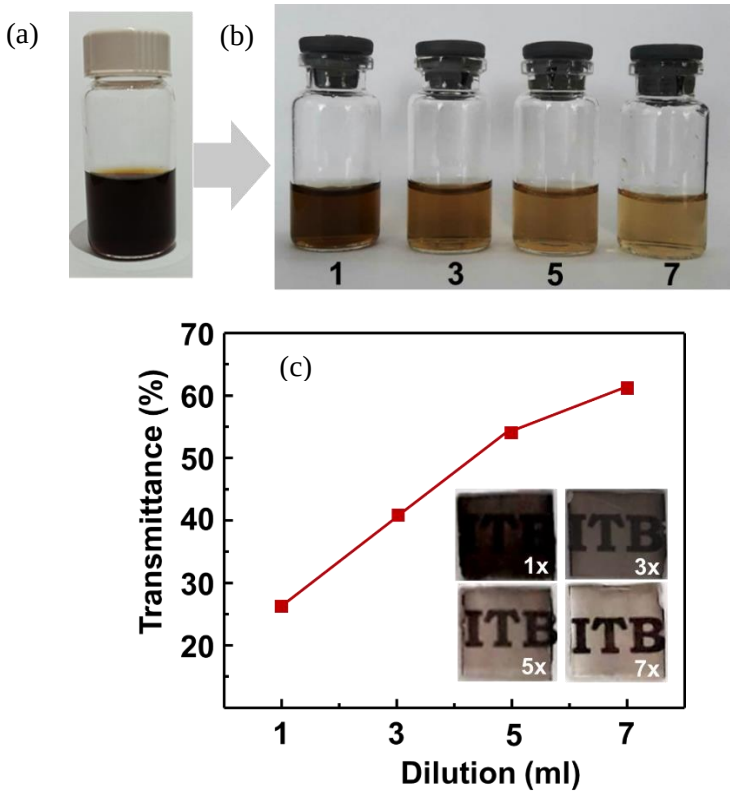

Figure 2. Appearance of GO supernatant (a) without and (b) with addition of 1, 3, 5, and 7 ml of DI water (left to right) (c) Transmittance of GO films prepared by diluting GO supernatant.

Figure 3 shows Rs value of the RGO films using I-V characterization. RGO films that were prepared with addition extra DI water show Rs of 3.42 kΩ/sq. Samples with 1, 3, 5, and 7 ml of DI water dilution give of 8.06; 9.43; 45.36 and 89.88 kΩ/sq, repectively. Based on UV-Vis and I-V characterization, it can be concluded that DI water dilution provides higher Tr and Rs values. This result is reasonable as more dilution will lower concentration of GO in solution. However, in order to be able to apply the sample as a TCF, material with high Tr and low Rs values is favorable. From I-V and UV-Vis characterization results, it can be concluded that the sample with 3 ml of DI water addition has the optimum Tr and Rs values. It is suitable enough to be applied as TCF materials.

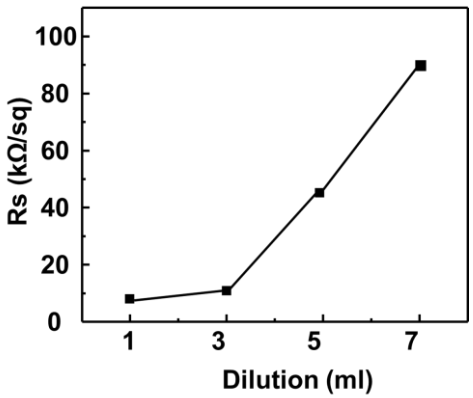

Figure 3. RGO-based TCF sheet resistance (Rs) value of RGO films prepared by diluting GO supernatant.

4. Conclusion

RGO-based TCF was successfully deposited by means of drop casting method. The effect of GO supernatant dilution with 1, 3, 5, and 7 ml DI water were studied based on optical and electrical characterization of RGO film. Sample with 3 ml dilution in DI water gives the best result with Rs 9.43 kΩ/sq and Tr 41.01 %, respectively. This result has potential to be applicated as TCF material.

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