

Green Synthesis and Characterization of Copper Oxide Nanoparticles Using Coffee Powder Extract

Saeid Taghavi Fardood, Ali Ramazani*

Department of Chemistry, University of Zanjan, Zanjan, Iran

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ABSTRACT

The use of plant extract is generating interest of researchers toward cost effective and eco-friendly green synthesis of nanoparticles. In the present work, Cupric oxide nanoparticles were synthesized using coffee powder extracts by the sol-gel method at different calcination temperatures. The synthesized nanoparticles were characterized by X-ray diffraction, scanning electron microscopy, ultraviolet-visible spectroscopy and Fourier transform infrared spectroscopy. The powder X-ray diffraction analysis revealed the formation of single-phase copper oxide with a monoclinic structure.

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INTRODUCTION

In recent years, nanoparticles have achieved huge attention and influenced material science considerably. It seems, this dominance will continue in the future years because of fundamental and technological importance with implementing incessant researches in this field. Particularly, metal oxide nanoparticles are in limelight receiving noticeable attention in a vast diversity of applications. The most fascinating properties that draw attention are: electronic, optical and magnetic properties [1-6]. The oxides of transition metals are an important class of semiconductors, having applications in catalysis, electronics, solar energy transformation, gas sensors, etc. Among all the metal oxides, cupric oxide has attracted remarkable interest due to its marvelous features causing eclectic applications such as organic catalysis [7], nanofluid in heat transfer [8], steam reforming [9], CO oxidation

of automobile exhaust gases [10], photocathodes for photoelectrochemical water splitting application [11], catalysts for the water-gas shift reaction [12], gas sensors [13], etc. The synthesis procedure determines the dimension and shape of the nanostructure and as a consequence influences different properties of the material. Cupric oxide nanoparticles are prepared by a few approaches [14-18].

In this study, we have synthesized cupric oxide nanoparticles using coffee powder extract and water as solvent by sol-gel process, a cheap and friendly approach to the nature.

MATERIALS AND METHODS

Methods

Coffee powder was obtained at a local health food store. Copper nitrate nonahydrate $\text{Cu}(\text{NO}_3)_2 \cdot 9\text{H}_2\text{O}$, was purchased from daijung (Darmstadt, Korea) used without further purification. The IR spectra were

*Corresponding author Email address: aliramazani@gmail.com

measured on a Jasco 6300 FT-IR spectrometer (KBr disks). UV-Vis absorption spectrum was analyzed using a Metrohm (Analytical Jena-Specord 205) double beam instrument. The measurement was carried out from 250 nm to 700 nm wavelength for all the samples. The structural properties of synthesized nanoparticles were analyzed by X-ray powder diffraction (XRD) with a X'Pert-PRO advanced diffractometer using Cu ($K\alpha$) radiation (wavelength: 1.5406 Å), operated at 40 kV and 40 mA at room temperature in the range of 2θ from 20 to 100°. The particle size and morphology of the surfaces of the sample was analyzed by a scanning electron microscopy) LEO Co., England, Model: 1455VP). The disc was coated with gold in an ionization chamber.

Preparation of coffee powder extract

To prepare the coffee extract, 0.8 g of coffee powder was dissolved in 100 ml of water and boiled for around 30 min. After cooling at room temperature, these were centrifuged for 20 min and filtered. The filtrates were stored at 5-10 °C for further experiments.

Synthesis of CuO nanoparticles using coffee extract

In To prepare CuO-NPs, 2g of $\text{Cu}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$ was dissolved in 10 ml of distilled water and then stirred

for 10 min. After that, 30 ml of coffee powder extract was added to the copper nitrate solution and the container was moved to a sand bath. The temperature of the sand bath was fixed at 75 °C. Stirring was continued for 12 h to obtain a green powder. The final product was calcined at different temperatures (500, 600, 700 and 800 °C) in air for 4h to obtain CuO-NPs.

RESULTS AND DISCUSSION

Characterization CuO nanoparticles

FTIR spectra were recorded in solid phase using the KBr pellet technique in the range of 400-4000 cm^{-1} . FTIR analysis (Fig. 1) Of green synthesized CuO nanoparticles revealed a strong band at 537 cm^{-1} can be attributed to vibrations of CuO, confirming the formation of CuO nanoparticles [19].

Fig. 2 shows UV-Vis spectrum of biosynthesized CuO NPs using coffee powder extract. The green synthesized CuO-NPs showed absorbance spectra at 262 nm in UV-visible spectroscopy, which are attributed to the formation of cupric oxide (CuO) nanoparticles [20].

