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Micro sphere CuO nanostructure for pollution applications

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Abstract

Nowadays, increasing extortions related to environmental problems and energy scarcity have stymied human society's development and endurance.The presence of inorganic and organic pollutants in water from agricultural, domestic, and industrial activities has prompted the development of advanced technologies to effectively address the challenges of water scarcity. To address this major issue, scientists and researchers are seeking novel and effective technologies for efficiently removing pollutants from wastewater.Because of their unique size, physical and chemical properties, and promising applications, nanoscale metal oxide materials have been proposed.The current research focuses on producing copper oxide nanostructures via a hydrothermal process, investigating the effect of 170°C hydrothermal temperatures on the fundamental properties of CuO microstructures, and analysing the photocatalytic behaviour of CuO nanostructures.

Keywords: Micro structure, methylene blue, Sun light, Degradation

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1.Introduction

Nanotechnology has emerged as an important area of research in all aspects over the last few decades.Nanomaterials, in particular, play an important role in human life due to their incredible applications in all fields of medicine, engineering, pharmacy, material science, and clinical applications [1].Semiconductor materials have recently been at the forefront of harvesting solar energy and converting it into chemical energy in order to address global energy demands and environmental issues [2]..Because of the promising quality of solar-driven photocatalytic reactions, low-cost and stable semiconductor materials are highly sought after as candidates for harvesting photon energy across the entire solar spectrum.Despite the fact that many inorganic semiconducting materials have been used as photocatalysts, the majority of them have inappropriate band positions for proton reduction, poor stability, low photoresponse, and the use of noble metals as co-catalysts [3].The copper oxide nanoparticle (CuO-NPs) is a useful metal oxide with several applications in domains such as, heat transmission, gas sensors, photocatalysisand optical devices [4-6]. CuO has the unusual property of acting as a semiconductor; semiconductors have attracted the curiosity of researchers due to their significant utility in electrical and optoelectronic processes such as electrochemical cells, gas sensors, magnetic storage devices, and catalysts[7].

The current research focuses on the hydrothermal synthesis of CuOnanostructures.The structural, morphological, and photocatalytic activity of CuO nanostructures against MB dye were investigated using XRD, EDS, SEM, and UV-Vis spectroscopy.

2. Experiment

Route of synthesis from copper acetyl acetonate [$Cu(C_5H_7)_2$] precursors In the first method, 3.5g copper acetylacetonate was used as a solvent along with 0.4g sodium hydroxide (NaOH) and distilled water.These solutions will be kept in stainless steel autoclaves at 170°C for 10 hours before being allowed to cool to room temperature naturally.After filtering, a dark precipitate will form, which will be washed with distilled water and absolute ethanol to remove the residue of inorganic/organic impurities.The finished products were dried in a hot air oven at 60°C for 48 hours.

X-ray powder diffraction (XRD) analysis was performed at room temperature) with Cu K radiation (= 0.15406nm), over the 2 collection range of 0-80 to determine the crystal phase CuOphotocatalystpowders.The FE-SEM (Field Emission Scanning Electron Microscope)

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images and EDX (Energy-dispersive X-Ray) spectra were obtained using the ZEISS-LEO SUPRA-55 and JEOL-JCM-6000 plus spectrometers, respectively. The UV-Visible investigations of the synthesised photocatalysts were completed using the Carry-60 UV/Vis spectrometer.

The photocatalytic capability of pure CuO nanostructures was tested by degrading MB-dye in the presence of visible light radiations.It was accomplished by removing UV light from the sun's spectrum using a UV cut-off filter.To achieve an equilibrium between the MB-dye and photo-catalyst, 5 mg of pure was mixed with 15mg of MB-dye with distiled for 60 minutes in the dark.Thephotocatalytic reaction vessel was placed under visible sunlight while being constantly stirred after the dark reaction to analyse the photocatalyticprocess.After 30 minutes, the 5 mL suspension was removed from the reaction vessel and centrifuged for 3 minutes to separate the photocatalyst.

