Research Article
Volume 11:3, 2022

Journal of Material Sciences and Engineering

ISSN: 2169-0022 Open Access

An Investigation of Novel Nano Material Silver Nano Dots Synthesis and Characterization Using Simple Sugar Fructose

A.G.J. Patriciaa*

Department of Physics, Mother Teresa Women's University, Kodaikanal, India

Abstract

Silver nano dots are new and smart materials for application in medical field. Their sizes are in the range of <=10 nm and have unique structural, chemical, physical properties which help in molecular diagnostics, in therapies, in devices used in medical procedures. In this report we present the chemical process in which the silver nano dots are synthesized using a simple ingredient fructose as reducing which is a less expensive and is a rapid phase method. It is a very feasible method to harvest silver nano dots in the lab at a very rapid pace than the conventional methods and without toxic side effects. The size of the silver nano dots were found to match the size of biological molecules and exhibited unique properties which can find a wide array of applications in the field of medicine and industrial electronics. UV-VIS study, XRD analysis, FTIR studies and TEM analysis was done to establish the fact that silver nano dots can be synthesized using simple chemical sugar like fructose. Based on the size of the silver nano dots created in the lab and their ability to penetrate the blood brain barrier in the human system they can be applied for diagnostic and therapeutic purposes.

Keywords: Silver nano dots • Fructose • Surface plasmon resonance • Nano medicine • Medical applications

Introduction

Nanotechnology is manipulation of matter on an atomic, molecular, and supra molecular scale with at least one dimension sized from 1 to 100 nano meters [1-5]. This definition reflects the fact that quantum mechanical effects are important at this quantum realm scale. Nanotechnology has arisen as a key player in the field of nano medicine [6-10]. A number of new and novel methods are used to fabricate silver nano particles. Each methodology is resulting in a variety of sizes and final products. In this article, we discuss how pure silver nano particles were created *via* chemical reduction synthesis which is an easy and simple chemical procedure [11-15]. The prepared silver nano dot samples had been examined under UV-VIS, XRD, TEM analytical methods of optical absorption spectroscopy. The silver nano dots created by the above method are compatible for medical application with zero chemical toxicity on application and without environment issues [16-22]. The silver nano dots are ecofriendly and their sizes match the biological molecule sizes [23,24].

Materials and Methods

Synthesis of silver nano dots

All the analytical grade chemicals used for synthesis were purchased from Sigma Aldrich. Silver nano dots of uniform sizes were prepared by the reduction of silver ions using the simple monosaccharide fructose. In this synthesis, fructose solution was prepared by mixing 0.0050 grams of fructose in 50 ml of de-ionized water taken in a conical flask and 0.001 grams of PVA was added. The Erlenmeyer conical flask was stirred by keeping it on a magnetic stirrer. Then 0.0010 grams of silver nitrate (1 ml of 0.1% $AgNO_3$ aqueous solution- 0.01 M solution) was added to the solution in the flask drop wise regularly. After adding the metallic precursor solution, colour of the solution changed into dark brown within 30 minutes duration as shown in Figure 1. The room temperature was 23˚C during this process and the prepared solution.

***Address to Correspondence:** A.G.J. Patriciaa, Department of Physics, Mother Teresa Women's University, Kodaikanal, India, Tel: 8122603846; E-mail: patriciatrichy@gmail.com.*

Received: 01 February, 2022, Manuscript No. JME-22-57012**; Editor assigned:** 04 February, 2022, PreQC No. JME-22-57012 (PQ)**; Reviewed:** 18 February, 2022, QC No. JME-22-57012**; Revised:** 04 April, 2022, Manuscript No JME-22-57012 (R)**; Published:** 12 April, 2022, DOI: 10.37421/ 2169-0022.2022.11.12

