

APPLICATION OF CuO NANOPARTICLES IN THE DEGRADATION OF METHYLENE BLUE

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ABSTRACT

In the present study CuO nanoparticles were synthesized by sonochemical method using Copper acetate as precursor and NaOH as stabilizing agent. The prepared CuO nanoparticles were characterized by PXRD, FTIR, UV-Visible and SEM-EDX. The photocatalytic activity of the CuO nanoparticles was investigated by degradation of Methylene Blue in aqueous medium under direct sunlight using UV-Vis spectrophotometer. The prepared nano CuO is found to be effective in removing water soluble dyes.

KEYWORDS: CuO Nanoparticles; Sonochemical Method; Degradation; Methylene Blue

Different industries discharge large amount of waste water to the eco system. They include organic dyes, insecticides, pesticides, heavy metal ions etc. Most of them are hazardous materials i.e. highly toxic and carcinogenic. How to eliminate them from waste water and prevent them from entering environmental system is an objective of international concern(Akrout,et al.,2015). A variety of physical chemical and biological methods are applied for the treatment of waste water which include catalytic reduction, electrochemical oxidation, adsorption, advanced oxidation process etc.

The Advanced oxidation Process is a perfect technique to destroy toxic pollutants to non-toxic compounds. The peroxide and superoxide radicals formed with oxygen and water are the active species of degradation (Al-Amiery,et al;2012). CuO nanoparticles are significant 'p' type semiconductor materials with narrow band gap, low electrical resistance and un-common characteristics (Liu, et al.; 2012).They have wide applications in solar energy conversion, magnetic storage, catalysis, sensors, electronics, optics etc.

The application of CuO nanoparticles depends on the size, morphology and specific surface area which depend strongly on the preparation method. A variety of methods like sol-gel (Su, et al; 2007), sonochemical (Pendashteh, et al.; 2014) microwave irradiation (Chao, et.al; 2014), pyrolysis (Chiang, et.al; 2012), etc have been reported. These methods require high temperature, inert atmosphere and long reaction time.

The present work is on the synthesis of CuO nanoparticles using a fast, room temperature, inexpensive and non-toxic method. The CuO nanoparticles were synthesised at room temperature from Copper (II) acetate and sodium hydroxide. Oxidative degradation of Methylene Blue was studied as a model reaction to test the catalytic performance of the prepared CuO nanoparticles.

MATERIALS AND METHODS

Copper (II) acetate. Dihydrate, Sodium hydroxide and Methylene Blue were of analytical grade and used as received without further purification. Distilled water was used throughout the experiment.

Synthesis of CuO nanoparticles

The CuO nanoparticles were synthesized by adding 0.02M (50 ml) Copper acetate solution to 0.04M (50ml) Sodium hydroxide solution drop wise with continuous stirring. During this process, the blue coloured solution first changed to a blue suspension and then finally to a black suspension. Then stirring was continued for one hour and then sonicated in an Ultrasound Sonicator for 30 minutes. The precipitate obtained was filtered and washed with water. The product was dried at room temperature and calcined in a muffle furnace at 300^oC for 2 hour.

Characterisation of CuO nanoparticles

The crystalline quality and grain size of the samples were evaluated using Powder X-ray diffraction (PXRD) measurements. The morphology of samples was characterized using Scanning Electron Microscopy (SEM) and also chemical composition using EDX. Chemical nature of the synthesised nanoparticles were analysed by FT-IR spectrum. The band gap and optical properties of the nanoparticles were evaluated using UV-Visible spectrum.

Methylene Blue degradation

Methylene Blue was selected as a model pollutant to evaluate the photo catalytic activity of the synthesised nanoparticles. During the degradation process 0.1gm of the catalyst was suspended in 200mL of Methylene Blue (1mg/L) aqueous solution. The solution was placed in direct sunlight in between 11am to 2 pm. The degradation of the methylene blue was recorded by measuring the

absorbance at every 30 minute interval using UV-Visible spectrophotometer.

