مجلة كلية التربية الاساسية
كلية التربية الاساسية – الجامعة المستنصرية
Journal of the College of Basic Education Vol.30 (NO. 125) 2024, pp. 41-52

Preparation Of Cerium Dioxide Nps And Its Adoption In Biomedical Applications

Ishraq Ahmed Shakir(1)
Zainab Hamzah Baqi (2) **Zainab Shakir Naser(3)**
Physics Department, Science College, Mustansiriyah University
Baghdad, Iraq
ishraqahmed96@uomustansiriyah.edu.iq
zainabshaker5@uomustansiriyah.edu.iq

Abstract:
A simple chemical approach was used to synthesize cerium dioxide (CeO_2) NPss (NPs). UV-Visible , (FTIR), (XRD) and (SEM) were used to characterize the CeO_2 NPs. It was found that band gap of the CeO_2 NPs (E_g = 4.1 electron volt) was enlarged as compared to bulk ceria (E_g = 3.19 electron volt) based on UV-Vis analysis. SEM scans indicated spherical-shaped particles with a diameter of 47.68 nm, which were verified by FTIR data at 594 $cm\text{-}^1$. Additionally, the generated CeO2NPs' antibacterial and antifungal efficacies were assessed, and the results showed that CeO_2 NPs had both antibacterial and antifungal activity. Activities had varied values because the two groups' cell walls and membranes had distinct compositions.

Keywords: cerium oxide nanoparticles, structural, optical and antibacterial properties

1.Introduction:

CeO2 is a lanthanide rare earth metal with an atomic number of roughly fifty eight. Ce's electrical arrangement, distinctive surface structures, and redox activity made it an appealing catalytic character. [1]. It can exist in both +3 and +4 stages, allowing it to produce Nano-scale cerium oxide particles like CeO_2NPs and Ce_2O_3NPs [2, 3]. CeO_2 is a semi-conductor with a high exciton binding energy and a wide band gap energy (3.19 eV). These NPs are gaining popularity because of their biomedical uses. Antimicrobial, anticancer, anti-inflammatory and anti-diabetic properties have been discovered in them. They also serve a protective role in the presence of hazardous radiations and toxicants, as well as in the presence of certain clinical diseases [4]. Recently, CeO2 NPs were made using honey, egg white, and fungal extracellular components, and there has been an increase in study into the therapeutic potential of cerium oxide at the nanoscale [5-7]. This bio-component, which serves as a capping and reducing agent and produces metallic oxide nanoparticles (NPs) with a variety of sizes and morphologies, is nanocrystal line in nature. [6,7,8].

2.The Researcher' Work

2.5 gm of $Ce(NO_3)_2$ were dissolved in 100 mL DW, a concentration of (1 molar) of sodium hydroxide (NaOH) dissolved with ethanol, and the two substances were mixed to conduct the chemical reaction in a Beaker (200 mL) with stirring. During this time, after adding 10 L of HF acid, NPs suspension developed. At 80°C, the suspension was sustained for an hour. To remove pollutants, NPss were centrifuged and then rinsed with pure water. The top solution was then pipette-collected. Digital image of the solution was display in Fig. (1).

Figure 1. Cerium dioxide NPs solution.

Agar well diffusion method used[8]to test antibacterial and fungal activities against three bacterial strains: Klebsiella pneumoniae, Escherichia coli, Gram + ve bacterium Staphylococcus aureus, and one type of fungus (candida). A sterile L-shaped glass rod was used to prepare and wipe nutrient agar plates, which were subsequently incubated for 24 hours at 37 °C. Each Petriplate featured a 6 mm well that was created using a sterile cork borer. Using a concentration of CeO2 NPs (50 g/well), the antibacterial and fungal activities was assessed.

