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Synthesis, Characterizaiton of CuO nano-rod for Supercapacitor Applications

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***Abstract:** A novel approach solvothermal synthesis method has been utilized to prepare CuO nanorods for electrochemical capacitors. A new method of synthesis has been adopted for the synthesis of CuO nanostructures. Structural, morphological features of the prepared material were studied by XRD and SEM respectively. Electrochemical supercapacitive performances of the modified electrode material were also analyzed by electrochemical workstation in three-electrode system. This material found to exhibit pesudocapacitive behavior with high capacitance of 135.23 F/g at the prevalent density of 1 A/g in 1M Na2SO4 electrolyte solution, proving a suitable candidate electrode material for supercapacitor applications.*

***Key words:** Metal oxide, Morphology, Electrochemical Properties, CuO nanorod*

I. INTRODUCTION

The power requirements for a number of portable electronic devices have increased rapidly in modern years and have excelled the capacity of batteries [1-3]. Supercapacitor also known as electrochemical capacitor has been a subject of interest to many majorities to apply in whole research [4, 5]. The pursuance of an electrochemical supercapacitor led voltage based on power densities and energy [6].

The supercapacitor based on electrochemical double-layer capacitance (EDLC) and psudocapacitor capacitance [7]. Carbon and its activated charcoal, carbon arogels, and nanotubes are frequently utilized as electrode [8]. Another class of supercapacitor is based on pseudocapacitance that stores and releases energy [9].

In recent years, metal oxides (NiO2 and CuO) activated carbon composite materials have been prepared as potential electrode materials [10]. Among oxides, Copper oxide (CuO) has promising characteristic over the supercapacitor material as well [10-12]. CuO is a well-known material its characteristic in density (650 A/g) and binding energy a [13-15] and it has high emission capability at RT and tranperent [16-20]. Because of its good eco-friendly nature, researchers have begun to study CuO to be a promising electrode material for the supercapacitance applications [21-30].

In this article, novel method of rod-like CuO nanostructure. This technique is found to be very simple, template-free method when compared to the other synthesis schemes[31-35].

II. EXPERIMENTAL METHODS

A. Material synthesis

CuO was synthesized via hydrothermal method. The synthesis procedure is as follows: initially, 9 g of mixed hydroxides solution was prepared in a beaker by adding equimolar ratio of NaOH and KOH pellets. The homogeneous solution was then transferred into an autoclave containing a Teflon vessel and kept in a furnace for 24 hours at a constant temperature of 180 °C. After completion of reaction, the autoclave containing solution was cooled down to room temperature naturally.

B. Characterization

The structure was studied by powder XRD, Rigaku miniflux (II)-c). The morphology was viewed on a SEM by using VEGA3 SBU, VGB 825111771N. The electrochemical property was analyze using CHI instruments. current was applied between 0.0-0.4V (Ag/AgCl).

III. RESULTS AND DISCUSSION

The phase structure of obtained product is depicted in Fig. 1. All the identified peaks are shown in Fig. 1 can be attributed to the hexagonal Wurtzite structure of CuO. The XRD pattern confirms the pure CuO structure and further reveals that no additional peaks were noticed, which confirms the high crystanallity of the material [16].

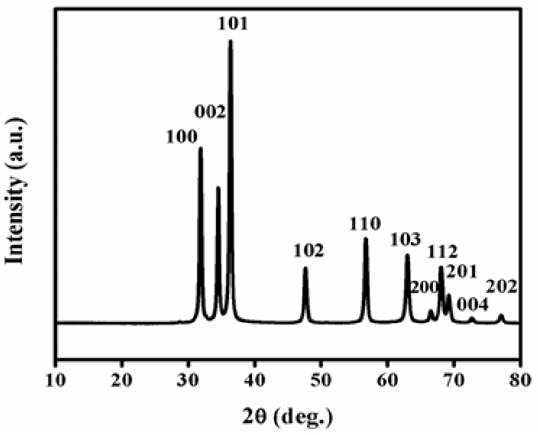

Fig. 1 XRD patterns of Pristine CuO nanorod

The average crystallite size was calculated using Debye Scherrer formula given in Eq. (1)

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$$L = \frac{0.89\lambda}{\beta \cos\theta} \quad \text{---- (1)}$$

The average crystallite size ‘L’ calculated from the region around 15-30 nm.

The SEM was used to investigate the morphological changes after hydroxide treatment of CuO material. The aggregation of particles (or formation of larger particles) could have originated from the surface energy of CuO nanoparticles. The aggregation might have been occurred during the process of drying. It can be seen that uniform distribution and thus reveal the single homogeneous phase [17, 18].

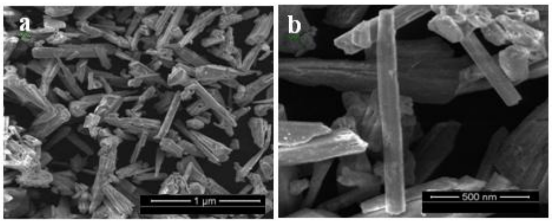

Fig. 2 SEM micrographs of CuO nanorod

To study the supercapacitor performances of the CuO and their potential application in electrochemical energy storage, cyclic voltogram (CV) analysis was carried out. Fig. 3 shows the cyclic voltammogram (CV) of CuO nanostructure, which demonstrating the noticeable pseducapacitive properties. The CV curve is measured in 1M of Na_2SO_4 at potential range from 0.0 to 0.4 V. The redox peaks observed in Fig. 3 can be ascribed to the faradic reaction of CuO which suggest the psedocapacitive behavior. The redox processes of CuO in alkaline electrolyte are based on the intercalation/deintercalation of C^+ ions into/ from CuO lattice, causing the electrochemical conservation of Cu^{2+} to the other valance states.

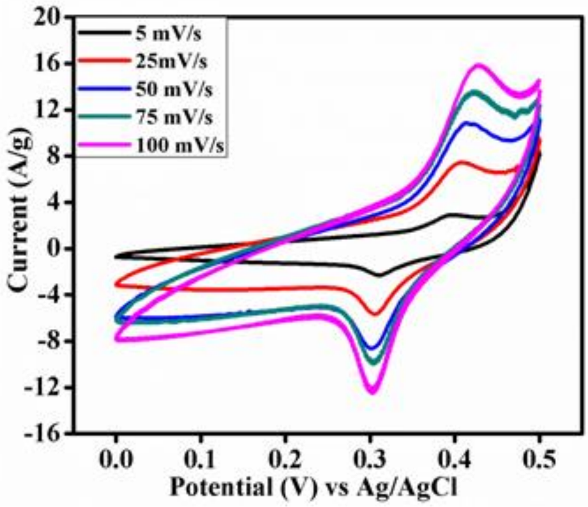

Fig. 3 CV curves of the CuO electrode material at different scan rate in 1M Na_2SO_4 electrolyte

IV. CONCLUSIONS

In summary, rod-like CuO nanostructure prepared. The morphology of CuO may supply more electrochemical active sites. The modified electrode exhibited pseudocapacitive performance serve as a potential electrode material applications. Supercapacitors have become realistic with developing more applications. It is hoped that these results can additional stimulate the necessary result and could serve as a point of departure for widening future applications.

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