RESULTS AND DISCUSSION

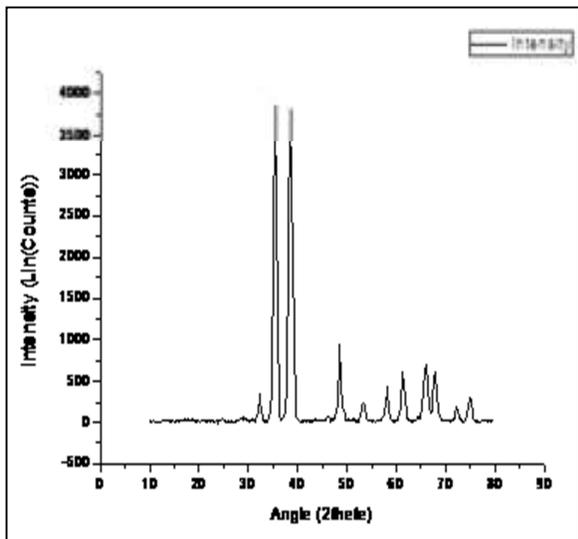


Figure 1: PXRD spectrum of CuO nanoparticles

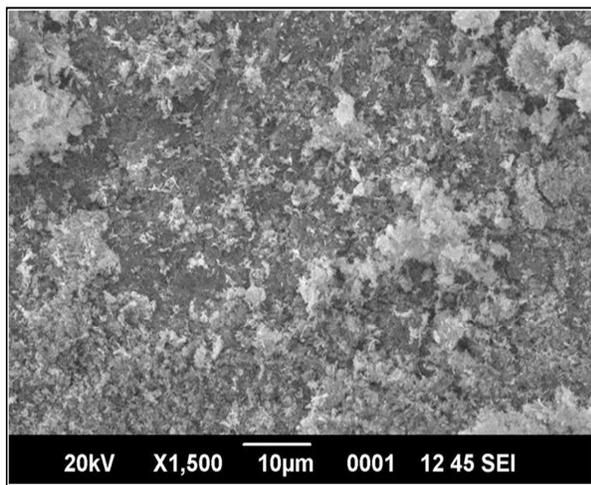


Figure 2: SEM image of CuO nanoparticles

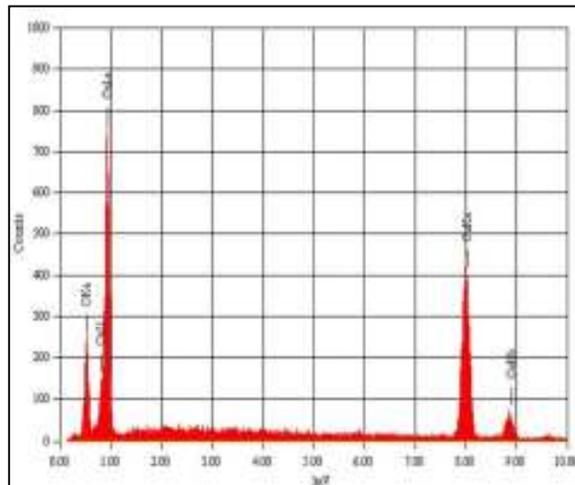


Figure 3: EDX Spectrum of CuO nanoparticles

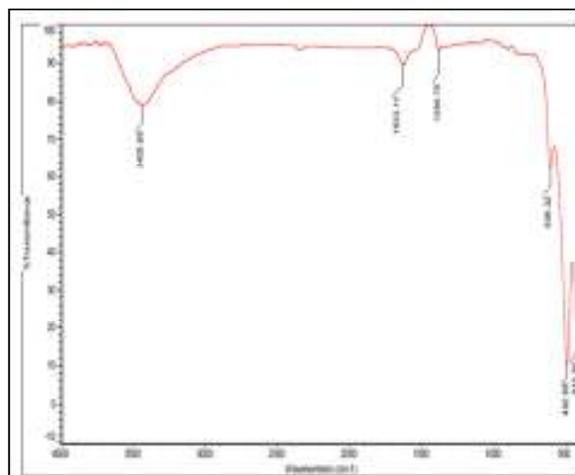


Figure 4: FT-IR spectrum of CuO nanoparticles

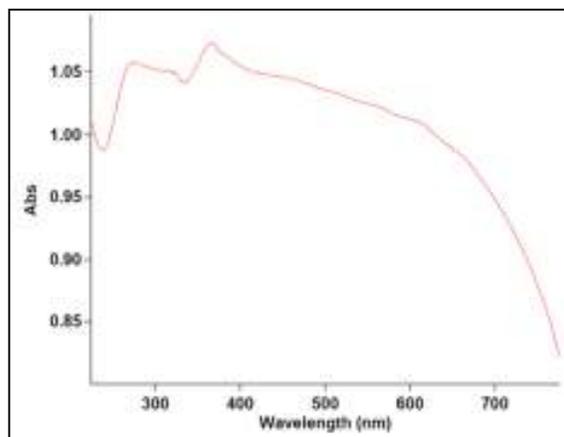


Figure 5: UV-Visible spectrum of CuO nanoparticles

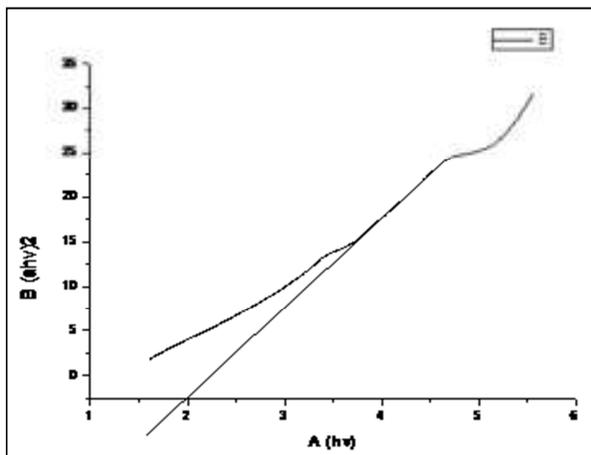


Figure 6: Tauc's plot of CuO nanoparticles

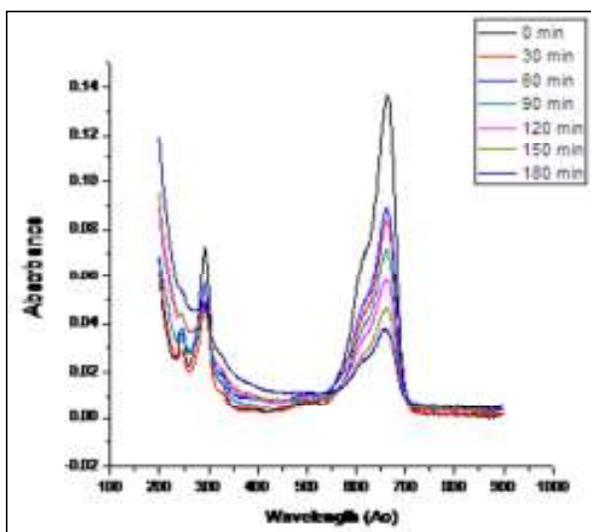


Figure 7: UV-Visible Absorption spectra of Methylene Blue at various time intervals

The X-ray diffraction is used to identify crystalline structure and particle size of the samples. X-ray diffraction patterns of our prepared CuO are shown in Figure.1. The diffraction peaks readily indexed to the monoclinic phase of CuO (JCPDS No.45-0937). From the crystallite size calculation, using Scherrer equation, $t=0.9\lambda/\beta\cos\theta$, the average size of prepared sample of CuO is nearly 14 nm.

SEM image shows the sphere like morphology of the prepared sample as in Figure.2.

EDX spectrum in Figure.3 confirmed the purity of CuO.

