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Preparation and characterization of DNA capped copper nanoparticles

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Abstract: In this research, deoxyribonucleic acid was used as solution electrolyte in order to synthesize copper nanoparticles through simple electrochemical process. In this method, copper ions scarified into the electrolyte solution forming DNA–copper complex, then ascorbic acid was used to reduce the obtained Cu ions into copper nanoparticles with an average size range between 12 nm.

keywords: Copper Nanoparticles, DNA and Electrochemical process.

1.Introduction

Study of nanoparticles have a great attention, because it has a lot of applications in different fields of technology and science. Nanoparticles are particles within the size range from 1 to 100 nm [1]. Nanoparticles not simple molecules but complex mixtures. Its properties connect between the behavior of large material and individual atoms or molecules. Nanoparticles unusual properties include, a high surface area to volume ratio; where the chemistry of the surface of the simplest nanoparticle, appear highly different from the material's core [2]. We can classify Nanoparticles into various categories according to their; morphology, size, chemical and physical properties. Such Carbon-based nanoparticles, Semiconductor nanoparticles, Ceramics nanoparticles, Lipid-based nanoparticles, Polymeric nanoparticles and Metal nanoparticles [3].

Studying of metal nanoparticles has great interest due to their chemical and physical properties and a has lot of range of application. Metal nanoparticles should be prepared using appropriate method in order to get a particular size of nanoparticle. There are various types of metallic nanoparticles and their derivatives (such as silver, gold, zinc, nickel, platinum, titanium, and copper nanoparticles) [4]. Copper nanoparticles is greatly in attention due its profuse amount, availability and low cost in comparison to gold and silver, so large scale productions of copper nanoparticles are using various physical and chemical method [5].

Copper nanoparticles have pulled great interest according to their mechanical, catalytic, optical and electrical properties, thus it has a lot of application area in the field of catalysis, metallurgy, optoelectronics and nano [6]. Copper nanoparticles can be manufactured using numerous chemicals, physical methods and Biological Methods. Biological Methods It has been found that using living organisms such as bacteria, fungi, and plants have a great potential for the synthesis of metal nanoparticles. physical methods as Pulse Laser Ablation/Deposition, Mechanical/Ball Milling Method, Pulsed Wire Discharge Method (PWD). Chemical methods as chemical reduction method, Microemulsion/Colloidal Method, plasma method, Photochemical Method, Thermal Decomposition and Electrochemical Method etc. In the electrochemical method, the electric force occurs when an electric current passes between two electrodes immersed in the electrolyte, thus the synthesis occur at the electrode/electrolyte interface [7]

2. Materials and methods

Materials

In this experiment, two pure rectangular platinum (Pt) and copper (Cu) plates were used as electrodes, deoxyribonucleic acid

(dsDNA), deionized water (resistivity > 2×10^8 Ω.cm) and ascorbic acid.

Method

In this experiment the copper nanoparticles were prepared using electrochemical method. The electrolyte solution was prepared by dissolving a 0.4 wt % of DNA in deionized water. Next, the electrochemical cell which consists of two- sheets, platinum as negative electrode (cathode) and copper as a positive electrode (anode) was placed vertically in the fresh prepared aqueous solution electrolyte at a constant distance of 5 cm. The reaction procedure was carried out under magnetic stirring (200 rpm.) at constant applied potential of 2.5 V (using potential power supply; ECOS) for 5hrs at the ambient condition. Finally ascorbic acid as a reducing agent used to convert DNA/Cu complex into Cu nanoparticles.

Mechanism

Copper ions electro-released from the copper anode sheet into the DNA electrolyte forming DNA-Cu complex chelated with the phosphate groups of DNA. Next, ascorbic acid added to reduce the Cu ions into Cu nanoparticles capped with DNA chains.

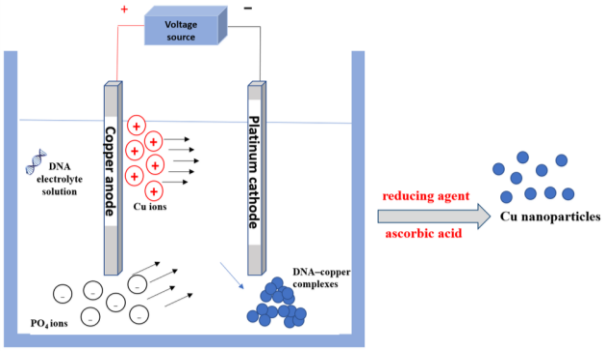

Figure 1: Schematic illustration of the electrochemical cell and the formation of copper nanoparticles.

3. Instrumental analysis

UV-visible spectroscopy.

The prepared nanoparticles were examined using the UV-vis spectroscopy in the range of 190-1100 nm with ±0.3 nm wavelength accuracy.

Transmission electron microscope

TEM was used to study the morphology and distribution of the prepared copper nanoparticles, as the solutions were sonicated using ultrasonic cleaner and sonicator then, a drop of the prepared solution was placed onto a carbon coated Cu grid then the solvent evaporated at ambient conditions before taking images.

