COMPARATIVE ASSESSMENT OF FRUIT PEEL DERIVED ZnO, CdO, NiO NANOPARTICLES

[a]Sunita Murty,

[a]School of Basic and Applied Sciences, Lingayas Vidyapeeth ,Faridabad

ABSTRACT

In the current era of ecofriendly innovations, green nanotechnology plays a crucial role in the development of nanoparticles, as it uses biowastes as a raw material and does not release toxic and harmful byproducts into the environment, which is a major disadvantage of chemical synthesis. This research work emphasizes the utilization of Orange, Banana and Pomegranate fruit peels as stabilizing and reducing agents in the synthesis of metal nanoparticles, using precursor salts. To validate the synthesis of pure nanoparticles, their crystallite size, and conformation, the samples were characterized using XRD (X-ray Diffraction), FTIR (Fourier Transformed Infrared Spectroscopy), and UV (UV Visible Spectroscopy). This research study reveals that ZnO nanoparticles from orange peel were analyzed using XRD, and the graph exhibited highest peak at 36.1. XRD graph of synthesized CdO nanoparticles showed diffraction peaks recorded at 2θ values of 33.03. Prominent peaks of NiO nanoparticles synthesized from pomegranate peels were obtained at 2θ values of 32.83. UV visible spectroscopy images of ZnO from orange peel revealed two absorption peaks, one at 327 nm and the other at 204 nm. UV-Vis absorption spectra for CdO nanoparticles synthesized from banana peel reveals characteristic absorption peak at 203 nm. NiO nanoparticles synthesized from pomegranate peel extract shows high intensity absoption peak at 206 nm and a small peak at 358nm. FTIR analysis of green ZnO nanoparticles synthesized from orange skins reveals stretching vibrations of the Zn-O bond at approximately 450 cm^{-1}. FTIR spectra of CdO nanoparticles and NiO nanoparticles synthesized from pomegranate peel extract reveals a prominent peak at 550 cm^{-1}.This study highlights various techniques which were employed to authenticate the synthesis and investigate the characteristics of nanoparticles.

KEYWORD

Comparative, analysis, ZnO Nanoparticles, Green Synthesis, Nanoparticles, Orange peel, Pomegranate Peel, Characterization Study, XRD, FTIR, UV absorption.

INTRODUCTION

Nanotechnology is a field within the realm of science and engineering that is dedicated to the conceptualization, fabrication, and utilization of structural apparatuses and frameworks for the purpose of manipulating atoms and molecules at the nanoscale, which is often defined as 100 nanometers. Nanoparticles can be generated using chemical processes or by environmentally friendly synthesis techniques. The global population is continuously expanding, resulting in an increase in the generation of biowastes. By utilizing these biowastes for the production of economically valuable nanoparticles, it is possible to mitigate the release of toxic by-products associated with conventional chemical production methods. Consequently, green synthesis has emerged as a significant contributor to minimizing environmental impact. (Doan Thi et al., 2020), *(Hager R Ali , Mohammad A Hassan ,2017)* Green synthesis helps to synthesize nanoparticles with renewable raw materials at low temperature, using less energy most importantly without production of toxic byproducts. Green nanotechnology is a boon to mankind and to environment as well (Alqarni et al., 2022). The use of plants for the production of nanoparticles has gained significant popularity owing to the convenient accessibility and abundance of plant components that possess inherent reducing agents, including amino acids, enzymes, flavonoids, sugars, aldehydes and ketones, amines, carboxylic acids, alkaloids, terpenoids, and other similar reducing agents (Ali Ibrahim et al., 2021). Extensive research has been conducted on the chemical properties of fruit peels with significant volumes, such as banana peel, orange peel, pomegranate peel, lemon peel, and citrus peels. The objective of these investigations is to enhance their utilisation potential. The use of fruit and vegetable wastes holds significant promise for the conversion of these materials into valuable goods through bioconversion processes.