3.Result & Discussion

X-ray diffraction measurements were performed to investigate the mechanism of CuO structure formation; Fig. 2 shows the XRD pattern of cupric oxide samples.In comparison to the JCPDS (48-1548) data, all diffraction peaks can be perfectly indexed to monoclinic CuO crystal structure with lattice constants a = 4.6883 A, b = 3.4229 A, c = 5.1319 A, and b = 998500, The monoclinic phase crystal structure of pure CuO lattice is represented by all other higher intensity peaks (1 1 1) and (2 0 0)[8].

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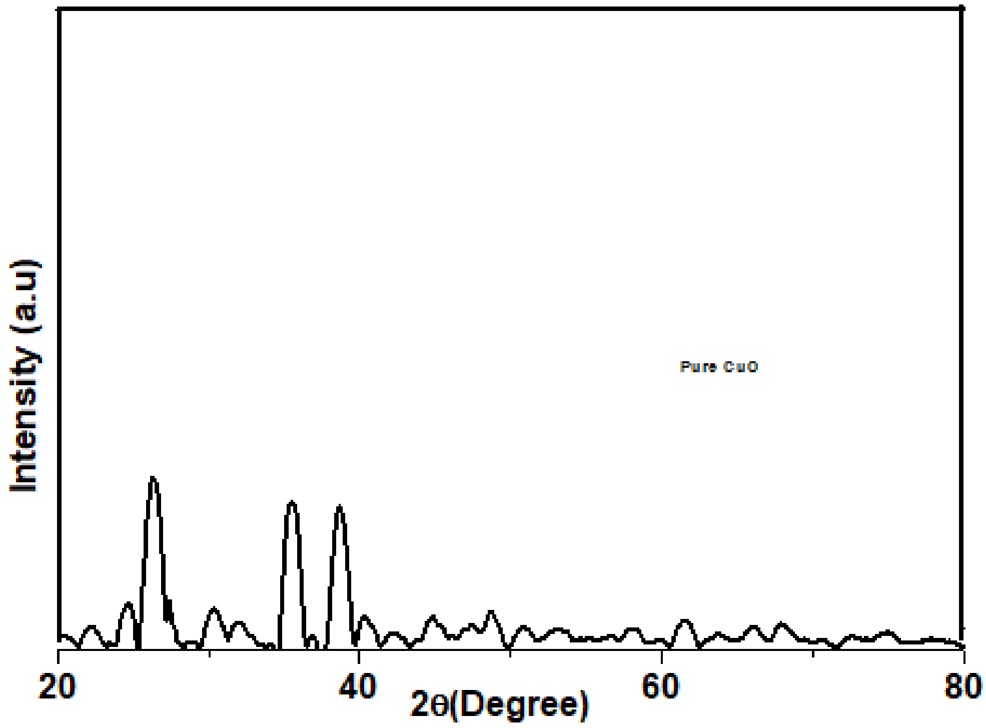

Fig 1. XRD pattern of CuO microstructure.

It was essential to confirm the elemental compositions of the synthesised products, which were examined using EDX, and the obtained result is shown in Fig. 2, whereby it was confirmed that the synthesised structures were CuO because the EDX demonstrated the presence of only two elements, namely Cu and O, with atomic% values of 68.21 and 31.79, respectively. The absence of characteristic impurity peaks in the XRD pattern of CuO microstructure is clearly visible.Furthermore, no other additional product (impurity) other than Cu and O can be detected.The XRD pattern evidence showed that our synthesis procedure is pure, controllable, and capable of reducing defects when compared to a closed system.