The XRD patterns of the calcined CuO NPs at different temperatures of 500, 600, 700, and 800 °C are shown in Fig. 3.

XRD analyses showed a series of diffraction peaks at 2θ of 32.58, 35.56, 38.78, 48.84, 53.41, 58.30,

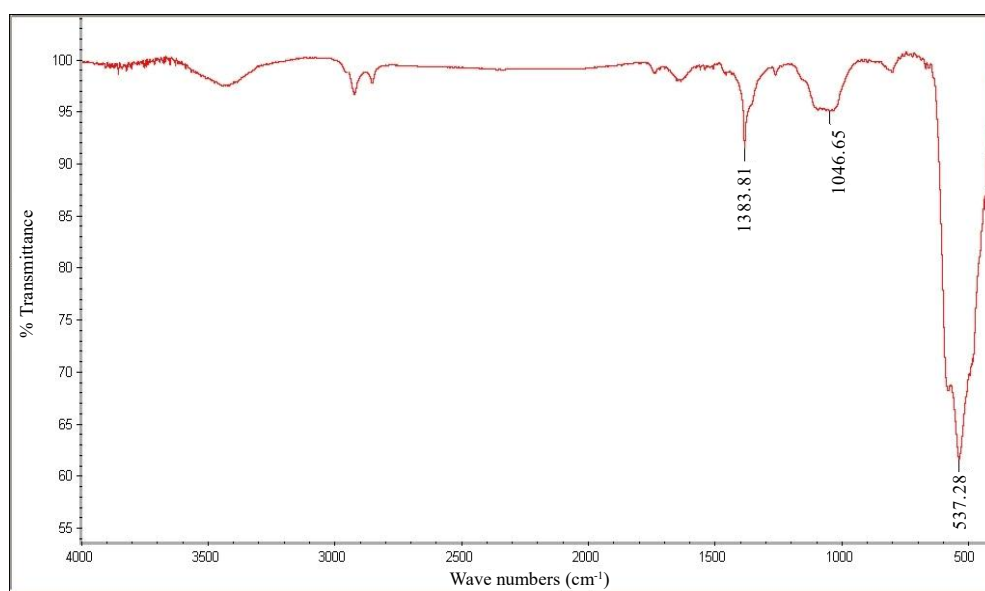


Fig. 1. FT-IR spectrum of CuO NPs.