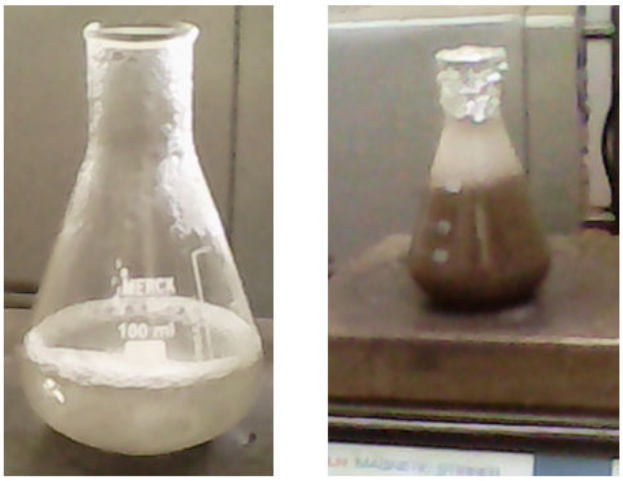

Figure 1. Silver undergoes chemical reduction.

Was stable for days without decomposition. The colour change indicates the reduction of silver ions and the formation of silver nano dots.

Results and Discussion

Silver nano particles of the sizes of 10-20 nm match the sizes of biological molecules and hence find applications in medicine for diagnostic and therapeutic purposes. UV-Vis studies were performed in a Shimadzu UV-2600 PC spectro-photometer.

Powder XRD analysis of the synthesized silver nanodots was done using Cu-Kα X-rays with wavelength (λ)=1.54056 Å. The surface morphology was analyzed in TEM (transmission electron microscopy). Functional groups were analyzed by FT-IR spectrometer using Ag nano dots KBr pellet.

UV-VIS absorption study

UV-VIS spectroscopy is one of the most widely used for structural characterization of silver nano particles. The nano dot nature of the sample can be identified from the UV-VIS spectra of the solutions. The UV-VIS absorption spectra of the silver nano particle were examined. The absorption peak was obtained at 417 nm.

The Figure 2 shows the UV spectra in the range 350 nm-550 nm. The silver nano dots exhibit an intense absorption peak due to surface plasmon resonance. The absorption band is in the visible light region. The plasmon peak was obtained at 417 nm.

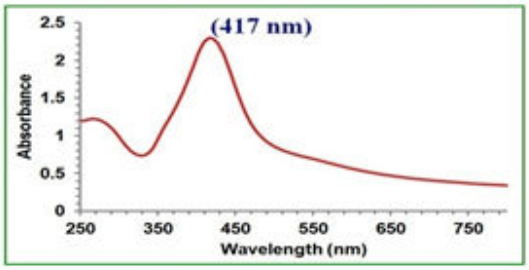

Figure 2. UV-Vis absorption spectrum of silver nanodots shows the SPR peak.

The relationship between particle size and SPR of the UV-Vis absorption spectrum supports for the particle size calculation.

XRD Study

Powder X-ray diffraction analysis of the synthesized sample is shown in Figure 3. It confirms the formation of silver nanodots. The diffraction peaks are observed at 2 θ values of 38.3°, 44.3°, 64.6° and 77.6°. These peaks are corresponding to the (111), (200), (220) and (311) crystalline planes of face cantered cubic (fcc) silver. Absence of peak related to any material other than Ag indicates the purity of the sample. Generally, (111) reflection of FCC materials has high intense peak.

Likewise, in the powder XRD of the sample, the (111) reflection (2 θ value 38.3°) has the most intense peak which is also noted. The observed peaks were compared with the standard silver of Joint Committee on Powder Diffraction Standards (JCPDS), silver file No. 04–0783. The most intense peak of JCPDS located at 2 θ value of 38.11°. The comparison agrees that the resultant particles are FCC silver nano dots.

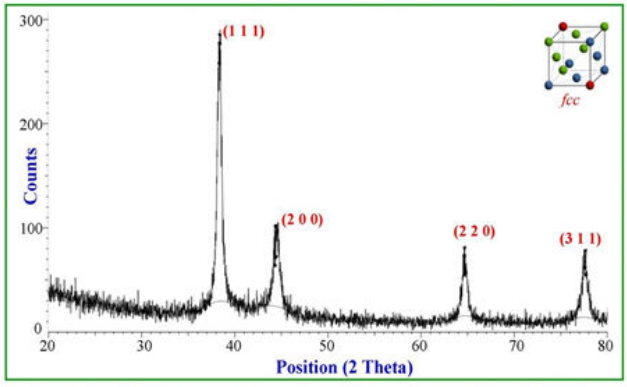

Figure 3. Powder XRD analysis confirms the silver nanodots (with FCC structure).

