Investigation of the super capacitor uses of $ZnFe_2O_4/Co3O_4/G$ composite

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Abstract: There have been several publications on the testing of ZnFe2O4, Co3O4, and graphene's viability for supercapacitor applications. The goal of the current study is to demonstrate how the qualities necessary to be considered as a candidate material for supercapacitor use are affected by the combination of these three materials. Simple drop casting is used to create these composites. X-ray diffraction (XRD) and scanning electron microscopy (SEM) are used to validate the composite's production. Cyclic voltammetry is used to determine the suitability of this composite electrode. The outcome demonstrated a superior specific capacitance of 590 Fg-1 at 20 mVs-1 demonstrating it to be a strong contender for supercapacitor applications.

Keywords: Energy, Graphene, XRD, SEM

1. Introduction

The increasing demand for energy storage systems with high energy density, rapid charge-discharge capabilities, and extended cycle life has fueled research into advanced electrode materials for supercapacitors. Traditional electrode materials have limitations such as low specific capacitance and limited energy density. To address these challenges, composite materials have gained significant attention due to their ability to combine the unique properties of different components.

This paper focuses on the development of a ternary composite electrode material composed of zinc ferrite ($ZnFe_2O_4$), cobalt oxide (Co_3O_4), and graphene (G). Zinc ferrite is known for its excellent conductivity and high theoretical specific capacitance, while cobalt oxide offers excellent redox behavior. Graphene, on the other hand, provides outstanding electrical conductivity and mechanical stability. The integration of these three materials is expected to create a synergistic effect, resulting in improved electrochemical performance for supercapacitor applications.

The synthesis of the $ZnFe_2O_4/Co_3O_4/G$ composite involves well-established methods for each component, ensuring the formation of uniform nanoparticles with high crystallinity. The graphene sheets are prepared via a modified Hummers' method [1], while zinc ferrite and cobalt oxide nanoparticles are synthesized using sol-gel and hydrothermal methods, respectively [2][3].

2. Results and Discussion

XRD is used to determine the crystal structure and phase composition of the ternary composite. The diffraction peaks in the XRD pattern confirm the formationof ternary composite in the electrode (Fig 1). Two set of the diffraction peaks of (220), (311), (400), (511), (440) are observed for $ZnFe_2O_4$ and Co_3O_4 and the (311) peak confirms spinal structure [4, 5]. All data were verified from JCPDS file and all such peaks were matches with the compound which is used in the compositions for the formation of ternary composite materials for electrode. The diffraction peak (002) present at 2θ of 26.82° represents presence of graphene in the composite.

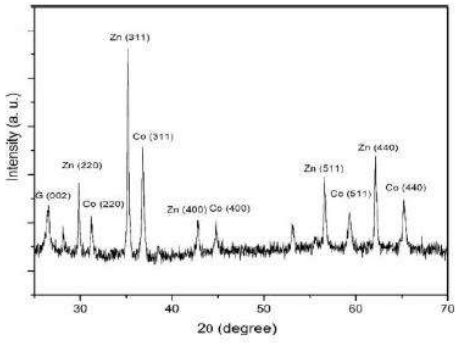

Fig 1 XRD spectrum of ternary composite electrode

Fig 2 (a) and (b) show the SEM micrographs of the ternary composite electrode at different magnification and location. In these images it is observed that, small granular structure of $ZnFe_2O_4$ form along with slightly bigger particle of Co_3O_4 over the surface of larger sheet like structure of graphite. It confirms the presence of $ZnFe_2O_4$, Co_3O_4 with graphitic sheet present in the composites. In SEM images, it is observed that the developed composite structure is porous in nature which is in favour to increase surface area of the electrode. In addition, presence of graphitic sheets also facilitates

to enhance the specific surface area of electrode which significant characteristics of two-dimensional material.

Therefore, such evolved structure ultimately increasing the capacity of the synthesized electrode. Moreover, the grain of $ZnFe_2O_4$ and Co_3O_4 are observed to be well connected to each other which is favourable for electron transport in the electrode by providing the path to the conduction electron.

