10. Synthesis and Characterization of Copper Nanoparticles

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Abstract

Copper nanoparticles in the nanometer size have been synthesized by using Co-precipitation method. Chemical reduction of copper salts by Citric acid is a new and green approach in which Citric acid is used as reducing and capping agent in aqueous medium. The particle size of the copper nanoparticles was found to be less than 40 nm. The UV-VIS absorption spectrum shows an absorption band at 256 nm due to Copper nanoparticle powder sintered at 200^0C.The energy band gap of copper nanoparticle calculated by Tauc relation. Fourier Transform infrared spectroscopy shows the presence of polyhydroxyl structure on the surface of copper nanoparticles and thus prevents the agglomeration of Copper nanoparticles.

Key words: Synthesis, Cu nanoparticles, UV-absorbance, FT-IR.

1. Introduction

Nanotechnology is the most promising technology that can be applied almost all sphere of life, ranging from pharmaceuticals, defense, electronics, transportations heat transfer to sports and aesthetics. Quantum confinement of both electron and hole in all three dimensions leads to an increase in effective band gap energy of the material with decreasing the size of the particle. By controlling the crystal size, band gap of the nanoparticle is tuned and leading to the band edge emission [1].Copper nanoparticles are very attractive due to their heat transfer properties such as high thermal conductivity. Some reducing and capping agents are very expensive and also have toxic effects. Copper nanoparticles production using chemical reduction method gives good results but use of hazardous reducing, costly and protecting agent makes the process toxic in some cases [2].To avoid the toxicity and to prepare Copper nanoparticles in green environment, we have used citric acid in our chemical reduction process. Citric acid works both as reducing and protecting agent, which makes the process economical, nontoxic and environment friendly. There are a large number of techniques available to synthesize different types of nanomaterials in the form of colloids, clusters, powders, tubes, rods, wires, thin films etc. Physical and chemical methods are two basic techniques for the synthesis of Copper nanoparticles. Chemical reduction method is one of the most convenient methods for the synthesis of metallic nanoparticles because this synthesis process is simple, shape and size of nanoparticles can be controlled. Copper nanoparticles are used in Nano electronics, Nano probes in medicines, Bio analytical areas, electronic, magnetic, catalytic, pharmaceutical, cosmetic energy applications [3, 4]. So in the present study, the influence of citric acid on concentration of $CuCl_2.2H_2O$ and reaction temperature on the oxidation and dispersion of the aqueous copper nanoparticles were investigated. Herein I have discussed the optical properties of synthesized copper nanoparticle.

2. Experimental

2.1 Synthesis of Copper Nanoparticles

A 25 ml of 1 molar Copper (II) Chloride solutions was prepared by dissolving that copper salt in de-ionized water. Solutions of 2.0M Citric Acid were prepared in 50 ml de-ionized water. A 25 ml of $CuCl_2.2H_2O$ solution were heated continuously at 90^0C temperature under vigorous stirring on magnetic stirrer with heater (electrical/ mechanical heated).The solution of 2.0M Citric Acid were added drop wise to single flask respectively. The heating and mixing continued till the color changed from no color to Blue, orange, brown, white finally dark white-green respectively. The white-green product was centrifuged for 20 minutes and washed three times with distilled water. Green color indicated the formation of fine nanoscale copper particles from citric acid assisted reduction. The obtained product was dry under IR lamp for few hours and sintered at 200^0C in air atmosphere for 1 hour. [5]

2.2 Optical Characterization

The infrared spectrum of the copper nanoparticle was measured at room temperature in the wave number range 400-4000 cm^{-1} by a Fourier Transform infrared spectrophotometer (FT/IR-6100Shimadzu). The samples were pulverized into fine powder and then mixed with KBr powder with weight ratio (1:100), respectively. The UV-visible optical absorption spectra of copper nanoparticle were measured in the range 200–400 nm. A record spectrophotometer (BSR UV-VIS-NIR Model No.UV-1900) was used for these optical measurements.

3. Results and Discussion

3.1 FT-IR Spectrophotometer analysis

The interaction of Citric acid, Copper nanoparticles and the mixture composition changes were studied by FT-IR spectrophotometer. The IR spectra of copper nanoparticles are represented in Figure 2.

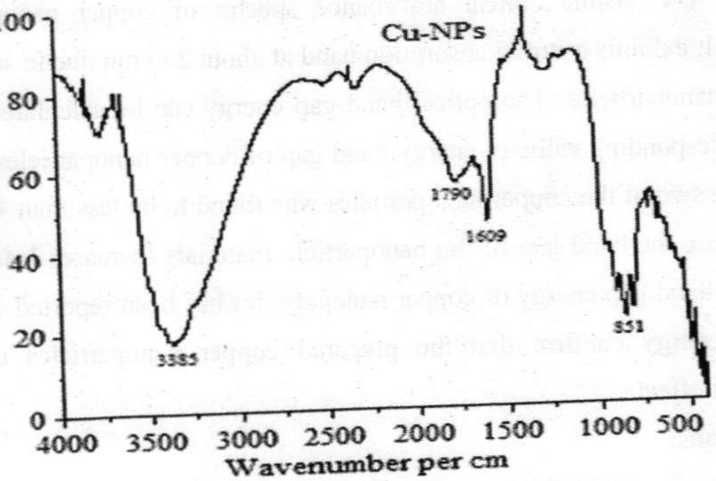

Fig: 2. FTIR of Copper Nanoparticles

The FT-IR of copper nanoparticles was observed that peaks 3385 cm^{-1}, 1709.01 cm^{-1}, 1609 cm^{-1} and 851 cm^{-1}. The peak found at 3385cm^{-1} due to stretching vibration of H_2O molecule. The peak found at 1709cm^{-1} due to bending vibration of H_2O molecule. These peaks assigned to hydroxyl, band due to scissor bending vibration of water molecules, acidic asymmetric stretch and C-H deformations of $-CH_2$ or $-CH_3$ groups (lignin) in aliphatic also observed during the reaction[6].