Using biological components also helps in reduction of overall cost of synthesis process as costly reducing agents or stabilizing agents are not required (Singh et al., 2018). Green synthesis eliminates the need for high energy and high pressure conditions, making it an energy-efficient method. Nanomaterials possess distinctive optical, mechanical, catalytic, and biological capabilities, rendering them very versatile for a wide range of applications (Xu et al., 2021).

The orange peel contains a diverse spectrum of natural antioxidants and chemical compounds, including as flavonoids, Lemolines, and carotenoids, which serve as ligation agents (Doan Thi et al., 2020). Peel of Punica gratum contains an abundance of flavonoids, tannins, and phenolic compounds. The characterization of nanoparticles is very important because they are synthesized from several different routes and they have varied applications and academic research interest across several fields. Nanoparticle characterization is performed to assess the surface area and porosity, pore size, solubility, crystallinity, fractal dimensions, Zeta potential, shape and size of nanoparticles. Several techniques can be used to determine nanoparticle parameters like UV-visible spectroscopy ,atomic force microscopy (AFM), transmission electron microscopy(TEM), scanning electron microscopy(SEM), X-ray photoelectron spectroscopy(XPS), powder X-ray diffraction(XRD), Fourier Transform Infrared Spectroscopy(FTIR) (Patra & Baek, 2014). Scanning electron microscopy (SEM) is a technique used to characterize morphology of nanoparticles through direct visualization. UV visible spectroscopy is used to confirm the formation of various types of nanoparticles, by measuring Plasmon resonance and evaluating collective oscillations of conduction band electrons, in response to electromagnetic waves. This provides information about size, structure, stability and aggregation of nanoparticles. Metal nanoparticles are associated with specific absorbance bands in characteristic spectra when the incident light enters into resonance with the conduction band electrons on the surface of nanoparticles ((Bakayok et al, 2019) . FTIR spectroscopy is conducted to identify the functional groups present on nanoparticles. Since each type of nanoparticle contains unique combination of atoms we can identify functional groups present inside the nanoparticles based on FTIR spectrum .This can help facilitate nanoparticle synthesis by green technology the number of functional groups present in the nanomaterial can be determined by the size of the peak of the spectrum(Rashid et al.2022).In light of the significance of nanoparticles synthesised using environmentally friendly means and their extensive variety of uses, we embarked on a study including the green synthesis of ZnO nanoparticles using orange peels, CdO nanoparticles using banana peels, and NiO nanoparticles using pomegranate peels. Various techniques were employed to authenticate the synthesis and investigate the characteristics of nanoparticles.

MATERIALS AND METHODS

ZnO nanoparticle synthesis from orange peel

For ZnO synthesis from orange peel zinc sulphate was used as the zinc precursor , orange peel , chosen for its high content of desired organic compounds were collected from in campus fruit juice vendor ,de-ionized water was used as the synthesis medium.

Preparation of Orange Peel Extract:

In order to obtain the orange peel extracts (OPE), orange fruit peels were washed and dried, the peel was then placed in an oven for 12 h until completely dry and was then grounded into a moderately fine powder. Afterwards, 10 g of the orange peel powder was placed in glass beaker with 200mL of de-ionized water and was stirred on a hot plate stirrer for 60mins, where temperature was maintained at 70 °C. Finally, the mixtures were centrifuged for 5 to10 min and filtered and the resulting extract was stored in refrigerator.

Preparation of ZnO nanoparticle:

ZnO nanoparticles were synthesized by mixing 50ml of 0.1 M solution of zinc sulphate with 50 ml of orange peel extract. The mixture was stirred for 3 hrs on a hot plate stirrer set at 60 degrees. pH of the solution was maintained in between 10 to 12 with the help of 1 N sodium hydroxide. Subsequently, the mixture was again centrifuged and filtered to separate the pellet of nanoparticles settled at the bottom of centrifuge tubes. Precipitate of nanoparticles was washed with water and then with ethanol subsequently dried in an oven. Later it was placed at 420 degrees in a muffle furnance for 3 hours . The resultant sample was stored in a sample vial and it was sent for characterization for further studies .