Briefly, a straightforward chemical process was used to create Nano cerium oxide. The films were made at 60°C using the drop-casting process. The outcomes of nm. Based on the results of scanning electron microscopy, the cerium oxide particles were found to be tiny, spherical nanoparticles measuring roughly 47.68 Nanometers. These outcomes validate the findings from X-ray diffraction. In the visible and near-infrared wavelength range, it was discovered that the membrane's absorbance decreases with increasing wavelength. Approximately, the band gap of the sample is 4.1 MeV, greater than the 3.1 MeV values reported for CeO2 in its bulk condition. Because of the smaller particle size, there is a difference in that range. A quantum confinement effect takes place and the band gap energy increases as the particle size drops when the size of the nanocrystals is less than the Bohr radius of the excited electron-gap pair. CeO2 NPs were demonstrated to be efficient against the isolates of antifungals, Escherichia coli, Staphylococcus aureus, Klebsiella pneumonia, and Candida using the agar well diffusion method. It was discovered that the inhibitory zone diameter of Candida isolates is greater than that of Bacteria isolates

3.Results and Discussion

X-Ray Diffraction Analysis

pattern of CeO_2 NPs generated by a simple chemical process and dropped onto a glass substrate ,see fig.1. The CeO_2 NPs diffraction pattern was agree with JCPDS card (43-1002). It possesses a poly-nanocrystal line structure, indicating that it is in the fluorite cubic phase [9-12]. The mean size of the ordered CeO2 NPss was determined using the full width at half-maximum (FWHM) and Sherrer's formula as follows:

$G = 0.98\lambda / \beta \cos\theta$

Where: λ is X-ray wavelength, 0.89 is the shape factor, β The line widening at half the maximum intensity is measured in rad., and θ the angle of Bragg . Nanocrysals have an average crystallite size of 28 nm.

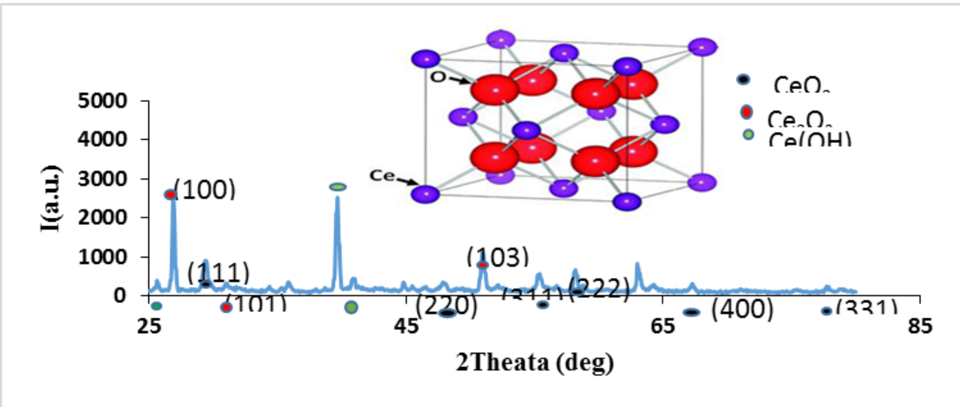


Figure 2. XRD pattern of CeO_2 nanostructure

Study Of Ultraviolet-Visible Spectroscopy

Figure 3 demonstrates the optical absorption spectra for the produced material examined by UV-Visible spectroscopy using a CARY100 CONC plus UV-Vis-NIR device fitted with a xenon light at a wavelength range of (200-1000 nm). A nanoscale solution was confirmed by the discovery of the Plasmonic resonance peak at 278 nm [13]. Along with significant absorption below 400 nm, the sample also displayed exceptional transmittance in the visible and infrared spectrums.

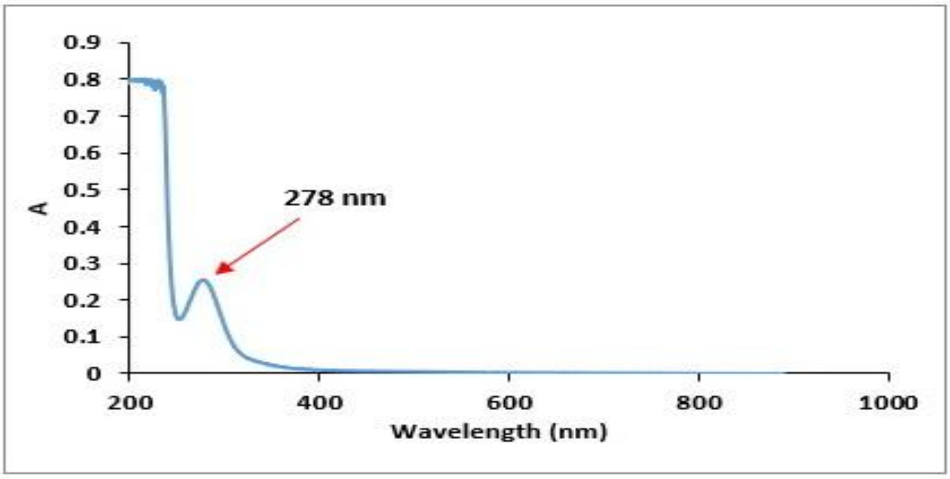


Figure 3. The optical absorption spectra of CeO_2NPs.