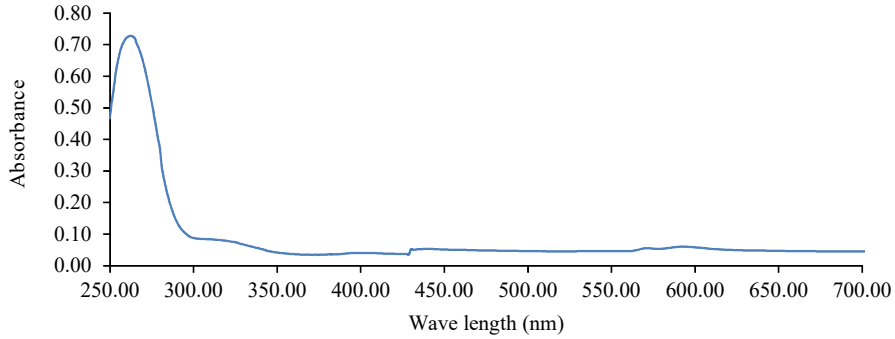


Fig 2. UV-Vis spectrum of CuO NPs

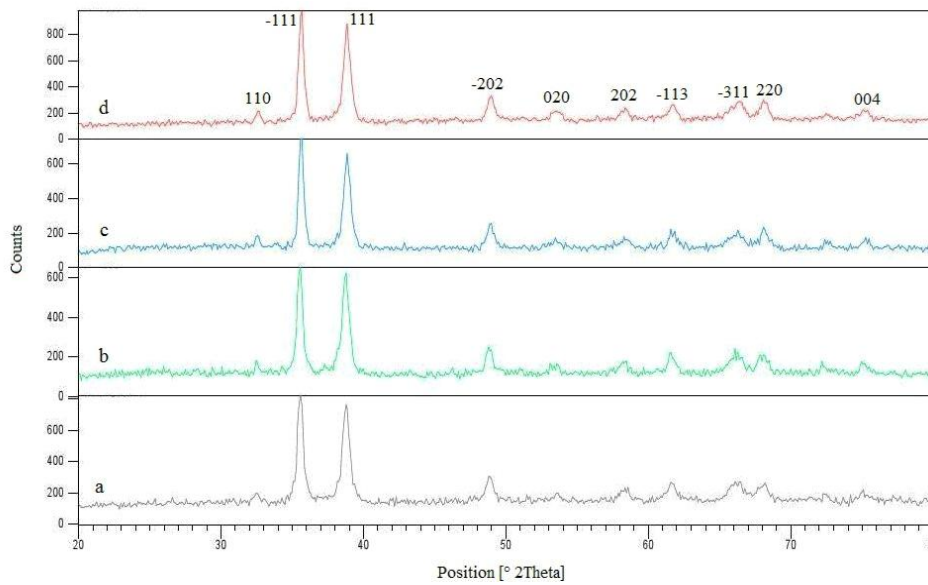


Fig. 3. XRD patterns of synthesized CuO-NPs in air at different temperatures (a: 500; b: 600; c: 700 and d: 800 °C).

Table 1. Variation of crystallite size with annealing temperature.

Temperature (°C)	Crystallite size (nm)
500	24.72
600	30.47
700	32
800	35.65

61.59 ,66.21, 67.98 and 75.16 which were assigned to (110), (-111), (111), (“202), (020), (202), (“113) , (-311), (220) and (004) planes and are in good agreement with Diffraction Data (ICDD) card no. 05-0661 (Fig. 3).All diffraction peaks can be indexed as

typical monoclinic structure and no other phases were observed. The average crystallite size of CuO nanoparticles was calculated using Scherrer formula, $D=0.9 \lambda/b\cos q$, where λ is the wavelength of X-ray radiation, b is the full width at half maximum (FWHM) of the peaks at the diffracting angle q .

The variation of crystallite size with temperature was calculated and the results are presented in Table 1.The SEM images Fig. 4 (a,b) show the particle size and external morphology of the calcined CuO nanoparticles at 600 °C for 4h. It can be seen from the image that the cupric oxide nanoparticles range from 20-60 nm.

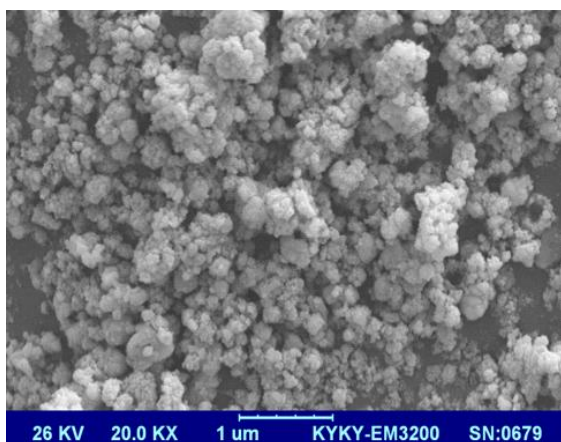


Fig. 4a. SEM images of CuO nanoparticles

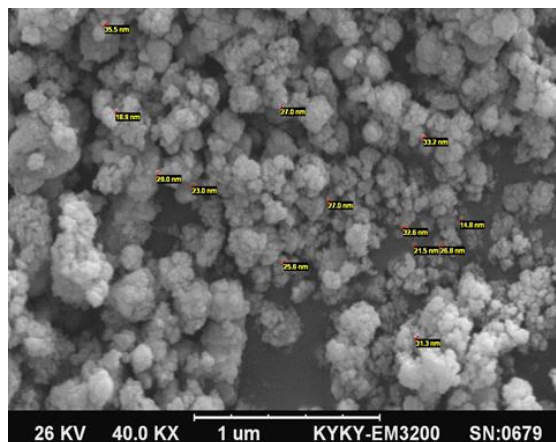


Fig. 4b. SEM images of CuO nanoparticles

CONCLUSION

In this paper, we have reported for the first time, the use of coffee powder extracts for the synthesis of CuO nanoparticles using water as solvent by the sol-gel method.

This method has many advantages such as non toxic, economic viability, ease to scale up, less time consuming and environmental friendly approach for the synthesis of CuO nanoparticles without using any synthesized organic materials. From XRD results, it was observed that all of the calcined CuO-NPs at different temperatures indicating the formation of single-phase CuO with a monoclinic structure. The size and morphology of the samples were characterized using scanning electron microscopy (SEM).

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