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Electrochemical Properties of Cobalt Doped $GdAlO_3$

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ABSTRACT

Nanocrystalline (GAG) $GdAlO_3:CO^{2+}$is prepaid by combustion process. The morphology, structure and particle size of the prepared $GdAlO_3:CO^{2+}$sample characterized by transmission electron microscope (TEM) image. The cyclic voltammetry (CV) and electrochemical impedance spectroscopy (EIS) studies clearly indicate that Co^{2+} dopant was successful doping material due to increasing the reversibility by reducing the E_O-E_R value of the electrode reaction. The R_{Ct} and double layer capacitance of the electrodes were recognized by fitting the equivalent circuit for EIS spectrum. $GdAlO_3:Co^{2+}$composite material could be a promising electrode material for the fabrication of super capacitors.

Keywords : Perovskite, GAG, TEM, Cyclic Voltammetry (CV) , Electrochemical Impedance Spectroscopy(EIS)

I. INTRODUCTION

Nanomaterials have attracted attention due to their interesting properties and potential application in many important areas such as: microelectronics, sensing, environmental remediation, biomedicine etc. Generally, the properties of these materials are due to their high quantum yield, high molar extinction coefficient, broad absorption spectra ranging from ultraviolet to near-infrared with narrow fluorescence emission in the visible region [1]. which generate interest in the synthesis of nanoparticles .Study of $GdAlO_3$ nanoparticles are attractive for nanoscience as well as for nanotechnology applications on photoluminescence, semiconductors, photocatalysists, gas sensors, UV photodetector, light emitting diodes (LEDs), solar cells etc [2,3].

In 21st century energy is a fundamental worldwide issue for the human society .Energy we needed is provided by fossil fules.But it is not renewable and also it emits pollutants while burning which degrade the environment and greenhouse gases lead to global warming problem[4,5]. Such frameworks require the advantages of compactness and energy effectiveness while being environmental friendly [6]. The technology and systems of an external thermal interface or that of an external electrical interface embrace by Energy

conversion and storage systems [7] .Based on amount of energy and power available for the load they are categorised into groups which includes batteries, fuel cells, capacitors and supercapacitors [8].

In order to study the effect of cation dopant on the structure , Cyclic Voltammetry and ac impedence of perovskite $GdAlO_3$, In this paper $GdAlO_3:CO^{2+}$ prepaired by solution combustion method [17]and observed its characteristics and study of cyclic voltammetry (CV), electrochemical impedance spectroscopy (EIS)[9] in presence and absence of Paracetamol in1MKOH electrolyte.

II. EXPERIMENTAL

2.1 Preparation of sample

GdAlO3:CO^{2+} (15mol) synthesised using the solution combustion method by using stoichiometric quantities of gadolinium nitrate [Gd $(NO_3)_3$], aluminium nitrate (Al $(NO_3)_2$**,** cobalt nitrate CO $(NO_3)_2$, laboratory prepared Oxalyl dihydrazide (ODH:$C_2H_6N_4O_2$) fuel were dissolved in doubled distilled water. A homogeneous solution obtained after stirring 15min. The resultant solution was placed in a furnace pre heated at 400^oC for, until surplus free water evaporated and natural ignition occurred ensuing in a fine powder product obtained after grinding. Finally, the as prepared powders were calcined at 1000^oC for 3 h. The resulting $GdAlO_3:CO^{2+}$powder were cooled down to room temperature and mixed well by using a pestle and mortar.

2.2 Preparation of the modified electrode

The sample, graphite powder and silicone oil ratio was 15:70:15 % by weight and were mixed in an agate mortar for about 40 min. the carbon paste was packed in to the of homemade carbon paste electrode and then smoothened on a tissue paper till the surface become uniform.

III. RESULTS AND DISCUSSION

3.1 Transmission Electron Microscope (TEM)

In order to determine the morphology of the sample, typical transmission electron microscopy (TEM) measurements were carried out and are presented in Fig. 1. represent the TEM micrograph of $GdAlO_3$ containing 15mol % of CO^{2+} It is clear from Figure 1 that irregular to round shaped, nanophosphors with particle size 100nm were formed

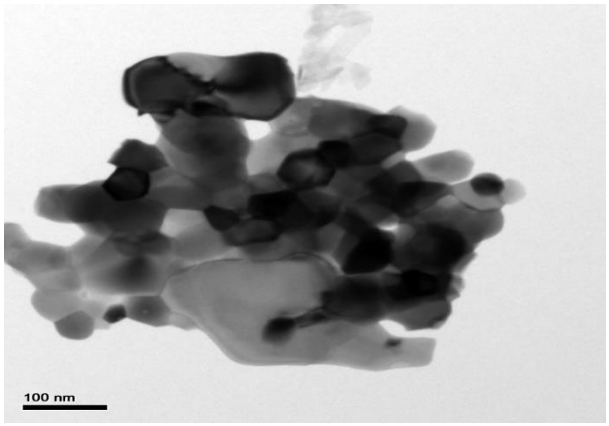

Fig 1. TEM images CO^{2+}doped $GdAlO_3$.