The calculated band gap of the CeO2 sample was 4.1 eV, as seen in figure 4. The CeO2 sample exhibits a rise in Eg of more than 0.81 electron volts as measured by UV-visible spectroscopy in comparison to the bulk CeO2 powders (Eg = 3.19 electron volt). When a particle is shrunk to a few nanometers in size, the quantum confinement effect takes place, which results in blue shifts in the UV absorption spectra. This is determined by the band gap estimated for pure CeO2NPs [14,15].

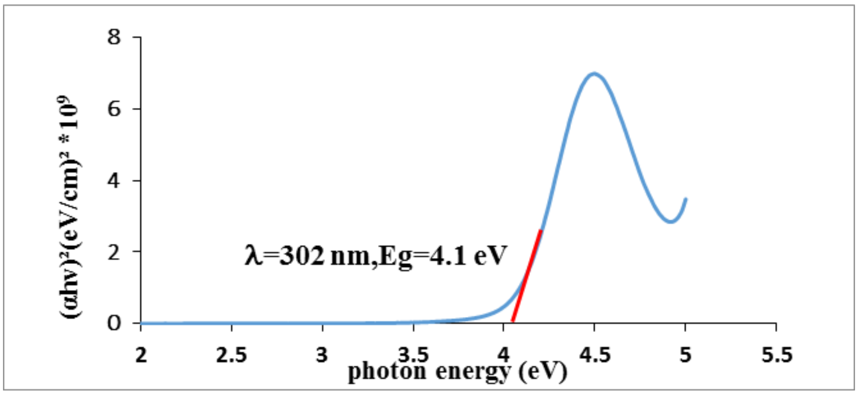


Fig.4: photon energy vs. ***(αhv)*** *² for* CeO_2 NPs

FTIR Spectrum Of Cerium Oxide Nanoparticles

FTIR spectral of CeO_2 NPs was in the range $5x10^2$– $4x10^3$ cm^{-1}. O-H stretching from leftover alcohols is responsible for the broad absorption in the frequency range 3317 cm^{-1}, while CeO2 stretching vibration is responsible for the absorption band at 594 cm^{-1}. The frequency of molecular N-H bending at 1635 cm^{-1} [16-21].

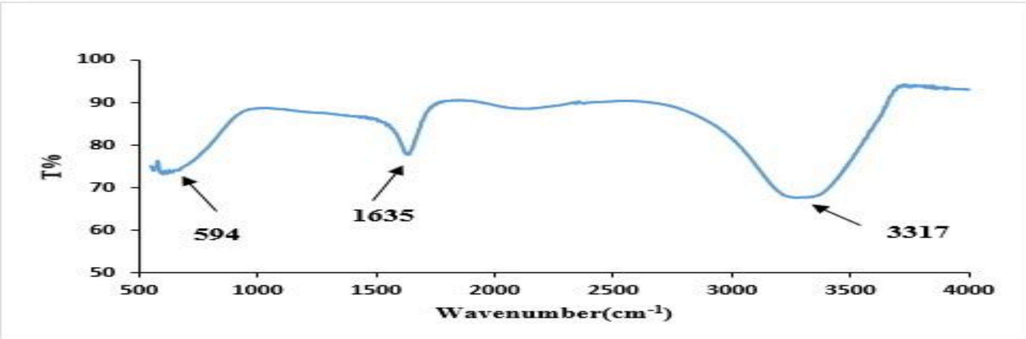


Fig.5: FTIR spectrum of CeO_2 NPs.

SEM Of Cerium Oxide Nanoparticles

The morphological of synthesized Ce-oxide NPs that prepared by simple chemical method and deposited on glass substrate were studied using the SEM. the particles as spherical small NPs approximately 47.68 nm in size. as shown in the Figure 6.

