Journal of Materials and Electronic Devices 1 (2022) 43-46

Phosporous doped graphene oxide thin film battery

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Phosporous doped graphene oxide (p-GO) was synthesized using modified Hummer's method to fabricate a battery. The chemical structure of phosporous doped graphene oxide was analyzed by X-ray diffraction and FT-IR techniques. The photoelectrical characteristics of the battery indicate that phosporous doped graphene oxide (p-GO) ,gives an open circuit voltage (1.0 V) and short circuit current (0.51 mA). These results that suggests that phosporous doped graphene oxide (p-GO) based battery can be used in energy applications.

Keywords: *Graphene oxide, spin coating, X-ray diffraction, battery*

Submission Date: 27 February 2022
Acceptance Date: 08 May 2022

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1. Introduction

The graphene is a promising materials due to interesting properties such as electrical, optical and mechanical properties. [1] and exhibited a high electrical and thermal conductivity, and mechanical properties [2-4]. The graphene can be used in various applications such as supercapacitors, nanocomposites sensors and batteries,[8]. There are some derivates of graphene such as graphene oxide and reduced graphene oxide (GO) [5-9].
The graphene oxide has been synthesized using various methods [10-13]. Modified Hummer's method is well known method. The single-layered graphene oxide is synthesized by exfoliation of graphite oxide [14] and it can then be coated on various substrates for various applications. The surface modifications of graphene can be done by oxygen functionalities in the graphene oxide [15]. The graphene and graphene oxide have been used for preparation of energy based devices batteries [16-17]. Metal oxide-graphene oxide nanocomposites have been prepared by hydrothermal method [18]. The electrical and optical properties of graphene can be iproved using various dopants such as phosphorous. Thus, in present study, we have prepared phosporous doped graphene oxide (p-GO) to prepare a battery. The electrical performance of phosporous doped graphene oxide (p-GO) based battery has been investigated.

2. Experimental

Hummer's method is used to prepare the graphene oxide was synthesized [19]. The nominal value of graphite was dissolved in H_2SO_4 in ice bath and stirred for 2 hrs. To the solution, the nominal values of KMnO4 and NaNO3 were added. The obtained solution was stirred for 30 min. After this stirring process, the de-ionized water was added, and the temperature of the solution was raised to 98 oC for 30 min. Finally, de-ionized water (300 mL) and H_2O_2 (40 mL, 35%) were added to the solution. The powders were washed, filtered, and dried at 50 oC for 48 hours.
Phosporous doped graphene oxide (p-GO) based battery was prepared on FTO glass. Firstly, the electrical resistance of the FTO glass was measured using a FYTRONIX 9000 Four Probe electrical system. This system measures automatically by applying optimum current. The electrical resistance of FTO glass was found to be 7.8 Ohm/Square. Then, FTO

glass substrate was ultrasonically cleaned in acetone for 15 min and in isopropanol for 10 minutes.

The phosporous doped graphene oxide was coated on FTO glass using a FYTRONIX Dip coater and was heat treated at 300 ºC for 30 min. The prepared phosporous doped graphene oxide based battery is shown in Fig.1. The current electrodes were prepared on P-GO oxide layer by silver paint. The copper chloride ($CuCl_2$) electrolyte was prepared in 3M water. X –ray diffraction pattern of P-GO was performed by a Bruker AXS (D8 Discover) X-ray diffractometer (CuKα (λ = 1.5405Å). A PARK system XE 100E atomic force microscopy was used to investigate surface morphology of p-GO film. FT-IR spectra of p-GO sample were performed using Thermo Scientific spectrophotometer.

The current-voltage characteristics of p-GO based battery were measured using a FYTRONIX 9712 electronic device characterization system.

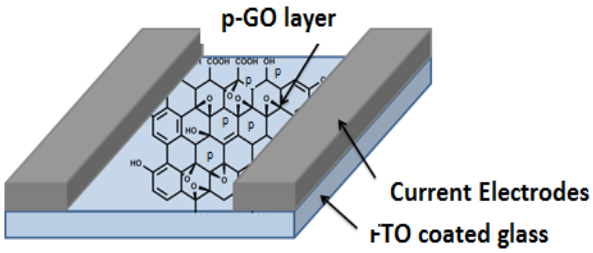


Fig.1. Schematic diagram of the phosporous doped graphene oxide (p-GO) based battery [19]

3. Results and Discussion

Fig. 2 shows X-ray diffraction pattern of p-GO sample. A peak was observed at 10.63º of XRD pattern which confirms the structure of the graphene oxide. The peak position (10.27º) is close to the graphene oxide [10].

