

# Hydrothermal Synthesis Of Copper Oxide/Cobalt Oxide Nanoparticles For Supercapacitor Applications

N. Maheswari, R. Nithya, S. Kalpana, S.Rafi Ahamed

**Abstract:** This paper analysis the results on CuO/Co<sub>3</sub>O<sub>4</sub> material prepared by hydrothermal method with addition of surfactant. The SEM, XRD and FTIR studies were used to analysis the morphology and structure of the samples. The electrochemical performance of the samples was analyzed by three electrode system. In Charge-discharge studies, the specific capacitance of 666 F g<sup>-1</sup> was obtained at a current density of 5 A g<sup>-1</sup>. From impedance spectrum, low charge transfer resistance value was obtained. Based on these studies, we confirm that that the prepared electrode is best material for electrochemical applications.

**Keywords :** Metal oxides, electrolyte, impedance, Specific capacitance. Copper oxide, electrode, Charge-discharge

## 1 INTRODUCTION

Electrochemical capacitors are essential electrical energy storage devices due for their high power density, easy and fast recharge and excellent cycle life better than batteries. These devices used in applications such as power devices such as camera flash, cellular phones and hybrid cars [1-4]. In Hybrid supercapacitors, the charge storage mechanism has been occurred both electrostatically and faradically (redox reactions). This can be classified into composite, asymmetric and battery type hybrid capacitors [5-8]. The electrolytes are one of the essential matters to measure the capacitance of the supercapacitor. Therefore in choosing an electrolyte one must consider the capacitance, ESR and potential. The choice of electrolyte also depends on the application of the supercapacitors [9]. Particle size and morphology can be controlled by adding particular functional groups that stabilize the nanoparticles and prevents them from aggregation[10]. These functional groups are known as capping agents / surfactants. Surfactants are a large group of surface active substances with a great number of applications. Here, disodium citrate is used as surfactant [11-15]. Mixing of copper oxide with Co<sub>3</sub>O<sub>4</sub> yields a metal oxide with greater electronic conductivity and electrochemical activity [16]. In the present paper we report the CuO/Co<sub>3</sub>O<sub>4</sub> electrode and their electrochemical behaviour

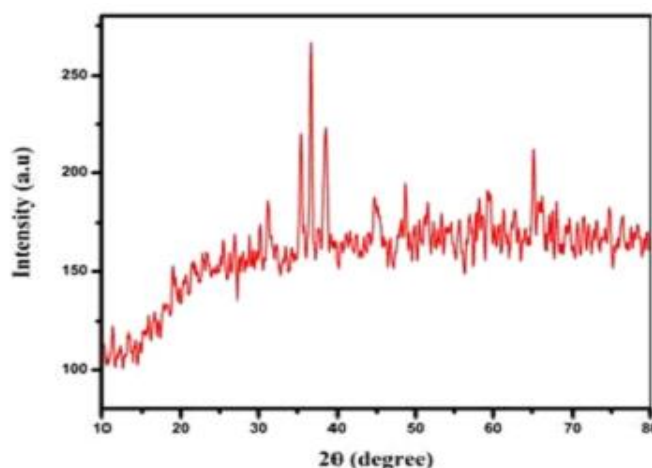
## 2 EXPERIMENTAL METHODS

In CuO/Co<sub>3</sub>O<sub>4</sub> was prepared by the hydrothermal method. In synthesis, Cu (NO<sub>3</sub>)<sub>2</sub>·3H<sub>2</sub>O and and Co (NO<sub>3</sub>)<sub>2</sub>·6H<sub>2</sub>O were dissolved in 40 mL of water. Disodium citrate was used as the capping agents. Urea as the reducing agent. After stirring, the solution was kept in stainless steel autoclave and maintained at 120 °C for 20 h.

The precipitate formed following this process was washed several times with distilled water and ethanol. The resulting precipitate was dried at 80 °C. The completely dried powder was ground and annealed of air at 600 °C for 5 h. Electrochemical analyses were performed using a three-electrode cell. 1 M NaNO<sub>3</sub> in PVA gel electrolyte was used as the electrolyte. The working electrode was prepared by solution casting technique. This electrode was dried at 80°C for 12 h in an atmosphere of air. The prepared working electrode was subjected to electrochemical measurements.