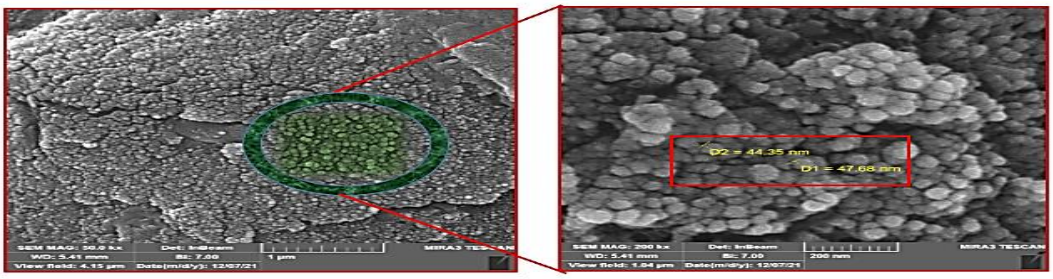
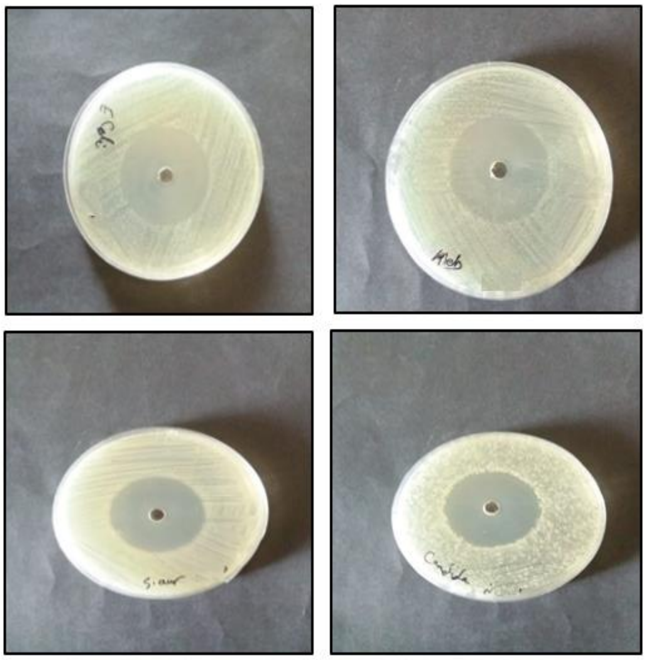


Fig.6: SEM image of CeO_2 nanostructure

Antibacterial And Antifungal Activity Test

The antibacterial and fungal activity potential of CeO_2 NPs was investigated using the agar well diffusion method against three pathogenic bacterial strains and one fungal strain E. coli, S. aureus, K. pneumoniae, and Candida. CeO_2 NPss had a good antibacterial and fungal activity, as demonstrated by the inhibition zones. A growth suppression was detected in bacteria (gram positive and negative) with diameters of 39 and 38 mm, and candida fungal with a diameter of 40 mm, as shown in the figure 8. As evidenced by the development of zones around the samples, CeO2 NPs effectively suppress the growth of numerous bacterial and fungal species. The cell membrane of the bacterial or fungal cell may have been damaged as a result of direct contact between CeO2 NPs and the membrane surface. Based on the type of bacteria, antibacterial agent concentration, sample surface area, shape, and size of the NPs, the inhibitory zone's size varied. Furthermore, differences in action against gram-positive and gram-negative bacteria may be explained by structural and configurational alterations in the cell membrane [22,23]. According to XRD and SEM measurements, the average CeO2NPs size is about 28 nm, with lower crystallite sizes being 3 nm [24]. The polar surface of the particles, which is dependent on the independent variables of size, surface area, and morphology, is what essentially determines the cytotoxic efficacy of the particles [25–27]. Because of the surface contact, the level of reactive oxygen species (ROS) may increase, putting the cell under oxidative stress [28]. The process of cell death may be explained by the interaction of the surface thiol (-SH) group of membrane surface proteins with the released ions of NPss [29-32]. The CeO2NPs' band gap energy varies when compared to bulk ceria, as shown by the UV-Vis research, which might help to increase ROS production. The diameter of CeO2NPs' inhibitory zone is shown in Fig. 9.



