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:Structural and Optical Properties of Copper Oxide Nanoparticles Synthesized by Chemical Precipitation Method

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Abstract:

Sodium bicarbonate was used as a precipitation agent and copper nitrate as a precursor in the chemical precipitation process to create copper oxide nanoparticles (CuO-NPs). After that, scanning electron microscopy (SEM), X-ray diffraction (XRD), and ultra-violet (UV) microscopy have been used for characterizing the NPs. The prepared CuO-NPs showed crystalline and nanosize XRD patterns. The 26 nm crystallite size of the CuO NPs is confirmed by Scherer's formula. According to the SEM image, the NPs have been spherical and tended of agglomerations. Copper oxide absorption spectrum at about 270nm is confirmed by the UV-visible.

Keywords: copper nitrate, copper oxide, scanning electron microscope, X-ray diffraction, uv-visible spectroscopy.

INTRODACTION:

The crucial pioneering role that nanotechnology played in modifying materials at the molecular and atomic level to significantly change the attributes of the final product attracted a lot of attention. When materials are lowered to the nanometric scale, their characteristics differ greatly from those at the microscale or macroscale. Nanomaterials are majorly employed in many different applications due to their special qualities. NPs in trace concentrations could be extremely important for the development of a material's characteristics. Because they are useful in so many different scientific domains, NPs are becoming more and more significant every day. Generally speaking, NPs range in size from 1 to 60 nm. Designing, building, and using functional structures having at least one characteristic dimension measured in nanometers is referred to as nanotechnology. Nowadays, NPs are used extensively in a variety of fields (Ahamed et al., 2014; Anandan et al., 2007, Khan et al., 2013; Kida et al., 2007; Kim et al., 2008; Manimaran et al., 2014; Mustafa et al., 2013; Suleiman et al., 2013; and Zhang et al., 2014). With a narrow band gap (e.g., 1.2eV), cupric oxide (CuO) is a significant transition metal oxide serving as foundation for a number of intriguing high temperature superconductors and enormous magneto resistance

materials (Jianliang et al, 2011). CuO is widely employed in several different applications, including gas sensor (Kaneshiro et al., 2010), macroscale (Yang et al., 2007), catalysis (Huang et al., 2009), and solar energy (Jianliang et al., 2011). Yet, synthesis of CuO nanostructures, which had demonstrated better performance compared with their bulk equivalents, could enhance such new features. A variety of CuO nanostructures are created, including nanowires, nanorods, nanoneedles, nanoflowers, and NPs. CuO NPs of different shapes and sizes were produced in recent decades using a variety of techniques, including thermal oxidation (Wu et al., 2010; and Zhu et al., 2004), quick-precipitation (Kaur et al., 2006), combustion (Narongdet et al, 2011), and sonochemical (Yamukyan et al., 2008). The precipitation approach is one of such simple procedures that has garnered a lot of interest from companies due to its low energy and temperature requirements, low cost, and high yield for large-scale production.

Experimental method:

Sodium bicarbonate solutions (0.1M) and copper nitrate (0.1M) have been made in distilled water as part of the chemical precipitation process used to create copper oxide. In order to keep the pH at 6.8, the sodium bicarbonate solution has been added drop by drop to the copper nitrate while stirring constantly. The reaction was then allowed to continue for two hours until all of the sodium bicarbonate had been added. Following the completion of the reaction by testing the entire precipitation, the precipitate was let to settle overnight before being filtered out and repeatedly cleaned with distilled water to remove any remaining excess bicarbonate. After noticing a pale blue precipitation, the supernatant solution was cautiously disposed of. The solution was cleaned, dried for five hours at a temperature of 100°C, and after that calcined for four hours at a temperature of 450°C.