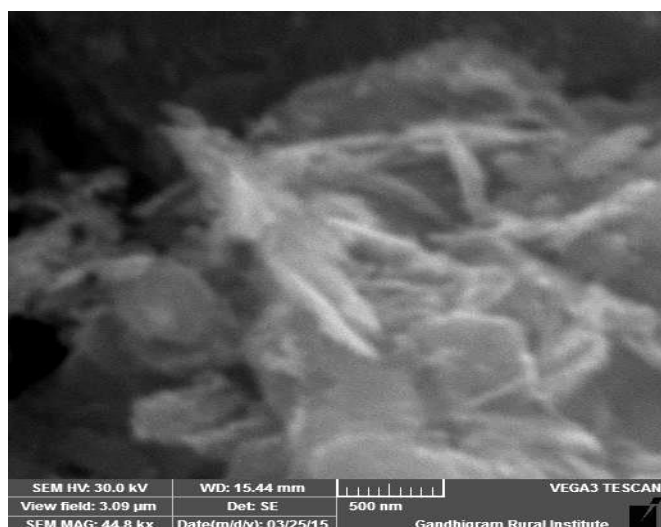
## 3 RESULTS AND DISCUSSION

Figure 1 shows the XRD Pattern. In confirms that presence of CuO/Co<sub>3</sub>O<sub>4</sub> particles. The FTIR analysis of CuO/Co<sub>3</sub>O<sub>4</sub> particles are examined. The bands centered at 570 and 659cm<sup>-1</sup> corresponds to Co-O bond of Co<sub>3</sub>O<sub>4</sub> and Cu- O bonds [16]. The weak band at 1385cm<sup>-1</sup> attributed to stretching vibrations of NO<sub>3</sub><sup>-</sup> ions [17]. All these spectra reveal absorption bands in the region 2800–2900 cm<sup>-1</sup> which is due to the C–H stretching mode of hydrocarbons [18]. The absorption band at 1000–1300 cm<sup>-1</sup> is assigned to the O–C and C–C bond vibrations [19]. The bands observed at 1637 and 3378 cm<sup>-1</sup> correspond to OH [20].



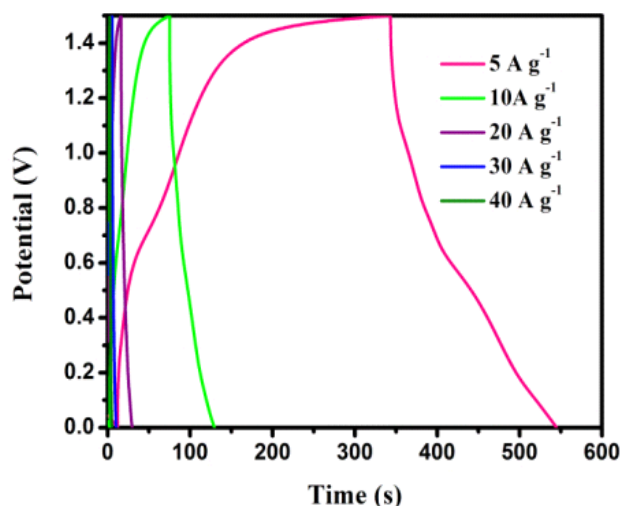
**FIGURE 1.** XRD pattern of CuO/Co<sub>3</sub>O<sub>4</sub>

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**FIGURE 2.** SEM images of CuO/Co<sub>3</sub>O<sub>4</sub>

SEM image of CuO/Co<sub>3</sub>O<sub>4</sub> material was analyzed in figure 2. It shows the a nanoflake like structure. This kind of morphological structure is more beneficial for the supercapacitor application. To study the electrochemical features of CuO/Co<sub>3</sub>O<sub>4</sub> nanostructure, charge- discharge and impedance spectroscopy measurements were carried out from 0 to 1.5 V. Figure 3 shows the CHDH sketch of prepared CuO/Co<sub>3</sub>O<sub>4</sub> electrode at different current densities



**FIGURE 3.** Charge-discharge curves of CuO/Co<sub>3</sub>O<sub>4</sub>

The galvanostatic charge-discharge curves of copper oxide were obtained in a potential window of 0 to 1.5 V. The specific capacitance of carbon electrode was estimated by the following equation [21], Where  $C_s$  is the specific capacitance ( $F g^{-1}$ ),  $i$  is the current density (A),  $m$  is the mass of the active material (g),  $\Delta V$  is the potential window (V) and  $\Delta t$  is the discharge time (s). Figure 5 shows charge- discharge profile of CuO/Co<sub>3</sub>O<sub>4</sub> electrode at different current densities. The calculated maximum specific capacitance value is  $666 F g^{-1}$  at  $5 A g^{-1}$  current density. To further elucidate the origin of high electrochemical performance, electrochemical impedance spectrum was obtained to examine the charge transport, internal resistance and charge transfer

kinetics of copper oxide electrode. EIS was recorded in the frequency range 0.01 to 100 kHz. From the resulting Nyquist plot the charge transfer resistance associated with the faradic reactions. The lowest charge transfer resistance  $R_{ct}$  ( $1.068 \Omega$ ) observed for mixed electrode prepared in the present work.

## 4 CONCLUSION

In last, We give a easy methodology to prepare CuO/Co<sub>3</sub>O<sub>4</sub> by hydrothermal method. CHDH analysis indicates that the CuO/Co<sub>3</sub>O<sub>4</sub> is able to deliver the maximum specific capacitance of  $666 F g^{-1}$  was obtained at  $2 A g^{-1}$ . These values are match with the CV analysis. So the prepared electrode can be a suitable material for electrochemical supercapacitors

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