



Structural and Optical Properties of Copper Iodide Nanoparticles Synthesized by Electro - Explosion of Wire

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ABSTRACT

The aim of this work is to synthesis of pure γ - CuI nanoparticles, by employing adaptation of the exploding wire phenomena in needle-plate geometry. γ - CuI p-type semiconductor is one of the promising materials it has a wide energy bad gap (3.1 eV) and unusual optical properties. It is very useful as hole collector in dye sensitized solar cells and also it is an important non-linear optical material. High purity Cu wire, 0.3 mm in diameter, is exploded against a Cu plate held at 50V with respect to the wire achieving a current of 100 amp. These explosions are carried out in a reactor vessel containing 3gm of I dissolved in 100 cm³ distilled water under ultrasonic stirring. The aqueous solution generates iodine ions and Cu⁺¹ ions are created by the explosion react with the I⁻¹ ions present in the chamber and produce CuI nanoparticles. Various characterization techniques were employed to study the properties of these CuI nanoparticles the structural by X-ray diffraction (XRD) technique, the elemental analysis by EDX analysis, optical absorption by UV-Vis spectrophotometer, Fourier transformed infrared spectroscopic analysis was done with FT-IR spectrometer, fluorimeter were used to record fluorescent behavior, and scanning electron microscopy (SEM) for the nanoparticles microstructure. All the characterization techniques confirmed that the synthesis material was pure and single phase γ - CuI. From this work it can be conclude that the exploding wire in needle-plate geometry proved to be easy and inexpensive method for the synthesis pure and single phase γ - CuI nanoparticles.

Keywords: Copper iodide; Nanoparticles; Wire

INTRODUCTION

Nanosize materials have been widely studied because of their unique properties compared to the bulk materials. They exhibit size-dependent quantum confinement effects and large specific surface area thus has distinct electronic, optical, magnetic, catalytic and thermal properties. Inorganic copper iodide is one of the promising materials for application in organic electronic devices [1]. CuI is water soluble and it is an important member of the I-VII and it has three crystalline phases, α , β and γ . The α -phase is cubic structure with high temperature of 392°C, hexagonal β -phase is an ionic conductor with temperature between 392°C and 350°C, while γ -phase is cubic structure with a low temperature below 350°C. γ - CuI is a wide energy bad gap (3.1 eV) p-type semiconductor with unusual optical properties. It is important as a non-linear optical material and also as an electrochemical sensor material [2]. CuI exhibits high optical transparencies in the visible region (over 80%) and is characterized by high conductivity. These properties make CuI thin films very useful as hole collector in dye sensitized solar cell [3, 4], organic light-emitting diodes (OLED) and organic photo cell (OPVC) [5, 6]. Also Nano sized CuI it has great interest because of several possible technical applications in catalysis, drug delivery systems, separation techniques, as well as piezoelectric and other dielectric devices. It is also one of the inorganic scintillation crystal materials with ultrafast scintillation property at a decay time of about 90 ps at room temperature [7]. CuI can be synthesized by precipitation, sol-gel processing, micro-emulsion, hydrothermal methods, solvo-thermal methods, template syntheses, biomimetic

syntheses [8] and others. Electro-explosion is a phenomenon in which a very high current, is suddenly applied to a thin conducting wire which causes it to fragment with conjugation with explosion [9]. The aim of our present work is to synthesize pure γ - CuI nanoparticles by employing adaptation of the exploding wire phenomena in needle-plate geometry.

EXPERIMENTAL WORK

Our method of synthesizing pure CuI nanoparticles is to employ adaptation of the exploding wire phenomena in needle-plate geometry. High purity Cu wire, 0.3 mm in diameter, is exploded against a Cu plate held at 50V with respect to the wire achieving a current of 100amp. These explosions are carried out in a reactor vessel containing, 3 g of I is dissolved in 250 cm³ distilled water under ultrasonic stirring. Nontransparent brown solution is obtained. The aqueous solution generates the iodine ions. As the free end of the Cu wire is in contact with the plate, the accompanying explosion fragments the cross sectional region of the Cu wire to atomic dimensions. Cu⁺¹ ions created by the explosion react with the I⁻¹ ions present in the chamber and therefore, produce CuI nanoparticles. Figure 1 show the exploding wire system used to synthesizing the pure CuI nanoparticles. Following several explosions, CuI nanoparticles are obtained as a white color colloidal suspension as the aqueous solution has convert its color from brown to white on the formation of CuI Nanoparticles as shown in Figure 2 . In order to make powder samples, this suspension is centrifuged at 5000 RPM for 60 minutes. Centrifugation segregates the CuI nanoparticles from liquid. A thin powder film of the nanoparticles is prepared by layered deposition of the colloidal suspension of the nanoparticles on a glass substrate. Various characterization techniques were employed to study the properties of these CuI nanoparticles. The structural studies were performed using X-ray diffraction (XRD) technique, The elemental analysis of CuI is investigated by EDX analysis, optical absorption of the samples in the wavelength range 200 to 1100 nm was investigated using Shimadzu UV-vis spectrophotometer, Fourier transformed infrared spectroscopic analysis was done with FT-IR spectrometer using KBr, fluorimeter were used to record fluorescent behavior at room temperature, and scanning electron microscopy (SEM) was used for study the CuI nanoparticles microstructure.