Fg.8: Antibacterial and fungal activity of CeO_2 NPs

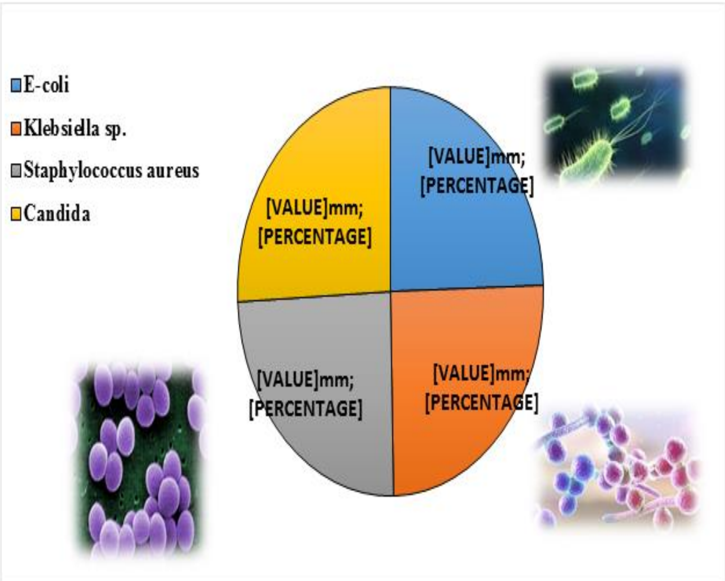


Fig.9: Diameter of inhibition zone of CeO_2NPs

4. Conclusion

The simplicity of preparation using a straightforward chemical approach, as well as the low cost and ease of depositing the nano-solution on the bases using a casting method eliminates the need to waste the nanomaterial to examine its qualities.

The generated nanomaterial showed efficacy against harmful germs and fungi.

used the Muller well diffusion agar plate method to examine bacteria and fungus, which produced positive findings.

The material could potentially be utilized in physical applications like solar cells and detectors, according to the optical and synthetic data.

This method is valid to be used to prepare NPss according to the results obtained. The size 47 nm can be used in biological applications, where CeO2 NPs achieve excellent activity of antibacterial and antifungal.

Acknowledgments

The authors would like to thank Mustansiriyah University, College of Science, physics Department, Baghdad, Iraq (ishraqahmed96@uomustansiriyah.edu.iq , zainabshaker5@uomustansiriyah.edu.iq) for their support.

References

[1] Seal, S., Jeyaranjan, A., Neal, C. J., Kumar, U., Sakthivel, T. S. and Sayle, D. C. (2020) “Engineered defects in cerium oxides: tuning chemical reactivity for biomedical, environmental, & energy applications” Nanoscale, 12,pp.6879–6899.

[2] Carneiro, J., Tedimb, J., Fernandes, S.C.M., Freirea, C.S.R., Silvestrea, A.J.D., Gandini, A., Ferreira, M.G.S., Zheludkevichb,M.L. (2012) Chitosan based self-healing protective coatings doped with cerium nitrate for corrosion protection of aluminum alloy 2024, Progr. Organ. Coat. 75 8-13.

[3] Ahamed, I.N., Anbu, S., Vikraman, G., Nasreen, S., Muthukumari, M. and Kumar, M.M. (2016) „Green synthesis of nano zerovalent iron particles (nZVI) for environmental remediation‟, Life Science Archives, Vol. 2, No. 3, pp.549–554.

[4] Culcasia, M., Benameurab, L., Merciera, A., Lucchesia, C., Rahmounia, H., Asteiana, A., Casanoa, G., Bottab, A., Kovacicc, H. and Pietria, S. (2012)“EPR spin trapping evaluation of ROS production in human fibroblasts

