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Investigation on the properties of Copper Oxide by Solution Combustion Synthesis

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Abstract - *Among diverse metal nanoparticles, copper oxide (CuO) nanoparticles have ensnared substantially due to their significant optical, catalytic, mechanical and electrical properties. The oxides of transition metals are an essential set of semiconductors, while most microstructural materials have akin properties to the consequent bulk materials. Nano metal oxides have a wide range of application in numerous fields. The current work is dutiful to the investigation of pure CuO nanoparticles formed from metal–organic compound, which have been prepared by using the combustion method, Pertinent properties of as-synthesized nanoparticles were investigated by XRD, FTIR, SEM over all the results suggests that the formation of CuO nanostructures with different, shape, size and morphology can be achieved.*

Key Words: **copper oxide; combustion synthesis; SEM; XRD; nanoparticles.**

1. INTRODUCTION

The pioneering monies of nano scale metal oxide particles have enthused pervasive exploration bustle on their application in electronics, optics and catalysis [1]. There are number of metal oxides that are accessible in nature but some of the metal oxides are more beneficial in accordance with their applications in our day to day life in science and technology. In the same way CuO is also one of the expedient metal oxide and comprises of so many applications in different fields [2]. It is a p-type semiconductor with a band gap of 1.2 eV with high conductivity and low charge carrier mobility [3,4]. The exclusivity of the CuO nanoparticles is that even though they possess metallic characteristics in bulk they behave like semiconductors when they are nanosized. Among the vast range of synthesizing techniques solution combustion synthesis (SCS) is considered to be as a novel, rapid and cost efficient method to synthesis CuO nanoparticles. In fact SCS is a redox reaction between the fuel and the oxidizer [5]. Different parameters such as the fuel-oxide ratio, fuel type etc., which determines the morphology, size, surface area and etc., despite the in-depth study of the parameters, the effect of ambient atmosphere in the characterization of the synthesized particles are poorly considered. Thus in this study the monoclinic CuO is synthesized by SCS with oxidizer to fuel ratio of 70:30 and its effect on the structural and optical features have been studied.

2. EXPERIMENTAL DETAILS

2.1 Preparation of CuO nanoparticles

Solution combustion synthesis was implied to synthesize CuO nanoparticles with analytical grade chemicals, copper (II) nitrate trihydrate $Cu(NO_3)_2.3H_2O$ as an oxidizer and glycine $C_2H_5NO_2$ as a fuel were dissolved in double distilled water in their required amount. The redox mixture was calculated centered on the principles of propellant chemistry, keeping the O/F ratio to unity to acquire a Stoichiometric composition. Aqueous solution is prepared in flat bottom flask and stirred constantly for 45 minutes. To evaporate the excess water, the mixture was kept in a mantle and heated at a constant temperature. At one point called the Ignition temperature which was around 300°C the solution auto-ignites with the rapid evolution of large volume of gases to produce fine powdered precursor. After this it is left to cool down to room temperature. Hence pure and well crystalline powder was obtained. The obtained material was grounded and was characterized for the structural and morphological properties.

2.2 Characterization of CuO nanoparticles

Structural studies of these samples were undertaken by XRD powder X-ray diffractometer in the 2θ range using Cu $K\alpha_1$ radiation (1.54056Å). The standard ICDD files of CuO (89-5895) was compared with the XRD pattern. FTIR absorption

behavior of the synthesized samples was obtained with scanning range of 4000–400 cm^{-1} and SEM.

3. RESULTS AND DISCUSSION

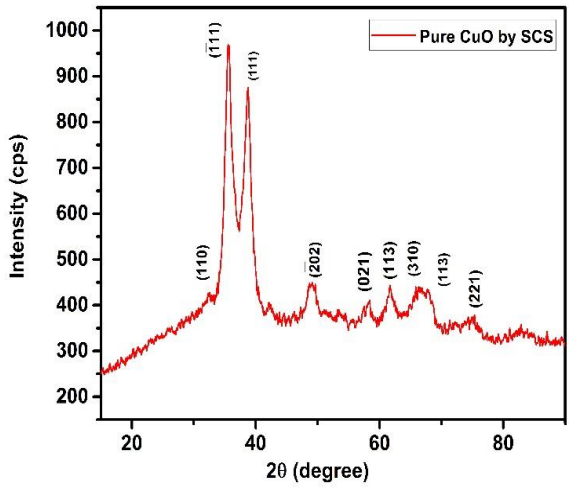

Figure-1: XRD Pattern for Pure CuO by SCS

3.1 Structural analysis: X-Ray diffraction

The idiosyncratic XRD pattern of the pure CuO is shown in figure-1. The Monoclinic structure of CuO was revealed by the peaks which was confirmed from the ICDD card No (89-5895). Further, no other impurity peaks was observed in the XRD pattern. The crystalline size was calculated using the Scherrer formula [6],

$$D = \frac{0.9\,\lambda}{\beta \cos\theta} \qquad (1)$$

where λ is the wavelength of X-ray radiation, β is the full width at half maximum (FWHM) of the peaks at the diffracting angle θ. Crystallite size is calculated for pure copper oxide and reported to be around 6 nm.