CdO nanoparticles from banana peel

Preparation of banana peel extract (BPE):

Banana peels from 600gm(6 medium sized bananas) were collected , washed with distilled water twice then they were cut into small pieces, boiled in 250 ml distilled water for 15 min then cooled and grounded to smooth paste and then filtered. This extract was stored as banana peel extract (BPE) in refrigerator.

Preparation of cadmium nitrate solution:

200ml 1N cadmium nitrate solution was prepared with the help of distilled water. This solution was placed on a hot plate stirrer for 30 min at 60 degrees centigrade.

Preparation of cadmium oxide nanoparticles from banana peel:

The prepared banana peel (BPE) extract and cadmium nitrate solution were mixed together and placed on a hot plate stirrer at 60 degrees centigrades for 3hours. pH was maintained with the help of 1N sodium hydroxide solution at around 10. The resulting solution was then centrifuged at 4000 RPM for 25 to 30 minutes and subsequently was filtered to collect the precipitate of nanoparticles. The collected precipitate was dried in the oven and then placed in muffle furnace at 420 degrees centigrades for 3 hours. . The resultant sample was stored in a sample vial.

NiO nanoparticle synthesis from pomegranate peel

Preparation of pomogranate peel extract (PPE):

Pomogranate peel was collected from in campus fruit juice vendor, collected peels were washed and air dried and subsequently dried in an oven for one hour. The dried pomegranate peel was grounded into fine powder. Afterwards 10 grams of the powder was placed in 100ml of distilled water and stirred on a hot plate stirrer for 1 hour where the temperature of the stirrer was maintained at 60 degrees. The extract was then centrifuged for 15 minutes at 3000 RPM and filtered. The extract collected was stored in refrigerator (Mohammed Hussain ,2019).

Preparation of NiO nanoparticles:

NiO nanoparticles were prepared by mixing 100 ml of 1N nickel nitrate solution with 100 ml pomegranate peel extract (prepared as stated above). Resulting solution was placed in a hotplate stirrer, set at 60 degrees for 3 hours. pH of solution was maintained at around 10 by adding 1N sodium hydroxide solution. Subsequently the solution was centrifuged at 3000 rpm for 25 min and precipitate was filtered and separated, consequently the precipitate was dried in an oven and then calcined in muffle furnance at 420 degrees. After which product was collected, stored in vials and which was for further sent for characterization.

CHARACTERIZATION STUDY

Finally all samples were sent for characterization to study the properties of the synthesized nanoparticles. The synthesized nanoparticles were characterized by different analytical techniques such as XRD, FTIR and UV-visible spectrophotometer.

RESULTS AND DISCUSSIONS

XRD analysis was used to confirm the crystal structure and crystallite size of nanoparticles and graphs of the sample were obtained.

XRD Analysis

XRD of ZnO nanoparticles from orange peel: Prominent peaks were obtained at 2θ values of 31.85, 34.48, 36.1, 47.6, 56.6, 62.7, 67.8 **(Figure 1).** These values are in coordination with 2θ values of zinc oxide, these peaks correspond to (100), (002), (101),(102),(110),(103),(200) crystal planes(3,4,2). crystallite size of nanoparticles was obtained by Debye Scherrer formula given by equation : **$D = k\lambda / (\beta \cos\theta)$**, where D is crystallite size, λ is wavelength of X-rays which is 0.154, k is Scherrers constant taken as 0.9, and β is line width at half wave maximum height. Average crystallite size obtained 21 nm, which is in good agreement with literature articles (Ali Ibrahim et al., 2021),(*Okpara et al, 2020)*