Figure 1: The exploding wire system used to synthesizing the pure CuI nanoparticles

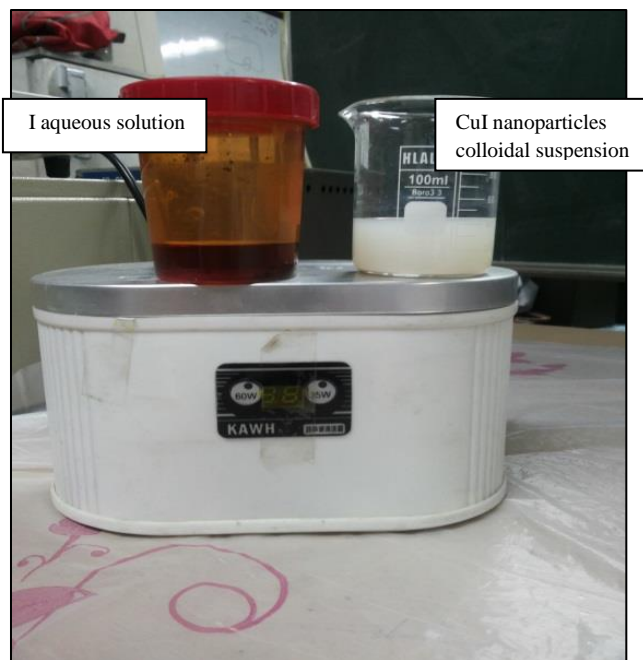


Figure 2: The white color colloidal suspension for the CuI nanoparticles and the brown color aqueous solution for iodide

RESULTS AND DISCUSSION

XRD analysis

Figure 3 shows the XRD patterns for nanoparticles of CuI. The XRD patterns show that the peaks for nanoparticles CuI matched well with the standard fcc structure of CuI. The diffraction peaks corresponded to the (111), (200), (220), (311), (400) and (331) planes of crystalline γ -CuI. No characteristic peaks of other phases were observed, so that a pure γ -CuI compound was synthesized. The average particle size was calculated to be 8 nm using Scherrer formula.

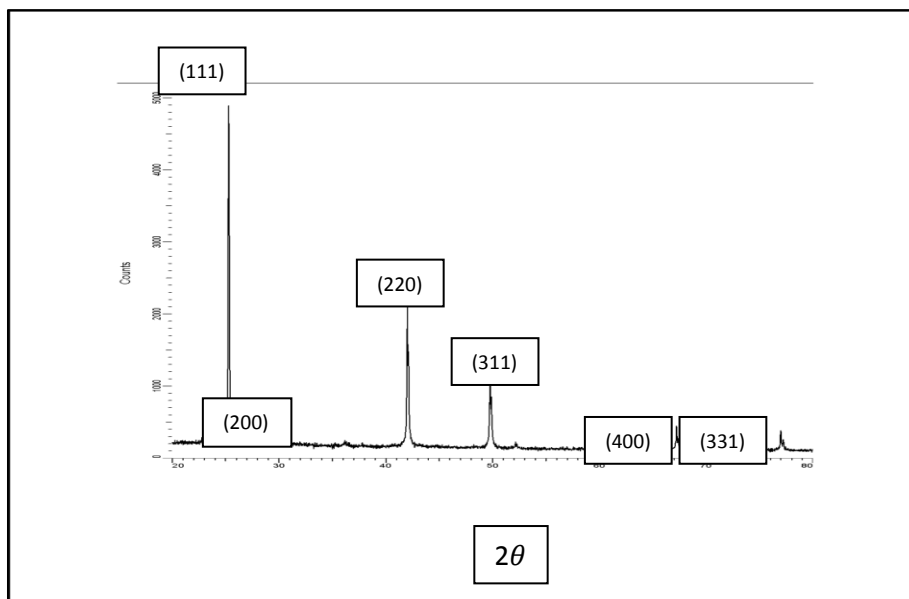


Figure 3: XRD patterns for nanoparticles of CuI

EDX measurement

The elemental analysis of CuI is investigated by EDX analysis as shown in Figure 4. The EDX measurement confirms the existence of CuI in the films. The weak peak of Si and Ca shown in the EDX spectra corresponds to the glass substrate material.