Structural Analysis:

X- ray diffraction:

XRD spectrum of CuO NPs is displayed in fig 1, and it is evident that both broad and sharp peaks are present, indicating that the resulting CuO products have been formed in a mixed phase of amorphous as well as crystalline states. According to the JCPDS data card (89-2529) (Phiwdang et al., 2013), the peaks of diffraction at $2\theta = 32.06^{o}$, 35.48^{o}, 38.74^{o}, 48.71^{o}, 61.53^{o}, and 66.07^{o} correspond to the (110), (111), (200), (202), (113), and (311) crystal planes of cubic phase CuO. With the use of Debye Scherrer's equation, the CuO nanocrystals' crystallite size has been calculated from a more intense peak in XRD spectra. The highly intense plane of (111) has an average crystallite size of 25 nm which was calculated by using the Debye-Scherrer equation (Ali et al., 2018; Al-Jarah et al., 2024).

$$D = k\lambda / \beta \cos\theta \qquad (1)$$

"Where, D is the average crystallite size, k is constant = 0.9, λ is the wavelength of X-ray radiation (Cu Kα=1.5406 Å), β is the full width at half-maximum (FWHM), θ is the Bragg angle 2θ".

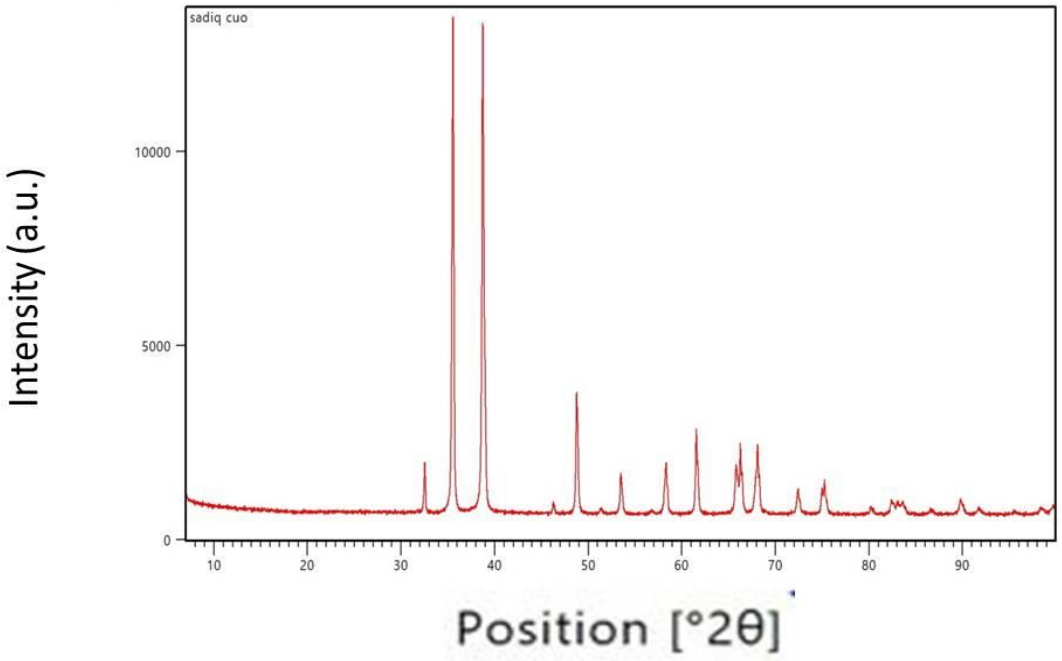

Fig (1): X-Ray diffraction of CuO nanoparticles

Scanning electron microscopy:

SEM study of the surface morphology of the copper oxide nanoparticles made with copper nitrate is depicted in fig 2. It demonstrates the existence of roughly shaped, yet varying-sized NPs with rough aggregate surfaces. According to the SEM scale, the size of crystalline CuO NPs ranged from 40 to 55nm, and the images showed that the particles were cuboid.