Stability test

The prepared samples were examined using UV-vis. spectroscopy to study its stability for a period of time.

Software

Magic plot and PowerPoint were used for graphs and schematic diagrams.

4. Results and Discussion

UV–visible spectroscopic analysis

In Figure 2, the formation of the CuNPs was promoted with the aid of UV-vis spectra of the solutions through emergence of two absorption peaks at about 305 nm and 690 nm[8]. We find that almost all the absorption curves have the same behavior. also, it was shown that increase the time led to strong absorption peak and the area under the curve of the characteristic absorption peaks of CuNPs increase[9].

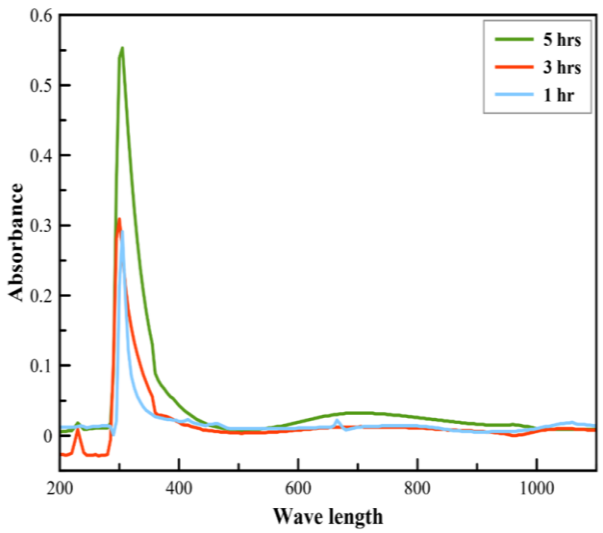

Fig 2: UV–visible spectra of the synthesized Cu nanoparticles for different times.

Transmission electron microscope (TEM)

The morphology and size of the electrosynthesised Cu nanoparticles in the solution was confirmed by using transmission electron microscopy (TEM) measurements. Figure 3, showed the TEM images of Cu nanoparticles with different magnification that indicate the formation of different sized copper nanoparticles that ranges from 3 – 12 nm[6, 9], very fine copper nanoparticles.

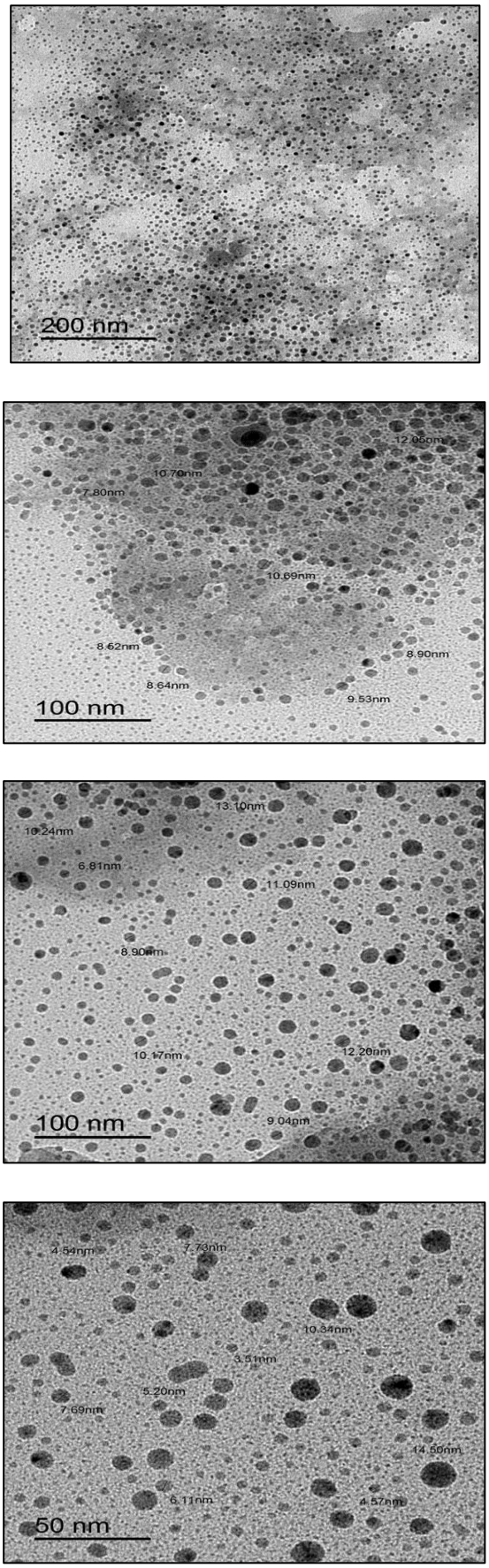

Fig3: TEM images of Cu nanoparticles for time 5 hrs.

The selective area electron diffraction patterns (Figure 4) of the electroformed CuNPs indicated that the formed CuNPs are crystalline. Moreover, the high-resolution TEM (HRTEM) investigations showed the crystal lattice fringes of CuNPs[7] (Figure 4). The value of fringe spacing was 0.18 nm for CuNPs prepared.