The oxidizer fuel ratio was to be considered as one of the factor for the reduced crystallite size, here we can see that the O/F ratio considered by us having a lot of impact on the structural property [7,8]. The lattice parameters and the crystallite size is as mentioned below.

Table-1: Estimated lattice parameters and crystallite size

Samples	a (Å)	b (Å)	c (Å)	D(nm)
Pure CuO	4.6758	3.4240	5.1312	6.2

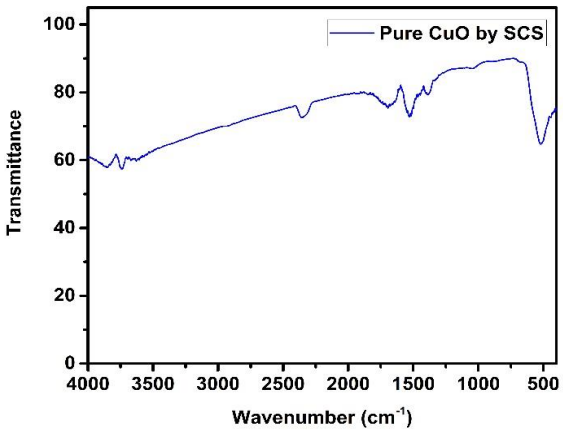

Figure -2: FTIR Spectra of Pure CuO

3.2 FTIR Analysis

The FTIR spectra for the CuO nanoparticles at room temperature was noted in the range of 400 to 4000 cm^{-1}[9] Fig.2 shows the FTIR spectra displays a transmission band around 516, 445 and 389 cm^{-1} which can be consigned to the vibrations of Cu(II)-O bonds. There is a sharp peak at 516cm^{-1} in the spectrum which is the characteristics of Cu-O bond formation, and the broad absorption peaks at 3739 and 1529cm^{-1} is due to the absorbed water molecules.

3.3 Morphological Analysis:

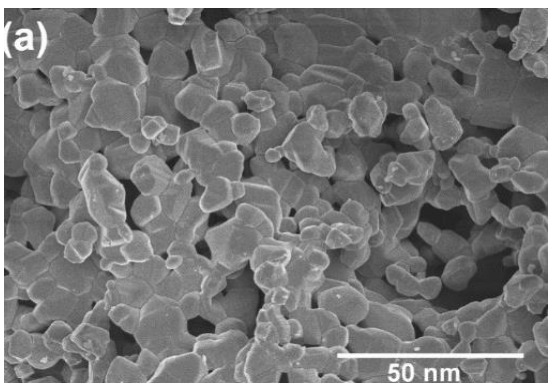

Figure-3: Pure CuO NPs SEM micrograph

Figure-3 shows the SEM micrograph of CuO nanoparticles synthesized by combustion synthesis. Average particle sizes acquired from SEM images were found to be about 20 nm. The SEM image of Pure CuO (Figure-3) discloses that the powder is agglomerated with polycrystalline NPs. The pores and voids can be endorsed to the amount of gases that fled during combustion. The progression of agglomeration takes place because of an upsurge in the rate of nucleation of the particles at higher temperatures.

4. CONCLUSION

A modest and instantaneous combustion synthesis method to prepare virtuous quality copper oxide nanoparticles are implemented, in which an aqueous solution of nitrates and glycine is heated to the point of ignition temperature about which it gets auto ignited. The resultant ash was found to contain finely divided particles of copper oxide depending on the fuel/oxidant ratio in the precursor. XRD patterns indicated that the synthesized structures have decent crystallinity with monoclinic crystal structure. Using of glycine as fuel in preparation of copper oxide and the considered O/F ratio exceedingly affects the structural and morphological assets of these materials. FTIR spectra authenticate the purity of CuO nanoparticles, the crystallite size varies in the range of 6 nm and the SEM analysis shows that the morphology and specific surface area of the samples are influenced by the O/F ratio.

5. ACKNOWLEDGEMENT

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