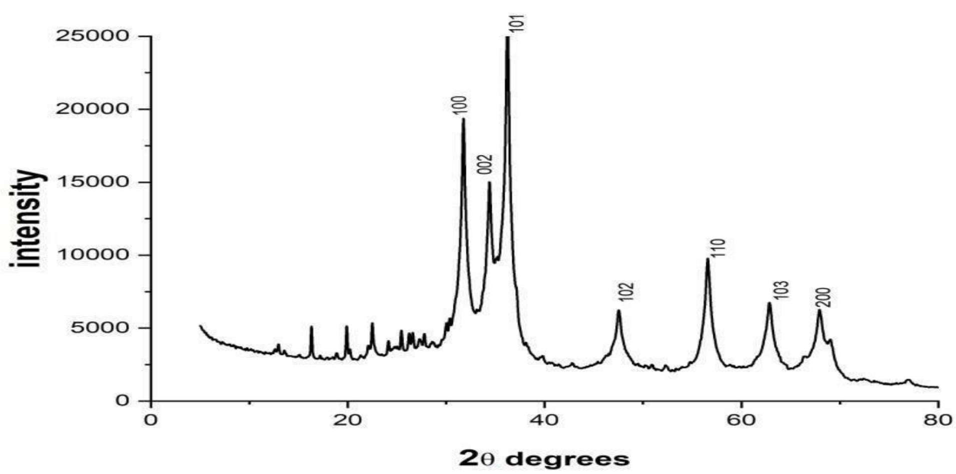


Figure 1: XRD spectra of ZnO nanoparticles from orange peel extract

XRD of CdO nanoparticles from banana peel: **Figure 2** shows that synthesized CdO nanoparticles showed diffraction peaks recorded at 2θ values of 33.03, 38.32, 55.30,65.95, 69.26 which correspond to hkl values of (111), (200),(220), (311),(222) crystal planes. crystallite size of CdO nanoparticles obtained by using Scherrer formula was 43 nm. The peak positions with 2θ values and hkl values are in close agreement with CdO synthesized by similar methods in reference articles.

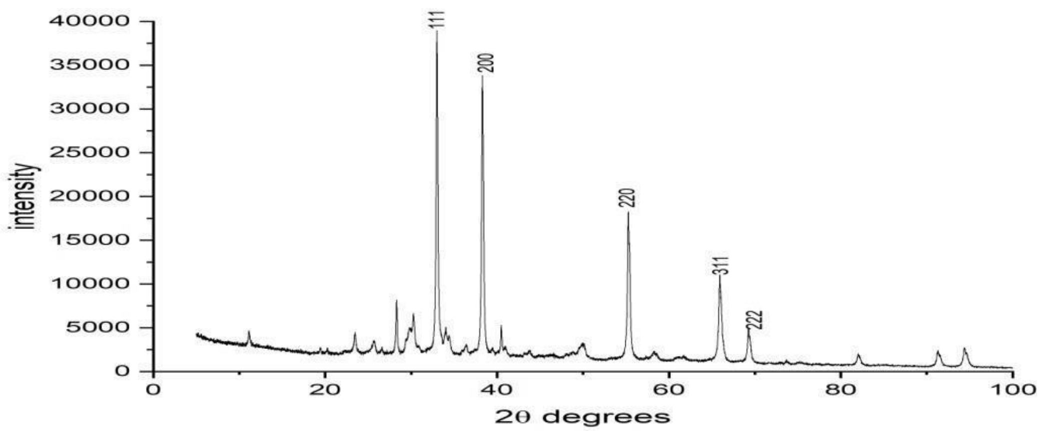


Figure 2: XRD spectra of CdO nanoparticles from banana peel

XRD of NiO from pomegranate peel: **Figure 3** shows the prominent peaks of NiO nanoparticles synthesized from pomegranate peels were obtained at 2θ values of 28.77, 31.54, 32.83, 37.23, 43.12, 51.40, 62.86 which correspond with crystal planes of (110),(111),(200) and (220). 2θ values of NiO from literature correlates well with obtained 2 theta values and average crystallite size obtained using Scherrer formula was 47 nm. (Baraa Y. Hussein, Ahmed Mishaal Mohammed, 2021)