The Miller indices (hkl) were assigned to each peak. The miller indices reveal the FCC structure of Ag nano dots (Table 1).

2 θ of the intense peak (deg)	(hkl)	FWHM of intense peak in radian	Size of the particle nm	d-spacing mm
38.3	(111)	0.0275	5.3	0.2338
44.3	(200)	0.0183	8.2	0.2039
64.6	(220)	0.0321	5.1	0.1444
77.6	(311)	0.0238	6.5	0.1224

Table 1. The particle size of silver nano dots.

The XRD peaks are broad in nature due to the size reduction i.e. nano size of the particles. The particle size and interplanar spacing (d-spacing) were calculated from the most intense peak at 2 θ Cos θ value 38.3° with hkl (111).

For these calculations, Debye–Scherrer formula and Bragg's Law presented in equations (1) and (2) were applied respectively.

$D=0.9\ \lambda/W \cos\theta$ ..... (1)

Where D is particle size, 0.9 is Scherrer's constant, λ is X-ray wavelength (1.5406 Å), W is FWHM (Full Width at Half Maximum) of the peak located at 2 θ = 38.3° and θ is Bragg's angle of diffraction. The observed θ value in radian is 0.023.

The inter planar spacing (d-spacing) was calculated using Bragg's Law:

$2 d \sin\theta = n\lambda$..... (2)

Where, d is d spacing and n=1. The particle size of the sample is 6 nm and the d-spacing is 2.34 Å. The d-spacing value related to the peak (111) of JCPDS file: 04-0783 is 2.3590 Å. It is observed that d-spacing value of the sample agrees with JCPDS. The powder XRD results confirm that the synthesized material is silver nano dots.

FT-IR analysis of silver nano dots

FT-IR analysis can be called as the finger print analysis. From this analysis, the elements involved in a synthesis can be traced. This analysis was done to understand the functional groups and formation mechanism (reduction and stabilizing) of Ag nano dots. It was examined that the interactions between the precursor salt ($AgNO_3$), fructose molecules and PVA stabilizing agent. The FT-IR spectrum related to Ag nano dots is shown in Figure 4.

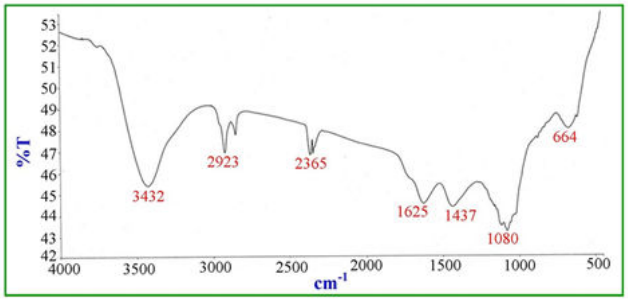

Figure 4. FTIR functional groups analyses of Ag nano dots synthesized by fructose molecules.

The peak details are enumerated in below in Table 2.

Frequency Range (cm^{-1})	Absorption (cm^{-1})	Appearance of Peak	Group	Compound Class
515-690	664	Strong	C-Br stretching	Halo Compound
1050-1085	1080	Strong	C-O stretching	Alcohol
1395-1440	1437	Medium	O-H bending	Carboxylic acid
1600-1650	1625	Medium	C=C stretching	Alkene
2000-2400	2365	Weak	O=C=O stretching	carbon dioxide
700-3200	2923	Weak, broad	O-H stretching	Alcohol
3200-3550	3432	Strong, broad	O-H stretching	Alcohol

Table 2. FTIR functional group analysis.