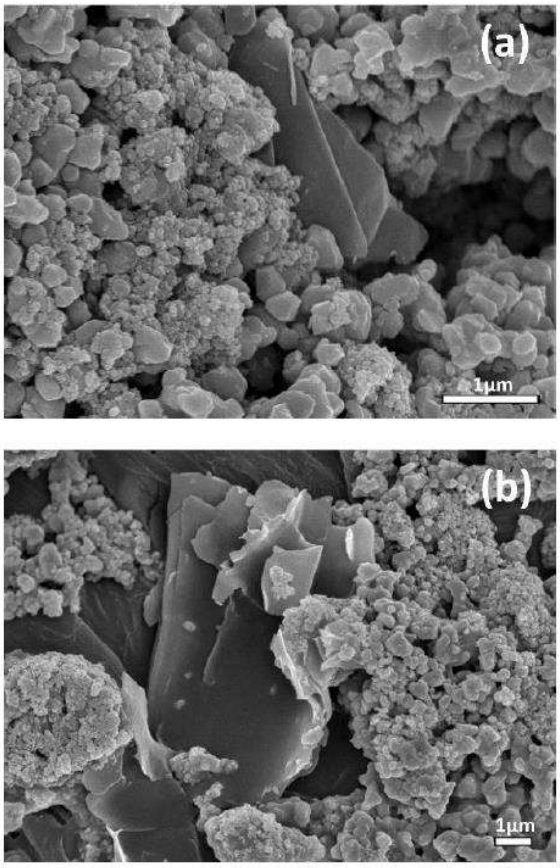

Fig 2 SEM micrographs (a) and (b) of ternary composite electrode at different places and magnifications

The synthesized electrode was then assembled in symmetric supercapacitor where 1M KOH solution used as an electrolyte. CV measurement was performed within a potential range between -0.5 to 0.5 with different scanning rate varying from 20-500 mVs^{-1} is shown in Fig. 3 (a). From the CV curve it is notice that, the curves form almost rectangular in shape, that is mainly characteristics of carbon based (Graphene) electrode performing EDLC. But there are some broad peaks developed in the CV portion in all the scan taken at different scan rates. It is because of the redox process occurred with the addition of Co_3O_4 and $ZnFe_2O_4$ over carbon (graphene) based electrode. Therefore, it indicates the ternary composite have some pseudocapacitive behaviour along with EDLC which is resulted in higher specific capacitance of value 590 Fg^{-1} at 20 mVs^{-1}.

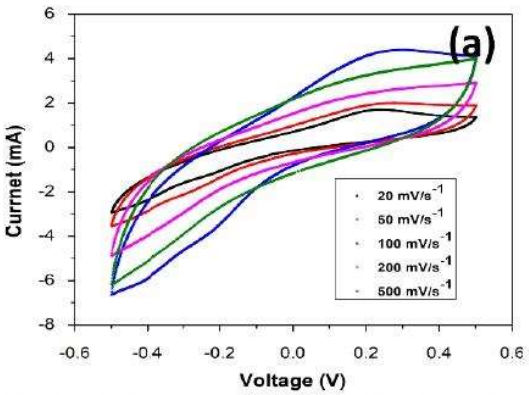

Fig 3 (a) CV curve of ternary composite at different scan rate

3. Conclusion and Future Directions

The as synthesized $ZnFe_2O_4/Co_3O_4$/graphene ternary composite electrode exhibited good electrochemical performance with enhanced value of the specific capacitance 590 Fg^{-1} at 20 mVs^{-1}. The facile synthesis of solution and drop casting method is cost effective, fast, easy and to have non-toxic procedure for generating composite electrode for supercapacitor with effective performance. XRD were used to for phase confirmation, SEM showed the formation granular structure of ternary composite over the entire electrode. The device performance was evaluated in two electrode system and the results obtained from the CV, GCD and EIS reveal enhanced capacitance of the electrode. The electrode exhibited a specific capacitance of 590 Fg^{-1} at 20 mVs^{-1}.

4. References

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