Figure.4 shows the FTIR spectrum of the synthesised nanoparticles the broad peak at 3437cm^{-1} and 1632cm^{-1} is due to OH stretching and bending vibration

of water molecules adsorbed on the sample. Bands at $608,493$ and 413cm^{-1} are due to Cu-O bonds in CuO.

From UV-Vis Spectra and Tauc's relation, $\alpha hv = A (hv - E_g)^n$ as in Figure(5) and (6), the band gap obtained is 1.9eV . The CuO prepared by sonochemical method is a good adsorbent and catalyst for the removal and degradation of methylene blue.

Evaluation of CuO in the oxidative degradation of methylene blue

During the course of the degradation the colour of the methylene blue solution became less intense and characteristic absorption of methylene blue decreased gradually with the time of reaction due to the oxidation of methylene blue in the presence of CuO nanoparticles. Figure.7 shows the UV-Visible absorption spectra of aqueous solution of methylene blue in the presence of CuO nanoparticles. The intensity of band at 664nm decreases with time during the catalytic oxidation without occurrence of new absorbance maxima.

ACKNOWLEDGEMENTS

I am thankful to Dr.B.Beena, supervising teacher, organizing committee-27th Swadeshi Science Congress, Amrita Vishwa Vidyapeetham, Kollam

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