3.2 CYCLIC VOLTAMMETRY

Cyclic voltammograms (CVs) analysis used for understand the electrochemical performance of the Cobalt doped $GdAlO_3$ electrode for super capacitor during charging and discharging processes. In order to understand the effect of various mol concentrations on the electrochemical performance of $GdAlO_3:CO^{2+}$ nanoporous carbon electrodes, the CV experiments were conducted for the electrodes with different mol concentration. Fig.2 successively represents the CV cures for $GdAlO_3:CO^{2+}$ (15mol%) electrodes at different scan rates (10, 20, 30, 40 and 50 mVs^{-1})in 1 M KOH electrolyte and with 2 ml of Paracetamol electrolyte concentration using a platinum wire as counter electrode and Ag/AgCl as a reference electrode in the potential window between –0.1 and 0.6 V[10]. Here, the capacitance was mainly based on the redox reaction because the shapes of the CVs were distinguished from the shape of the electric double-layer capacitance, which is normally close to an ideal rectangle [11,12].

The quantification of charge efficiency, charge-discharge of electrodes and the reversibility of the electrode reaction were carried out using cyclic voltammetry. The reversibility of the electrode reaction was measured by taking into account the difference between the oxidation potential (E_O) and the reduction potential (E_R) [13] at 20 mV/s scan rate. Smaller the value of E_O-E_R, more reversible was the electrode reaction. This result shows the prepared electrode material is used for sensor applications.

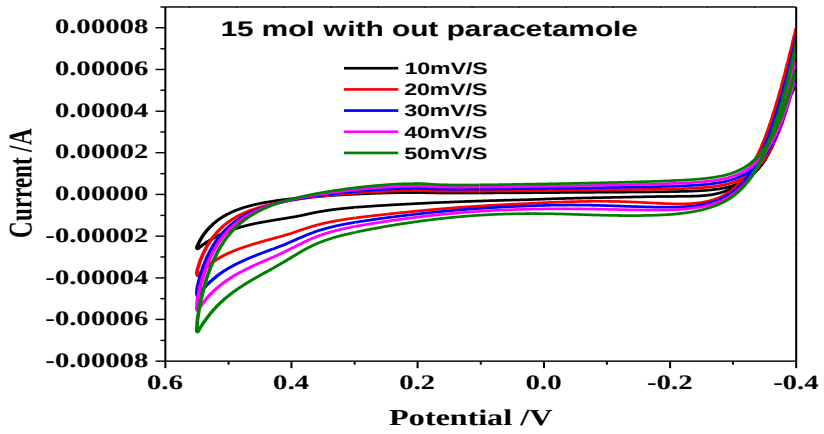

Fig.2. a) Cyclic voltammogram of Cobalt doped $GlAlO_3$ in 1M KOH electrolyte.

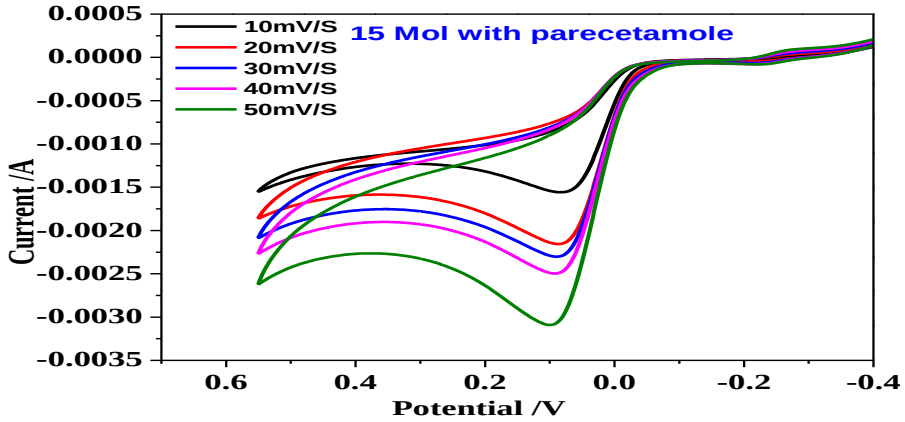

Fig.2 b) Cyclic voltammogram of Cobalt doped $GlAlO_3$ in 1M KOH electrolyte with 2 ml of Paracetamol

