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Synthesis and Characterization of Copper Oxide Nanoparticles Using Precipitation Method

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ABSTRACT

In materials Science Synthesis has gained extensive attention as a reliable, Sustainable and Eco- friendly protocol for Synthesizing a wide range of materials/ nanomaterials including Metal/metal oxides, Nanomaterials, Hybrid materials and bioinspired materials. As such green Synthesis is regarded as an important tool to reduce the destructive effects associated with the traditional methods of synthesis for nanoparticles commonly utilized in laboratory and industry.

Nanoscale metals are widely used in many fields such as environment, medicine, and engineering that synthesis of nanoscale metals is a timely topic. At present, nanoscale metals are mainly synthesized by chemical methods that have unintended effects such as environmental pollution, large energy consumption, and potential health problems.

CuO nanoparticles have been successfully synthesized by precipitation method using copper sulphate as a starting material at different reaction temperatures 300 0C,400 0C, AND 600 OC with the aim of tuning properties and greatly expanding the range of applications. Then nanoparticles were characterized by using X-ray Diffraction (XRD) method. The XRD patterns showed that the prepared CuO-NPs were highly pure, crystalline and nano-sized.

Keywords: Copper Oxide, Nano Particles, Chemical Precipitation, X-Ray Diffraction

I. INTRODUCTION

Nano science has been established recently as a new interdisciplinary science. It can be defined as a whole knowledge on fundamental properties of nano-size objects. The results of Nonoscience are realized in nontechnology as new materials and functional facilities. Frequently, monometer- size metallic oxide particles shows unique and considerably changed physical, chime cal and biological properties compared to their macro

scaled counter, due to their high surface to volume ratio Thus, nanoparticles have been the subject of substantial research years(1)
Metal oxide nonoparticles is a versatile material with many scientific and industrial application (2) Synthesis of high- quality nanoparticles with respect to chemical purity, phase selectivity, Crystallinity, and homogeneity in particle size with controlled state of agglomeration in a cost – effective procedure is still challenge to material chemists (3) The nanomaterials haveattract redmuchscientific attention due to their interesting size- dependent chemical and physical properties and also the potential technological application (5) The science of nonoparticles during the last decade is characterized by, among other things, the enormous efforts which have been made to organize nanoparticles in three and two dimensions, and to some extent one dimension, three dimensional organization if babioartuckes us however, not always a simple matte, since, with some exceptions, particles of afew up to some dozens of monometers in size usually to not possess exactly the same number of atoms or, consequently, the same shape . classically only identical species were believed to atoms or consequently the same shape. Classically, only identical species were believed to form crystals. Then we learned that particles of similar but not identical size and shape may be able to organize three- even two dimensionally (6) Recently, copper- based nanomaterials have received attention because of their applications in optoelectronic devices, catalysis and superconductor (7) The p – type semiconductor of nonostructu5red copper oxide (Cuo) is an important functional material having direct energy band gap and unique optical and magnetic properties and it is used for gas sensors magnetic storage media solar power transformation, electronics, semiconductors varsities, and catalysis (8) It has therefore been studied together with other copper oxides in particular with respect to its applications as a photo thermally active and photoconductive compound (9)
In CuO, the lattice has a monoclinic symmetry (m CuO; space group-c2/c) and each atom of this compounds has four nearest neighbours of their kind, Cu atoms are at the center of o rectangle, and the O atoms are at the center of the distorted tetrahedron of Cu(9) CuO with a narrow babe gap of 1.2 eV is extensively used in various applications such as catalysis solar energy conversion, gas sensor and field emission (10) Different nanostructures of CuO are synthesized in the form of nanowire (11) nanofalakenanorodnononeedlenanoflowerandnonoparticle (12)
Finite size effects in magnetic nanoparticles have been studied intensively due to their fundamental and technological relevance (13) As the particle size decreases the magnetic stability of nanoparticles due to thermal agitation will become an important issue in technical applicationsThe antiferromagnetic ordering in CuO is due to the exchange interaction between Cu2+ ions via 02- ions. It is well known that th4e unique functions of semiconductors nanoparticles have led to the development of novel photovoltaic and light emitting devices.
Thus thereis renewed interest in understanding the fundamental physical properties of CuO as well as for upgrading its performance in applications (14)
Metal nanoparticles can be prepared by two routes; the first one is a physical approach that utilizes severalmethods such as evaporation/ condensation and laser ablation. The seconds one is a chemical approach in which the metal ions in th4e solution are reduced in conditions favouring the subsequent formation of the small metal cluster or aggregates(15) Recently use of nono size semiconductors used to do photocatalytic oxidation of toxic pollutants is being increasingly valu7ed (16)
The aim of the present work is to investigate the effect of the calcinations temperature on the crystal structure and the morphology of the nanoparticles by characterization using X- ray diffraction (XRD) (17) _ and optical properties of the nanoparticles by UV- Vis spectrum (18)

II. EXPERIMENTAL DETAILS:

2.1. Material use

CuSO4.5H2O Molecular Weight: 249mg, copper chloride (cuC12) Molecular weight: 5g Sodium hydroxide(NaoOH) Molecular weight: 10ml, 100ml deionized water

2.2. Synthesis

For the C$_u$O nanoparticles synthesis, 5g of copper chloride ($CuCl_2$) and using 24.9g of copper sulphate (Cu$_4$ So$_4$%H$_2$O). first each precursor was dissolved in100ml deionized water to from0.1m Concerntration $CuCl_2$ and cusomixture Solution was taken boiled to 60-80Cs Using magnetic stirrer heater. Then 10 ml NaOH solution was dropped under vigorous stirring until pH reached to 14. The precipitate was allowed to settle down and the superant liquid was poured off (Elsevier,2013). The oxide was transferred to 250ml flask and the volume was made up. The content was washed up by repeated decantation until it become chloride ion, and then filtered to residue, by washing with double distilled water. The residue was dried at 80 C in an over for two hours to get Cu2O and further Calcined at 300S, 400C, & 600^0C for 3 hours to get Cu2O and further calcined at 300^0C, 400^0C, & 600^0C for 3 hours for CuO nanoparticles.