3.2 UV-Visible Spectrophotometer Analysis

The UV-visible optical absorption spectra were measured from a double beam spectrophotometer in the range 200–800 nm. A record spectrophotometer (JASCO UV-VIS-NIR Model No.V-670) was used for these optical measurements of copper nanoparticles.

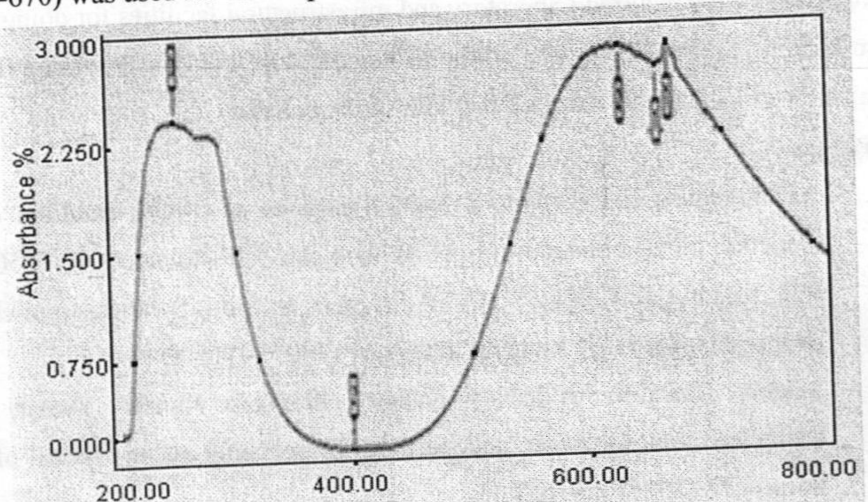

Fig:3. The Absorbance Spectra of Copper Nanoparticles

The UV visible optical absorbance spectra of copper nanoparticles are represented in Figure 3.It exhibits a strong absorption band at about 256 nm due to surface Plasmon resonance in Copper nanoparticles. The optical band gap energy can be calculated using the Tauc relation [7], the corresponding value of energy band gap of copper nanoparticles was found to be 4.8 eV. The particle size of the copper nanoparticles was found to be less than 40 nm [8]. As the particle size increases, the band gap of the nanoparticle materials increases leading to blue shift region. The optical band gap energy of copper nanoparticles has been reported with E_g= 4.2eV [9].Large band gap energy confirm that the prepared copper nanoparticles exhibits strong quantum confinement effect.

4. Conclusions

Copper nanoparticles are synthesized by chemical rout. This is a simple, economical and green method for the synthesis of copper nanoparticles with no toxic and hazardous effect. The Citric acid protected copper nanoparticle prepared using chemical reduction of cupric chloride. The FT-IR of copper nanoparticles peaks 3385 cm^{-1}, 1709.01 cm^{-1},1609 cm^{-1} and 851 cm^{-1} correspond to hydroxyl, band due to scissor bending vibration of molecular water, acidic asymmetric stretch and C-H deformations of $-CH_2$ or $-CH_3$ groups (lignin) in aliphatic respectively. The product is of uniform size 30-40 nm and has uniform distribution curve. The optical energy band gap of copper nanoparticle was observed 4.8 eV. The high stability of copper nanoparticles was observed for long time, it shows no suspension or sedimentation.

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References

1. P.G Prabhash and Swapna S Nair, Syntheses of copper quantum dots by chemical reduction method and tailoring of its band gap, AIP Advances, 6 (055003) (2016) 7-10.
2. P.K. Khanna, S. Gaikwad ,P.V. Adhyapak ,N. Sing, Synthesis and characterization of copper nanoparticles. Material letters, 61 (2007) 4711-4714.
3. Sulekh Chandra, Avdhesh Kumar, Praveen Kumar Tomar, Synthesis and characterization of cooper nanoparticles by reducing agent. Journal of Saudi Chemical Society 18 (2014) 149-153.

4. Y. Niu and R M Crooks, Dendrimer-Encapsulated Metal Nanoparticles and Their Applications to Catalysis, Chem. Mater.,15 (2003) 3463
5. Shikha Jain, Ankita Jain, Vijay Devra, Experimental Investigation on synthesis of copper Nanoparticles by chemical Reduction Method. International Journal of Scientific & Engineering Research 5(11) (2014) 974-978.
6. Madiha Batoool and Bilal Masood, Green Synthesis of Copper Nanoparticles Using Solanum Lycopersicum (Tomato Aqueous Extract) and Study Characterization, Journal of Nanoscience & Nanotechnology Research, , Vol.1 No.1;5 (11) (2017) 1-4.
7. S.B.Kulkarni, S.S. Joshi and C.D.Lokhande, Facile and efficient route for preparation of nanostructured polyaniline thin films: Schematic model for simplest oxidative chemical polymerization. Chemical Engineering Journal 166 (2011) 1179-1185.
8. S. M. Sathiya, G. S. Okram , M. A. Jothi Rajan1* Structural, optical and electrical properties of copper oxide nanoparticles prepared through microwave assistance, Advanced Materials Proceedings, 2(6) 2017,371-377.
9. Detlef Klimm, Electronic materials with a wide band gap; Recent developments, IUCr Journal (Crystallography Journals Online), 1(5) (2014) 281-290.