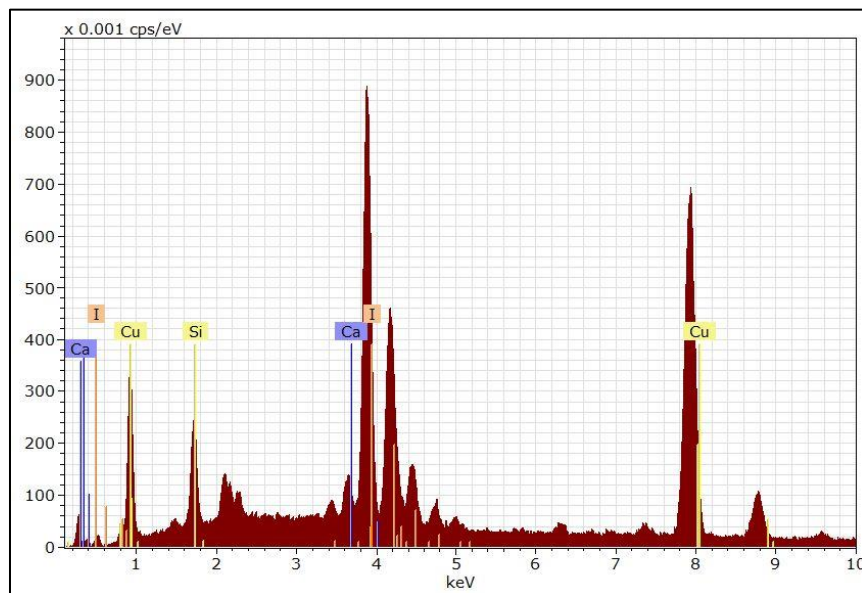


Figure 4: The EDX pattern of the CuI nanoparticles

SEM analysis

Figure 5 shows the SEM micrograph of the synthesis CuI nanoparticles. It can be seen that the nanoparticles formed are well-dispersed and equally distributed in all directions and have little agglomeration. It is also very clear that most of the particles are spherical in shape but it was difficult to determine the particle size from the Photograph because of the small particle size (less than 50nm) also the magnification was not high enough. This result is prove the possibility of production of nanoparticles by explosive wire technique in liquids.

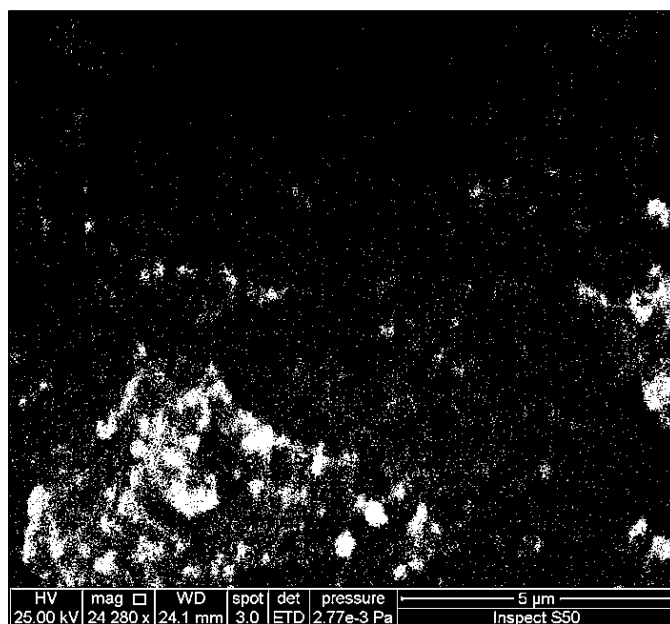


Figure 5: SEM image of the as-synthesized CuI nanoparticles

UV – vis measurement

Figure 6 shows the absorbance spectra, and room temperature fluorescence emission behavior of as-prepared CuI spectrum which was acquired at room temperature using excitation energy of 332 nm .It can be see that high absorption in the UV region was founded three high peaks at the UV region at 235,287, and352nm.This value agrees with the Matsushima and etal. [10].two luminescent peaks were observed at 398 nm (3.1eV). This is attributed to exciton band gap recombination of γ -CuI and 558 nm (2.22 eV). The UV absorbance and the fluorescence peaks reveal that this material is wide band gap with direct transition.