Figure 1: X-ray Diffraction:

X-ray diffraction analysis (XRD) is a technique used in materials science to determine the crystallographic structure of a material (1). A primary use of XRD analysis is the identification of materials based on their diffraction pattern. As well as phase identification, XRD also yields information on how the actual structure deviates from the ideal one, owing to internal stresses and defects (2).

2.3. Characterization

Crystals are regular arrays of atoms, whilst X-Rays can be considered as waves of electromagnetic radiation. Crystal atoms scatter incident X-rays, primarily through interaction with the atoms electrons. This phenomenon is known as elastic scattering; the electron is known as the scatterer. A regular array of scatterers produces a regular array of spherical waves. In the majority of directions, these waves cancel each other out through destructive interference, however, they add constructively in a few specific directions, as determined by Bragg's Law:

2dsinø = nλ

Where d is the spacing between diffracting planes, ø {theta} is the incident angle, n is an integer, and λ is the beam wavelength. The specific directions appear as spots on the diffraction pattern called reflections.

Consequently, X-ray diffraction result from electromagnetic waved impinging on a regular array of scatterers. X-rays are used to produce the diffraction pattern because their wavelength, ƛ is often the same order of magnitude as the spacing, d between the crystal planes.

III. RESULTS AND DISCUSSION

3.1. XRD Pattern

Figures 1 & 2 shows XRD patterns of nanosizedCuO samples. All the diffraction data confirm the information of pure single-phase CuO with the monoclinic phase (JCPD80-1268). No diffraction peaks of impurities (Zhang et al., 2008) were observed in the patterns. It showed that nano size of CuO was successfully synthesized under current mild experimental conditions. The crystallite size of samples was estimated from XRD peak broadening using Scherer's formula (Ahmad R and Mehrnaz G, 2012).

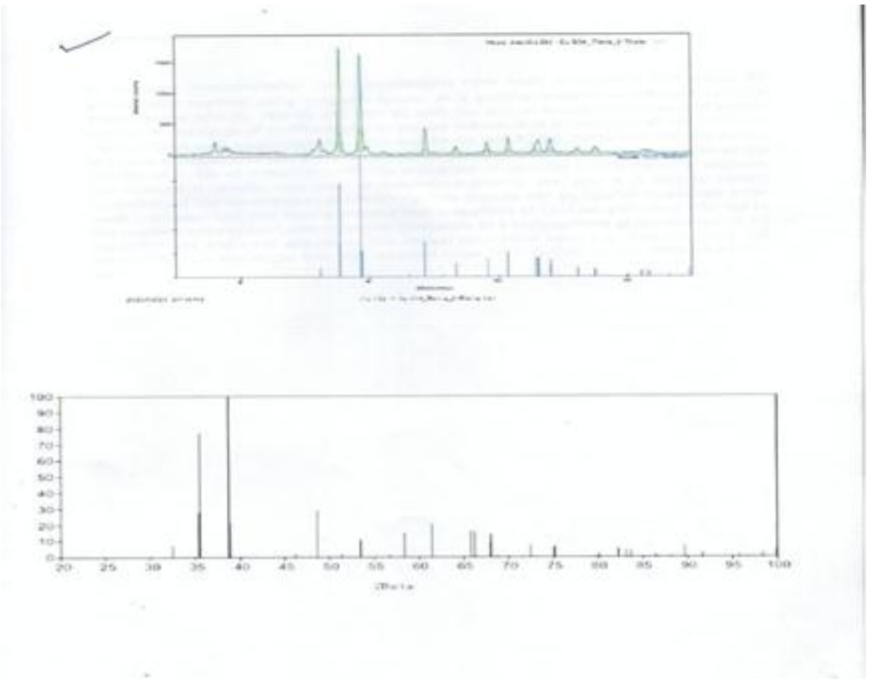

Figure 2

Where t is the crystalline size, ƛ is the wavelength of x- ray radiation, ø is the Bragg angle, and is the full width at half maximum (FWHM) of the most intense diffraction peak. The influence of the temperature on crystalline sizes of samples is shown in Table 4.1 The FWHM of the diffraction peaks decreases with increasing temperature disclosing that the average crystalline size is becoming bigger correspondingly. Our results showed that by increasing temperature, the intensity of peaks slightly increases and diffraction peaks becomes sharper. This indicates the enhancement of the crystalline size originated from the increment of the crystalline volume ratio due to the size enlargement of the nuclei

IV. CONCLUSION

In summary, semiconductor CuO nanoparticles have been successfully synthesized by precipitation method using copper sulphate as a starting material at different reaction temperatures 3000C,4000C, AND 600 OC with the aim of tuning properties and greatly expanding the range of applications. Our results indicate that preparation of spherical CuO nanoparticles was achieved when temperatures was 6000C. This result shows the considerable role of temperature on the properties of nanosizeCuO samples. In addition, the method is simple, low cost, environmental- friendly and also it is able to control properties of the nanosizedCuO effectively. This process can be applied to prepare other oxide nanoparticles. Our results showed that properties of CuO samples were affected by the reaction temperature and ultrasonic irradiation as a consequence of the changes in the crystalline size and band gap value. The optical absorption band gap of as-prepared CuO semiconductors was larger than the reported value for bulk CuO due to obtained particle sizes.

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