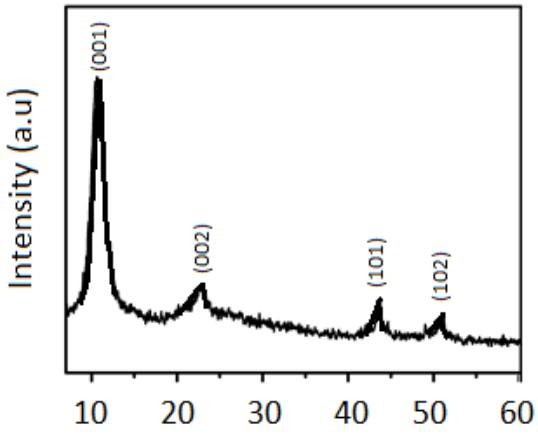
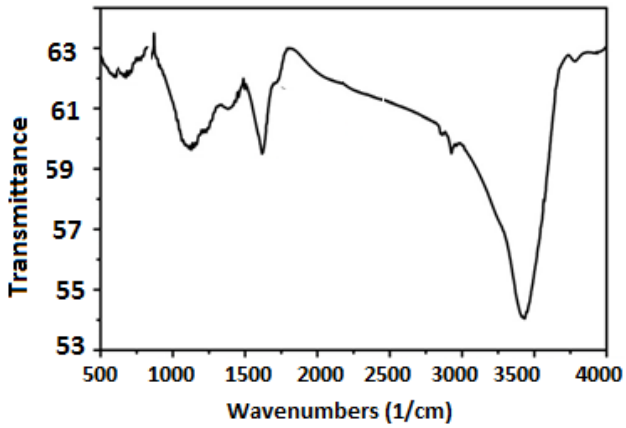


Fig. 2. XRD pattern of p-doped graphene oxide

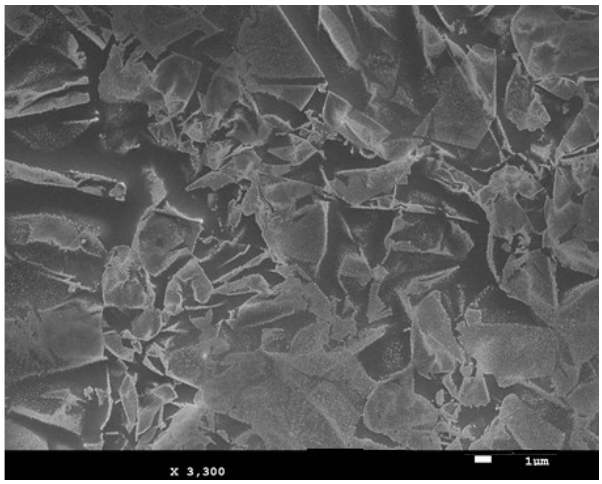
The chemical composition of p-GO sample was analyzed FT-IR spectroscopy. FT-IR spectrum (Fig.3a) of the doped graphene oxide. A C=O stretch peak was observed at 1734 cm^{-1} which corresponds to the carboxylic group [21]. The peaks at 1102 cm^{-1} and 1622 cm^{-1} corresponds respectively to the alkoxy C-O stretching vibration and C-O stretch mode of the carboxylic groups [22].

A absorption peak (3300–3500 cm^{-1}) is observed and this peak is arising from hydroxyl groups. The obtained FTIR peaks confirm the chemical structure of the graphene oxide [23, 24].

Scanning electron micrcope image of p doped graphene oxide is shown in Fig.a. As seen in Fig.3a, the graphene oxide is interacted with electrolyte. The p-graphene oxie layer is absorbed the electrolyte and in turn, the battery gives a power.



(a)



(b)

Fig.3. a) FT-IR spectra of p-doped graphene oxide b) SEM image

The current-voltage characteristics of p-doped graphene oxide were measured using a FYTRONIX battery analyzer and I-V characteristics of the p-doped graphene oxide based battery are shown in Fig.4. As seen in Fig. 4, the I-V plot gives an open circuit voltage

(1.03V) and short circuit current (0.55 mA). The power-voltage plot of the battery is shown on Fig.4. The battery exhibited a maximum power at 0.145 mW. The electrical parameter is higher than the graphene oxide battery [24]. It is evaluated that the phosporous increased the battery performance. The performance of the graphene oxide battery can be improved using various dopants.

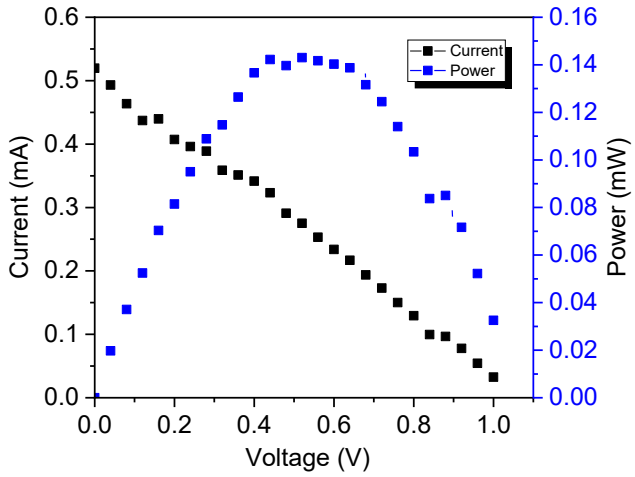


Fig. 4. Current-voltage characteristics, (b) power-voltage characteristics of p-doped graphene oxide based battery

4. Conclusion

P-doped graphene oxide based battery has been fabricated on FTO glass. The The chemical structure of graphene oxide was investigated by X-ray diffraction and FT-IR studies. The The open circuit voltage and short circuit current parameters were found respectively to be 1.03 V and 0.51 mA. The obtained results suggest that the graphene oxide based battery can be improved with various dopants.

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