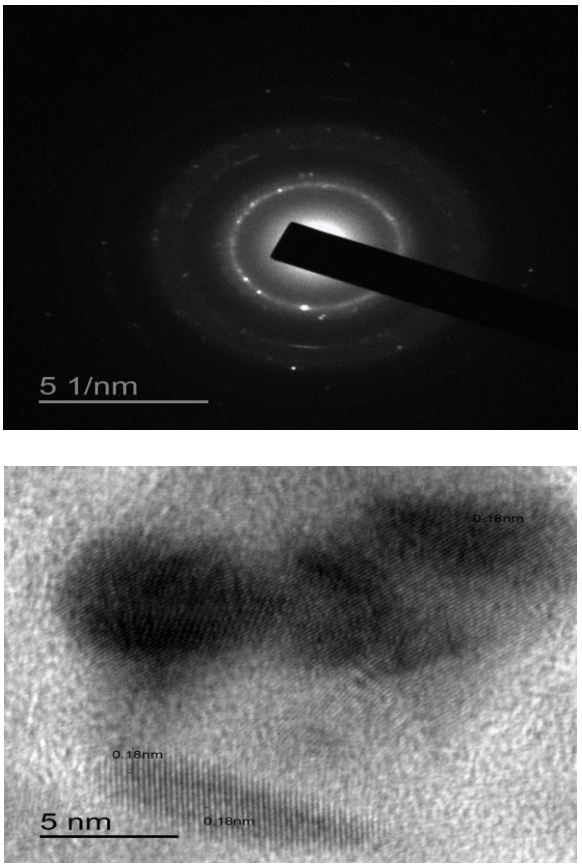

Figure 4: HRTEM images and electron diffraction of Cu nanoparticle**.**

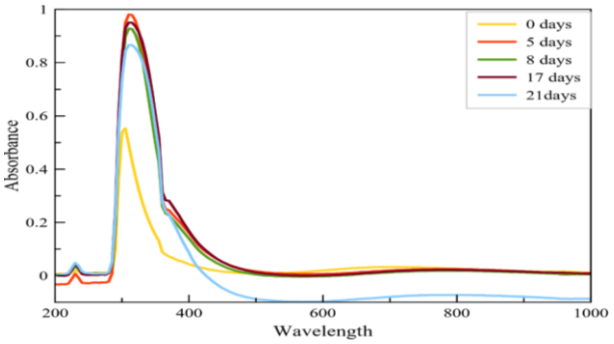

Figure 5: UV-vis. spectra of formed CuNPs stored at 4^{o} C for one months.

time stability

We study the stability as a function of time against aging and aggregation for the formed CuNPs by using UV–vis, the results show that the absorption spectra of the nanoparticle solution at 305 nm and 690 nm showed no change under the effect of time for approximately one months, so UV–vis patterns revealed that the formed CuNPs could last at 4 °C for approximately one month [8].

5. conclusion

This study introduced a facile one-step and cost-effective process to synthesis of DNA/copper complexes by anodic oxidation through a simple electrochemical process. these structures may be the chain of longer complexes or smaller complexes depending upon the number of bonded DNA and copper ions and microstructurally. then by using reduction agent we can get copper nanoparticles.

4. References

1. Adamo, G., S. Campora, and G. Ghersi, (2017)Functionalization of nanoparticles in specific targeting and mechanism release, in Nanostructures for Novel Therapy., Elsevier. p. 57-80.
2. Christian, P., et al., (2008) Nanoparticles: structure, properties, preparation and behaviour in environmental media.. **17**(**5**): p. 326-343.
3. Khan, I., K. Saeed, and I.J.A.j.o.c. Khan, Nanoparticles: Properties, (2019) applications and toxicities.. **12**(**7**): p. 908-931.
4. Yaqoob, A.A., et al., (2020).Recent advances in metal decorated nanomaterials and their various biological applications: a review. **8**: p. 341.
5. Shah, K.W., Y.J.C. Lu, and B. (2018) Materials, Morphology, large scale synthesis and building applications of copper nanomaterials.. **180**: p. 544-578.
6. Dhas, N.A., C.P. Raj, and A.J.C.o.m. Gedanken(1998),Synthesis, characterization, and properties of metallic copper nanoparticles.. **10**(**5**): p. 1446-1452.
7. Khodashenas, B. and H.R.J.K.J.o.C.E. Ghorbani, (2014)Synthesis of copper nanoparticles: An overview of the various methods.. **31**(**7**): p. 1105-1109.
8. Elkayal, R., et al., (2021)Novel electro self-assembled DNA nanospheres as a drug delivery system for atenolol. Nanotechnology,. **32**(**25**).
9. Wang, G., J. Wan, and X. Zhang, *TTE DNA-Cu NPs:* (2017.) enhanced fluorescence and application in a target DNA triggered dual-cycle amplification biosensor. Chem Commun (Camb), **53**(**41**): p. 5629-5632.