exposed to nanoceria: evidence for NADPH oxidase and mitochondrial stimulation” Chem. Biol. Interact., 199 (3) (2012), pp. 161-176.
[5] S. Maensiri, C. Masingboon, P. Laokul,W. Jareonboon, V. Promarak, P.L. Anderson, S.
Seraphin, Cryst. Growth Des. 7 (2007) 950–955.
[6] M. Darroudi, S.J. Hoseini, R.K. Oskuee, H.A. Hosseini, L. Gholami, S. Gerayli, Ceram. Int. 40 (2014) 7425–7430.
[7] S.A. Khana, A. Ahamad, Mater. Res. Bull. 48 (2013) 4134–4138.
[8] R.P.Senthilkumar, V. Bhuvaneshwari, R. Ranjithkumar, S. Sathiyavimal, V.Malayaman, B.Chandarshekar " Synthesis and Characterization of Cerium Oxide Nanoparticles using Curvularia lunataand Their Antibacterial properties", *Int. J. Biol. Macromol.* 104, 1746-1752, 2017.
[9] M. Darroudi, S. J. Hoseini, R. K. Oskuee, H. A. Hosseini, L. Gholami, S. Gerayli 2014, Ceramics Int. 40, 7425-7430. 23XRD. C. Tamuly, I. Saikia, M. Hazarika, M.R. Das, RSC Adv. 4, 53229–53236 (2014)
[10] EM Ali, KH Rasool, WK Abad, AN Abd , 2021," Green Synthesis, Characterization and Antimicrobial activity of CuO nanoparticles (NPs) Derived from Hibiscus sabdariffa a plant and CuCl ", Journal of Physics: Conference Series Conf. Ser. 1963 012092
[11] A. Nilchi, M. Yaftian, G. Aboulhasanlo, S. Rasouli Garmarodi3"Adsorption of selected ions on hydrous cerium oxide" Journal of Radioanalytical and Nuclear Chemistry, Vol. 279, No.1 (2009)
[12] M. Farahmandjou, M. Zarinkamar and T.P. Firoozabadi, "Synthesis of Cerium Oxide (CeO2) nanoparticles using simple CO-precipitation method", Revista Mexicana de F´ısica 62 (2016) 496–499
[13] Aseel M. Abdul Majeed, Ahmed N. Abd, Ali A. Hussein, Nadir F. Habubi,"Fabrication and Characterization of Copper Oxide Nanoparticles/PSi Heterodiode", International Letters of Chemistry, Physics and Astronomy, (2015)
[14] Nadir F. Habubi · Ahmed N. Abd · Mohammed O. Dawood· A. H. Reshak.
"Fabrication and Characterization of a p-AgO/PSi/n-Si Heterojunction for Solar Cell Applications", Silicon (2016).
[15] Sumalin Phokha1 , Supree Pinitsoontorn1 , Prae Chirawatkul2 , Yingyot Poo-arporn2 and Santi Maensiri3 "Synthesis, characterization, and magnetic

properties of monodisperse CeO2 nanospheres prepared by PVP-assisted hydrothermal method" Nanoscale Research Letters 2012

[16] M. Farahmandjou∗ , M. Zarinkamar and T.P. Firoozabadi" Synthesis of Cerium Oxide (CeO2) nanoparticles using simple CO-precipitation method", Revista Mexicana de F´ısica 62, 496–499, (2016)

[17] Thirunavukkarasu Arunachalam , Muthukumaran Karpagasundaram , Nithya Rajarathinam," ultrasound assisted green synthesis of cerium oxide nanoparticles using prosopis juliflora leaf extract and their structural, optical and antibacterial properties", materials science-poland, 35(4), pp. 791-798, , 2017

[18] K.Sheela1, J. Madhusudhanan, J.Thirumagal,Niti Chawla4,S. Jagannathan5 and M.I. Niyas Ahamed1,"Biosynthesis and Biological Applications of Cerium Oxide Nanoparticles", Annals of R.S.C.B., ISSN:1583-6258, Vol. 25, Issue 6, Pages. 203 – 213, , 2021

[19] Reza Zamiri, Hossein Abbastabar Ahangar , Ajay Kaushal , Azmi Zakaria1 *, Golnoosh Zamiri1 , David Tobaldi2 , J. M. F. Ferreira2 "Dielectrical Properties of CeO2 Nanoparticles at Different Temperatures", PLOS ONE, 2015

[20] D. Valechha,S.Lokhande,M.Klementova,J.Subrt,S.Rayalu,N.Labhsetwar,N., Studyofnano-structuredceriaforcatalyticCOoxidation,J.Mater.Chem.A21 3718–3725, (2011).

[21]W.J.Roth,W.Makowski,B.Marszalek,P.Michorczyk,W.Skuza,B.Gil,Activity enhancement ofzeoliteMCM-22byinterlayerexpansionenablinghigherCe loading androomtemperatureCOoxidation,J.Mater.Chem.A2,15722–15725, (2014).