It shows the absorption peaks at wave numbers 3432, 2923, 2365, 1625, 1437, 1080 and 664 cm^{-1}. The peak observed at 3440 cm^{-1} are due to O-H stretching and deformation. It indicates the absorption of water on the metallic surface. Also, the O-H stretching on the large peak of 3400 cm^{-1} indicates the intra-molecular and inter-molecular hydrogen bonds. The peaks at 1600 cm^{-1} and 3400 cm-1 are confirmation for water and hydroxyl groups absorbed by the surface. The absorption peak at 1625 cm^{-1} indicates the presence of NO_2. It may be from the $AgNO_3$ solution which was utilized as metal precursor during the synthesis process of Ag nano dots. Strong interaction in between water and silver surface is the reason for the O-H stretching mode at 2923 cm^{-1} peak. Absence of COOH functional group supports for the strong luminescence emission.

TEM Analysis of Silver Nanodots

TEM (Transmission Electron Microscopy) analysis reveals the accurate data about the average size, shape and size distribution of the synthesized nano particles. The TEM image of the synthesized silver nano dots are shown below in Figure 5. It is observed from the TEM analysis that the silver nano dots are in uniform spherical shape. Approximate size of a silver nano dot is 6 nm. Size of the silver nano

dots estimated by both TEM and XRD analyses are in good agreement.

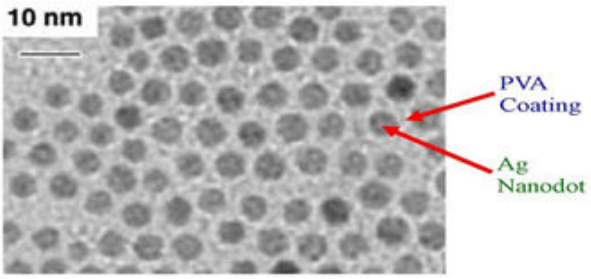

Figure 5. TEM image of silver nano dots of sizes 10 nm.

Every nano dot has been detached from each other and stands alone separately. This analysis reveals that the formation and size distribution of silver nano dots is fairly and evenly. It exhibits the thin layer of PVA coating on the silver nano dots. This polymer coating prevents the agglomeration/aggregation of silver nano dots that leads to their protection and stabilization. Also, it supports to enhance the anti-microbial activities of the silver nano dots.

Conclusion

In conclusion, we introduce a simple, fast, and economical method to synthesize silver nano dots. This method provides a clean, nontoxic and ecofriendly and efficient route for the synthesis of nano dots with tunable particle size, at room temperature conditions. There is no need to use high pressure, energy, temperature, toxic chemicals, downstream processing etc. Also the handling of the nano particles is also much easier than other methods. Nanotechnology wise, this is a significant advancement to synthesize silver nano dots. The synthesized Silver nano dots are in spherical shape with particle size of 10 nm. Their characterizations have been successfully done using the UV-VIS, spectra XRD analysis, FTIR and TEM studies exhibit the nano nature of the prepared samples and justify the purpose of this study. So we conclude that silver nano dots can be harvested at the lab using low cost, eco friendly methods and materials like fructose. It is a rapid and convenient method and can find a variety of nano medicinal applications.