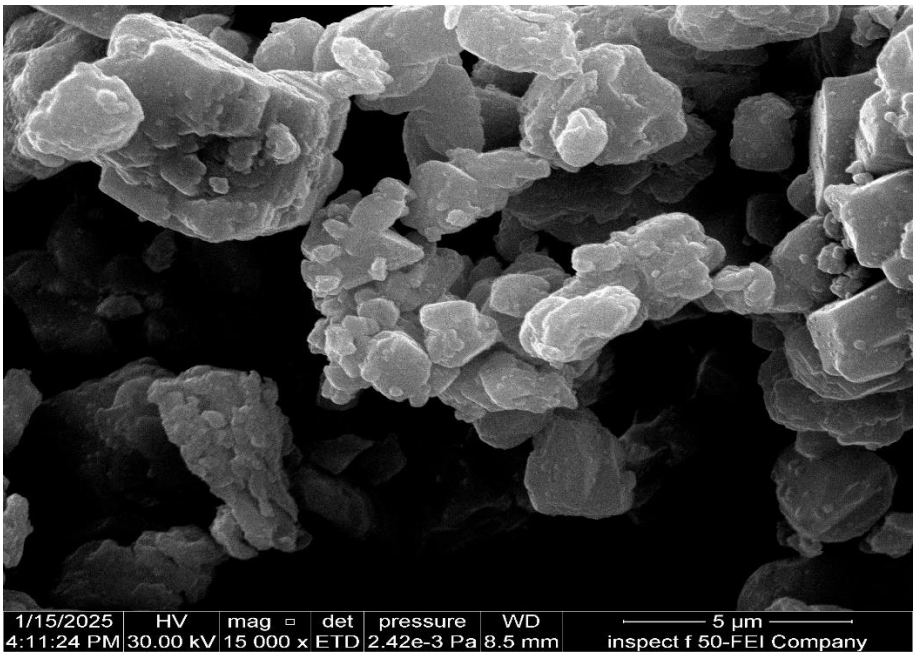

Fig (2): Scanning electron microscopy of CuO nanoparticles

UV- VISIBLE:

The optical characteristics of the produced CuO NPs were investigated using the optical absorption spectrum (Ragunath et al., 2021). Fig 3 displayed the copper oxide NPS's UV–vis absorption spectra. The formation of cuprous oxide NPs is responsible for the absorption peak at 270 nm in UV visible spectra, which is in good agreement with previous observations.

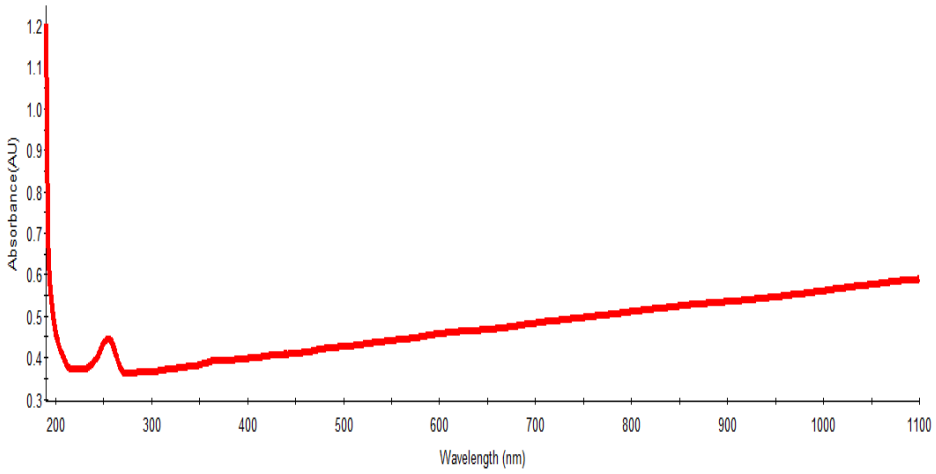

Fig (3): Absorbance spectra as a function of wavelength for of CuO nanoparticles

Conclusions:

Copper nitrate was used in the chemical precipitation process to create copper oxide NPs. XRD data, which displays all peaks with particle sizes of 26 nm, was used to confirm the structure regarding the CuO NPs. Using UV-visible spectroscopy; the optical characteristics of CuO NPs were examined.

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Conflicts of Interest Statement

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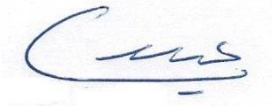
Dr. Uday Ali Sabeeh Al-Jarah		**2025/3/18**