3.3 AC IMPEDENCE

Electrochemical impedance spectroscopy (EIS) measurements are very essential in assessing the resistive characteristics of the electrode. It shows the response of components performance in the frequency domain [14]. EIS were carried out with ac amplitude of 5 mv and frequency range of 1hz to 1Mhz in order to evaluate the frequency response of $GdAlO_3:CO^{2+}$(15mol%) electrode in 1 M KOH electrolyte and with 2 ml of Paracetamol. The Nyquist plots for the electrodes are depicted in Fig. 3The EIS data was analysed using Nyquist plots and each data point is at a different frequency. The Nyquist plots consists of two frequency regions, a high frequency region denoted by a semicircle which represents the transfer of charges occurring at the electrode/ electrolyte interface and the low frequency region signified by a straight line representing the diffusion of ions in the electrolyte. The equivalent series resistance (ESR) can be obtained from the x- intercept of the Nyquist plot and the charge transfer resistance Rct can be directly measured as the diameter of the semicircle arc on the real axis [15]. The ESR and Rct values of the electrochemical is indirectly proportional to results of the specific capacitance, specifically, the higher the Rct value, the lower the specific capacitance of the electrochemical capacitor . specific capacitance get affected due to the presence of paracetamol in the electrolyte

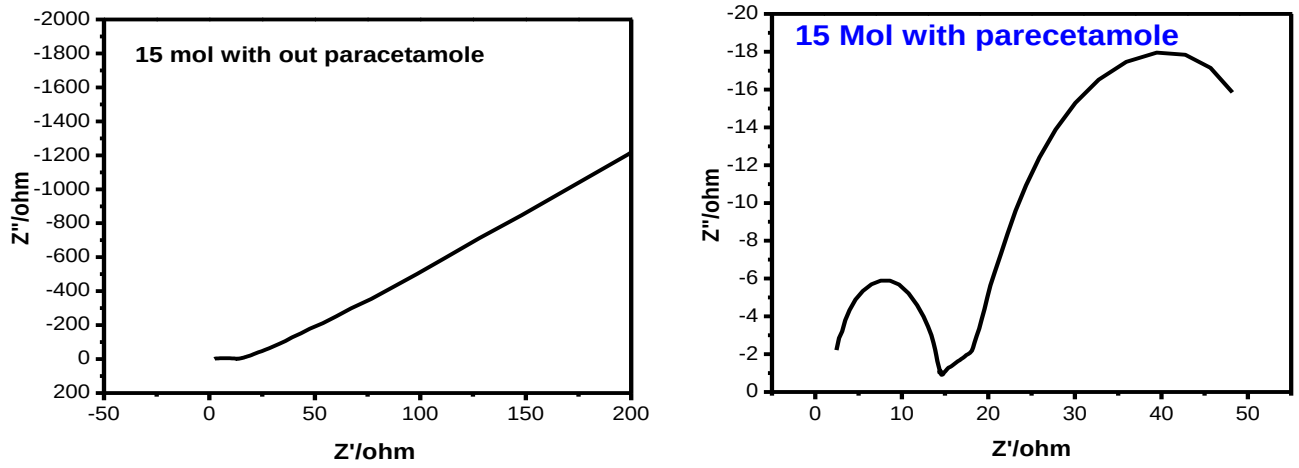

Fig.3.a) Nyquist plot with simulation of Cobalt doped $GdAlO_3$ in 1M KOH electrolyte .

b) Nyquist plot with simulation of Cobalt doped $GdAlO_3$ in 1M KOH electrolyte with 2 ml of Paracetamol

Table 1 Impedance parameters of $GdAlO_3:CO^{2+}$ and Oxidation potential (E_O), reduction potential (E_R), the difference between E_O and E_R

CO^{2+}mol%	ESR(Ω)	R_{ct}(Ω)	E_O(V)	E_R(V)	E_O-E_R(V)
15	15	13	-0.2	-0.300	-0.1
15 with parecetamol	14	11	0.08	-0.02	0.06

IV. CONCLUSION

Cobalt doped $GdAlO_3$ compositions were prepared by solution combustion method. The structure were analysed by TEM. The CV studies clearly indicate that Paracetamol additive were successful in increasing the reversibility by reducing the E_O-E_R value of the electrode reaction. Paracetamol additive enhances the

performance of the positive electrode by reducing the resistance of the $GdAlO_3:CO^{2+}$electrode. As a future perspective, we believe that $GdAlO_3:CO^{2+}$ composite material could be a promising electrode material for the fabrication of various sensors, super capacitors and solar cells .

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