References

1. Wang X, Zhuang J, Peng Q and Li Y, et al. A general strategy for nano crystals synthesis . *Nature* 431 (2005): 03968.
2. Taleb A, Petit C and Pileni MP. Optical properties of self-assembled 2D and 3D super lattices of silver nano particles. *J Phy Chem B* 102 (1998): 2214-2220.
3. Sastry M, Ahmad A, Khan MI and Kumar R, et al. Biosynthesis of metal nanoparticles using fungi and actinomycete . *Curr Sci* 85 (2003): 162–170.
4. Tien DC, Tseng KH, Liao CY and Huang JC, et al. Discovery of ionic silver in silver nanoparticle suspension fabricated by arc discharge method. *J Alloys Compd* 463 (2008): 408–411.
5. Mafune F, Kohno J, Takeda Y and Kondow T, et al. Structure and stability of silver nanoparticles in aqueous solution produced by laser ablation. *J Phys Chem B* 104 (2000): 8333–8337.
6. Mafune F, Kohno J, Takeda Y and Kondow T, et al. Formation of gold nanoparticles by laser ablation in aqueous solution of surfactant. J Phys Chem B 105 (2001): 5114–5120.
7. Kabashin AV and Meunier M. Synthesis of colloidal nanoparticles during femtosecond laser ablation of gold in water. *J Appl Phys* 94 (2003): 7941–7943.
8. Sylvestre JP, Kabashin AV, Sacher E and Meunier M, et al. Stabilization and size control of gold nanoparticles during laser ablation in aqueous cyclodextrins . *J Am Chem Soc* 126 (2004): 7176–7177.
9. Dolgaev SI, Simakin AV, Voronov VV and Shafeev GA, et al. Nanoparticles produced by laser ablation of solids in liquid environment. *Appl Surf Sci* 186 (2002): 546–551.
10. Kim S, Yoo B, Chun K and Kang W, et al. Catalytic effect of laser ablated Ni nanoparticles in the oxidative addition reaction for a coupling reagent of benzylchloride and bromoacetonitrile . *J Mol Catal A Chem* 226 (2005): 231–234.
11. Link S, Burda C, Nikoobakht B and El-Sayed M, et al. Laser-Induced shape changes of colloidal gold nanorods using femtosecond and nanosecond laser pulses . *J Phys Chem B* 104 (2000): 6152–6163.
12. Tarasenko N, Butsen A, Nevar E and Savastenko N, et al. Synthesis of nanosized particles during laser ablation of gold in water. *Appl Surf Sci* 252 (2006): 4439–4444.
13. Kawasaki M and Nishimura N. 1064-nm laser fragmentation of thin Au and Ag flakes in acetone for highly productive pathway to stable metal nanoparticles . *Appl Surf Sci* 253 (2006): 2208–2216.
14. Tsuji T, Iryo K, Watanabe N and Tsuji M, et al. Preparation of silver nanoparticles by laser ablation in solution: influence of laser wavelength on particle size . *Appl Surf Sci* 202 (2002): 80–85.
15. Tsuji T, Kakita T and Tsuji M. Preparation of nano-size particle of silver with femtosecond laser ablation in water. *Appl Surf Sci* 206 (2003): 314–320.
16. Tien DC, Tseng KH, Liao CY and Huang JC, et al. Discovery of ionic silver in silver nanoparticle suspension fabricated by arc discharge method. *J Alloys Compd* 463 (2008): 408–411.
17. Jacob JA, Mahal HS, Biswas N and Mukerjee T, et al. Role of phenol derivatives in the formation of silver nanoparticles. *Langmuir* 24 (2008): 528–533.
18. Hsieh CT, Pan C and Chen WY. Synthesis of silver nanoparticles on carbon papers for electrochemical catalysts. *J Power Sources* 196 (2011): 6055–6061.
19. Ipekoglu M and Altintas S. Silver substituted nanosized calcium deficient hydroxyapatite . *Mater Technol* 25 (2010): 295–301.
20. Tai C, Wang Y-H and Liu HS. A green process for preparing silver nanoparticles using spinning disk reactor. *AIChE J* 54 (2008): 445–452.
21. Bo L, Yang W, Chen M and Gao J, et al. A simple and 'green' synthesis of polymer-based silver colloids and their antibacterial properties . *Chem Biodivers* 6 (2009): 111–116.
22. Gao X, Wei L, H Y and Xu B, et al. Green synthesis and characteristic of core-shell structure silver/starch nanoparticles. *Mater Lett* 65 (2011): 2963–2965.
23. Venkatpurwar V and Pokharkar V. Green synthesis of silver nanoparticles using marine polysaccharide: Study of *in-vitro* antibacterial activity. *Mater Lett* 65 (2011): 999–1002.
24. García-Serrano J, Herrera AM and Ocampo-Fernaández M. Synthesis of Ag particles using an ion-exchange polymer with phosphonic acid groups. *Mater Sci Forum* 691 (2011): 113–118.

How to cite this article: Patriciaa AGJ. "An Investigation of Novel Nano Material Silver Nano Dots Synthesis and Characterization Using Simple Sugar Fructose." *J Material Sci Eng* 11 (2022) : 012.