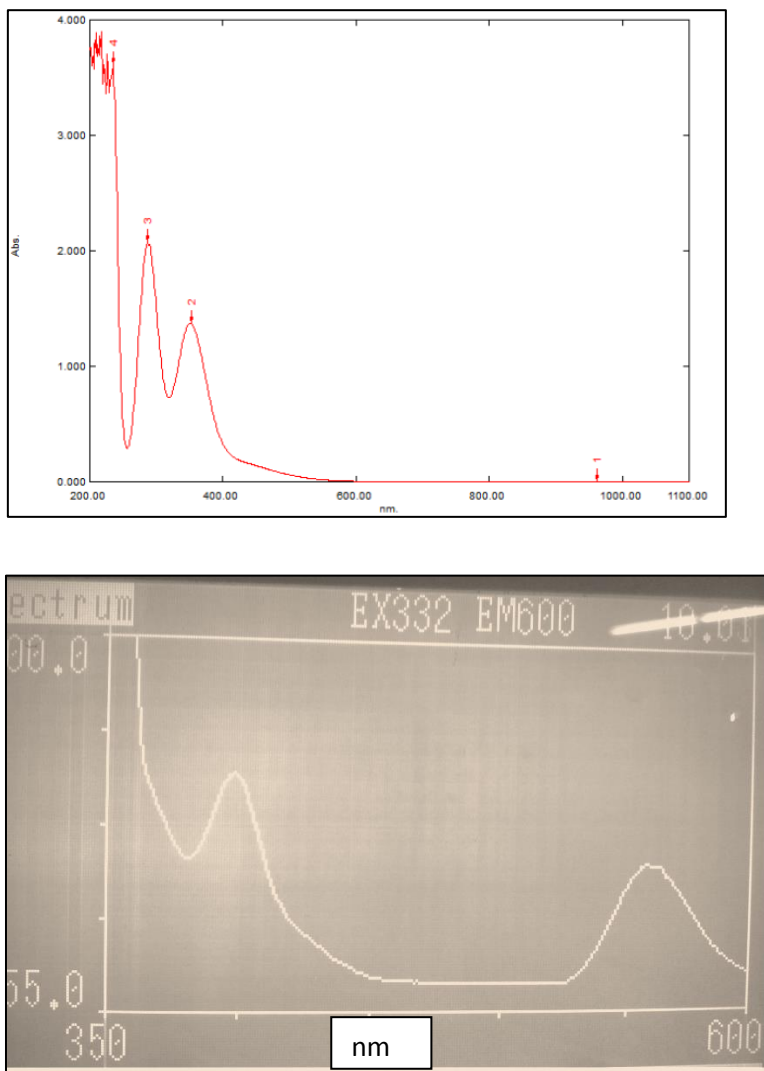


Figure 6: a: The absorbance spectra; b: the fluorescence emission of CuI nanoparticles excited at 332nm

FTIR analysis

Figure 6 shows the FTIR spectrum for CuI nanoparticles. The spectrum shows a broad band between 3100 and 3600 cm^{-1} due to the intermolecular hydrogen bonding present in the water molecules. The stretching frequency of 3421 cm^{-1} is contributed to the O-H bond. This shows that the alkyl group is present in the system, due to the presence of water. The peaks at 622 and 457 cm^{-1} are the two characteristic peaks of CuI sample. The peak at wave number 457 cm^{-1} is assigned to Cu-I stretching vibrations. And the peak at 1625 cm^{-1} corresponds to CO adsorbed on the surface.

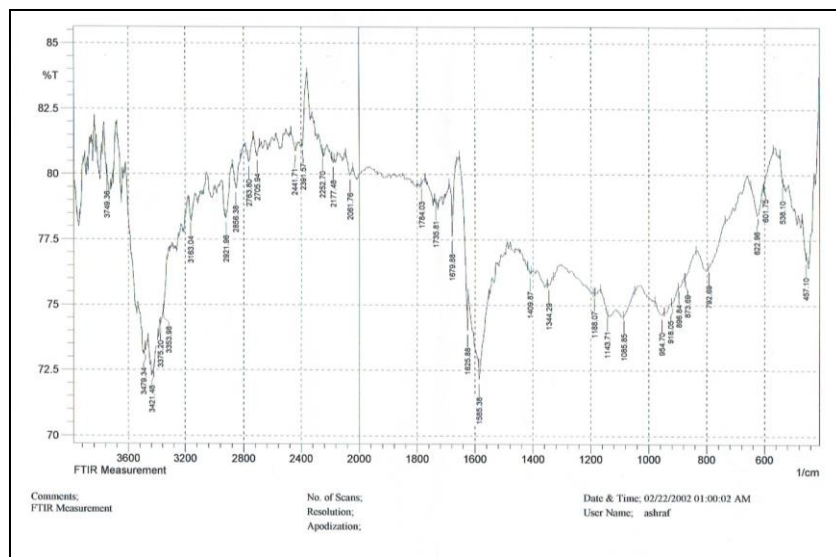


Figure 7: FTIR spectrum of CuI nanoparticles

CONCLUSIONS

This work proves that the synthesized material is a wide energy band gap (3.1 eV) p-type semiconductor. The diagnostic results showed that the use of explosive wire technique is easy and an inexpensive method for synthesis of pure and single phase γ -CuI nanoparticles. Since there is no any further chemical material except those involved in the synthesis of CuI.

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