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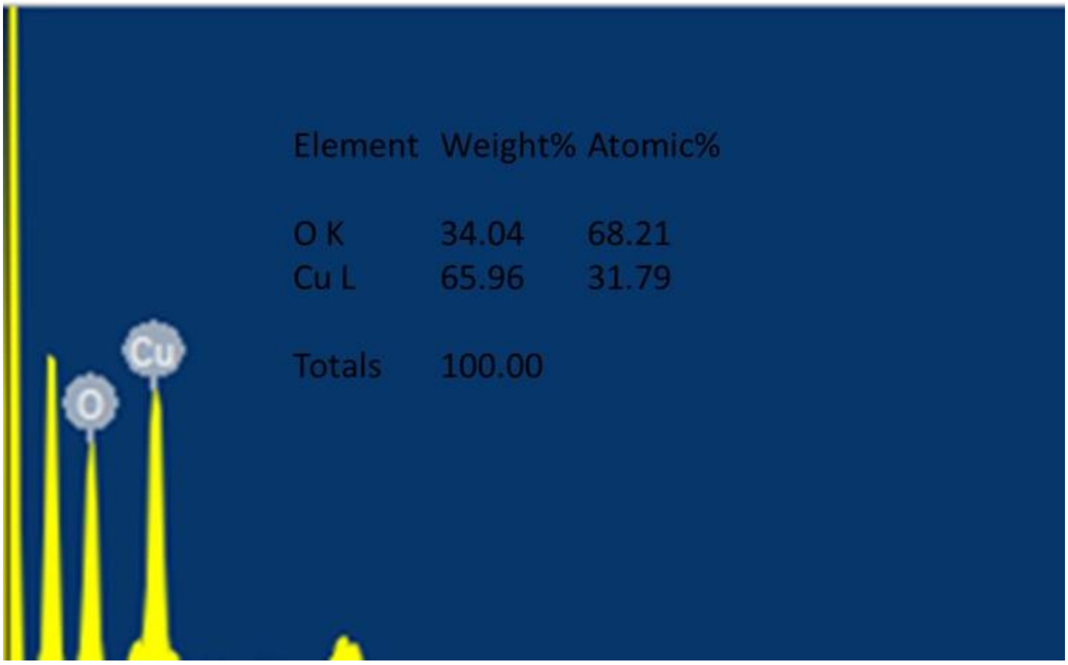

Fig 2. EDX of CuO microstructure.

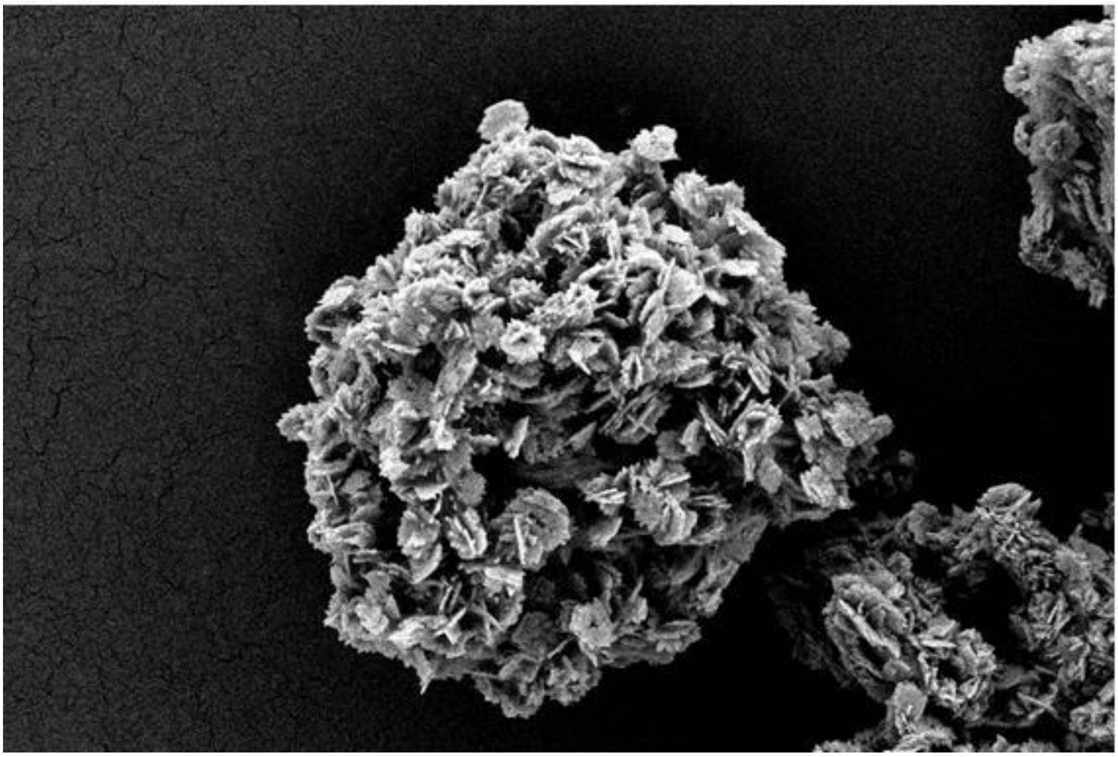

Fig 3. Micro spear of CuO image from SEM.