[22] Hafiz Ejaz Ahmed , Yasir Iqbal , Muhammad Hammad Aziz ,Muhammad Atif , Zahida Batool ,Atif Hanif , Nafeesah Yaqub , W. A. Farooq , Shafiq Ahmad , Amanullah Fatehmulla 3 and Hijaz Ahmad"Green Synthesis of CeO2 Nanoparticles from the Abelmoschus esculentus Extract: Evaluation of Antioxidant, Anticancer, Antibacterial, andWound-Healing Activities", Molecules 2021,

[23] T. R. Lakshmeesha, M. K. Sateesh, B. Daruka Prasad, S. C. Sharma, D. Kavyashree, M.Chandrasekhar, H. Nagabhushana, Cryst. Growth Des. 14 ,4068-4079, (2014).

[24] Hameed A.S.H., Karthikeyan C., Sasikumar S., Kumar S., Kumaresan S., Ravi G., J. Mater. Chem. B,5950 , (2013),.
[25] Xia T., Kovochich M., Brant J., Hotze M., Sempf J., Oberley T., Sioutas C., Yeh J.I., Wiesner M.R., Nel A.E., Nano Lett., 6 ,1794, (2006).
[26] Xia T., Kovochich M., Liong M., Madler L., Gilbert B., Shi H., Yeh J.I., Zink J.I., Nel A.E., Acs Nano, 2 ,2121(2008).
[27] Burello E., Worth A.P., Nanotoxicology, 5 ,228(2011),.
[28] Devasagayam T., Tilak J.C., Boloor K.K., Ketaki S.S., Saroj S.G., Lele R.D., J. Assocn. Physicians Of India, 52 (2004), 796.
[29] Li Y., Zhang W., Niu J.F., Chen Y.S., Acs Nano, 6 (2012), 5164.
[30] Tong G.X., Du F.F., Liang Y., J. Mater. Chem. B, 1 (2012), 454.
[31Ahmed N. Abd, Majid H. Hassoni and Mazin H. Hasan "properties and biomedical applications of copper oxide nanoparticles", *Biochem. Cell. Arch.* Vol. 18, No. 2, pp. 1763-1766. (2018)
[32] Ehab Mohammed Ali , Khetam H.Rasool, Wedian K. Abad, Ahmed N. Abd4 ."Green Synthesis, Characterization and Antimicrobial activity of CuO nanoparticles (NPs) Derived from Hibiscus sabdariffa a plant and CuCl" Journal of Physics: Conference Series(2021)

مجلة كلية التربية الاساسية
كلية التربية الاساسية – الجامعة المستنصرية
Journal of the College of Basic Education Vol.30 (NO. 125) 2024, pp. 41-52

تحضير ثاني أكسيد السيريوم Nps واعتماده في التطبيقات الطبية الحيوية

إشراق أحمد شاكر (1) زينب حمزة باقي (2) زينب شاكر ناصر (3)
قسم الفيزياء، كلية العلوم،الجامعة المستنصرية،
بغداد- العراق
zainabshaker5@uomustansiriyah.edu.iq
ishraqahmed96@uomustansiriyah.edu.iq

مستخلص البحث:
تم استخدام طريقة كيميائية بسيطة لتخليق ثاني أكسيد السيريوم (NPs) NPss (CeO_2). تم استخدام الأشعة فوق البنفسجية المرئية، ((XRD ،FTIR)) و (SEM) لتوصيف CeO_2 NPs. لقد وجد أن فجوة النطاق في CeO_2 NPs (على سبيل المثال = 4.1 إلكترون فولت) تم توسيعها مقارنةً بالسيريا السائبة (على سبيل المثال = 3.19 إلكترون فولت) بناءً على تحليل الأشعة فوق البنفسجية. أشارت عمليات المسح SEM إلى جزيئات كروية الشكل يبلغ قطرها 47.68 نانومتر، والتي تم التحقق منها بواسطة بيانات FTIR عند 594 سم-1. بالإضافة إلى ذلك، تم تقييم فعالية CeO_2NPs المضادة للبكتيريا والفطريات، وأظهرت النتائج أن CeO_2 NPs كان لها نشاط مضاد للبكتيريا ومضاد للفطريات. كانت للأنشطة قيم متنوعة لأن جدران الخلايا والأغشية في المجموعتين كانت لها تركيبات مختلفة.

الكلمات المفتاحية: جزيئات أكسيد السيريوم النانوية، الخصائص الهيكلية والضوئية والمضادة للبكتيريا