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CuO microstructure was clearly detected, as shown in Fig 3.The nanoplates agglomerated to form a microsphere CuOstructure.CuOnanoplates had a thickness of 70-80 nm and a width ranging from 300 nm to 400 nm.

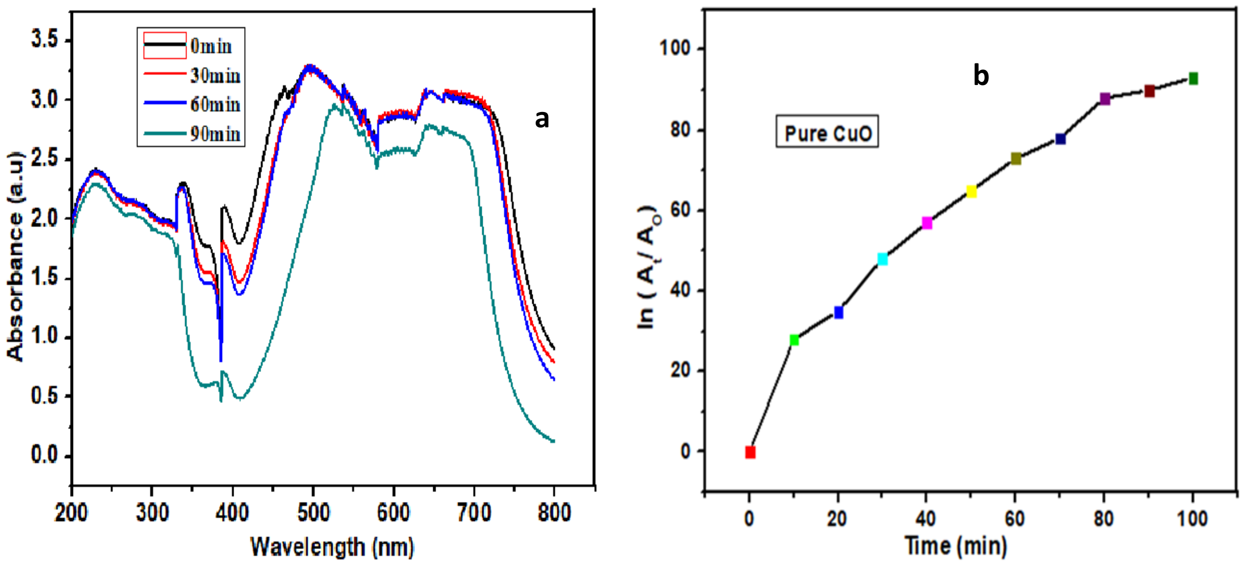

Fig 4. Absorption spectra of MB dye with (b) Degradation CuO microstructure.

To assess the photocatalytic capabilities of CuO nanostructures under sunlight illumination, the photo-degradation of MB was carried out. Figure 4 displays the spectrum fluctuation in MB dye absorption at various time intervals (a).It is essential to note that all grown samples have deteriorated in the presence of MB dye.According to the pattern shown in Fig. 4(b), the degrading efficiency of pure CuO nanostructure.CuOphotocatalystshave CB and VB potentials approximately 0.46 V and 2.16 V, respectively, which are higher than the usual redox potential and adequate for releasing the OH and O_2 radicals needed for photo degradation [9,10].

4.Conclusion

Innovative CuO nanostructures created via a hydrothermal method.The compositions, morphologies, and photocatalytic activity of material were investigated at 170oC hydrothermal temperatures.TheCuOphotocatalyst synthesised was discovered to have the highest photocatalytic activity, which was attributed to a synergistic effect on the specific adsorption property and effective electron-hole separation at the CuOphotocatalystmorphology.This study could provide new insights into the development of novel sunlight photocatalysts.In some ways, the efficient photodegradation dye by CuOphotocatalyst under sunlight is an exciting aspect of the photocatalytic domain.

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