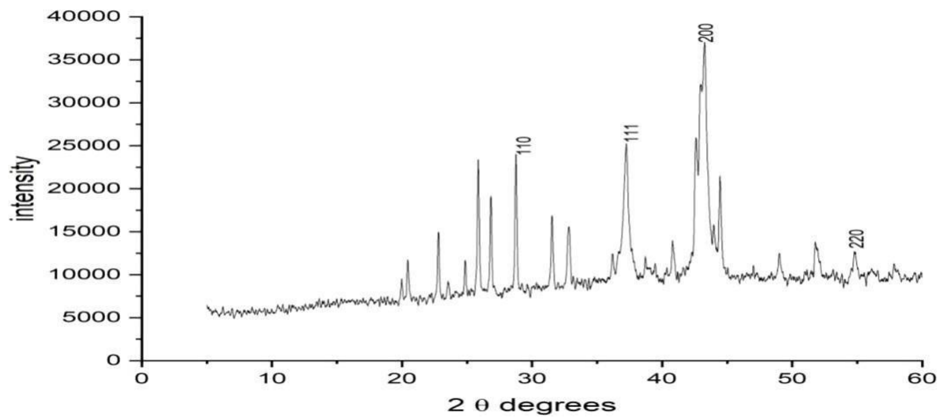
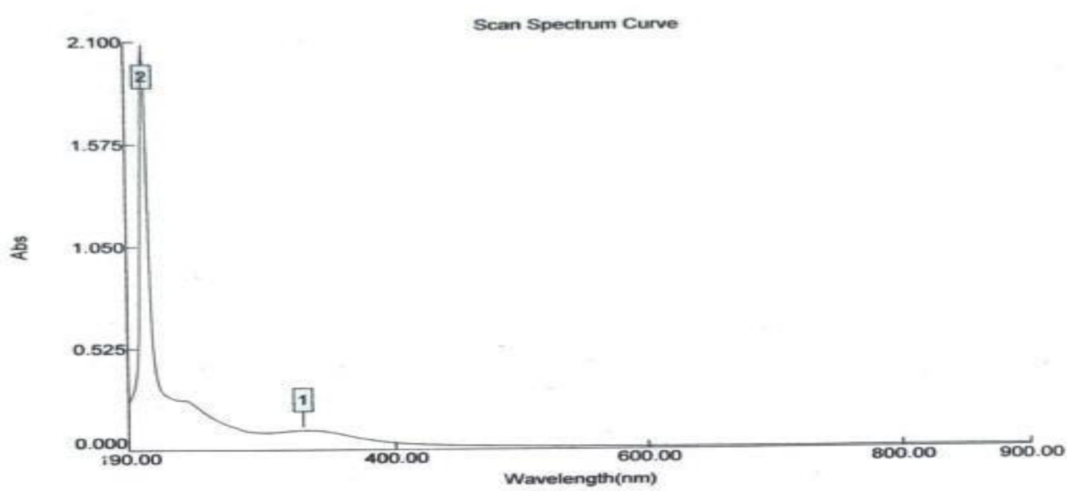


Figure 3: XRD spectra of NiO from pomogranate peel

UV-Visible Spectroscopy

UV visible spectroscopy of ZnO from orange peel

Figure 4 shows 2 absorption peaks one at 327 nm and another peak at 204 nm which correlates with literature values of ZnO nanoparticles which usually show absorption around 350 to 400 nm.



s

Figure 4: UV spectra for ZnO nanoparticles from orange peels

UV-Vis absorption spectra for CdO nanoparticles:

This was synthesized from banana peel reveals characteristic absorption peak at 203 nm (Figure 5) which can be co-related to data reported by literature articles (Sadiyha Yasir Jubory , 2020 , K.Karthik et al.2017).

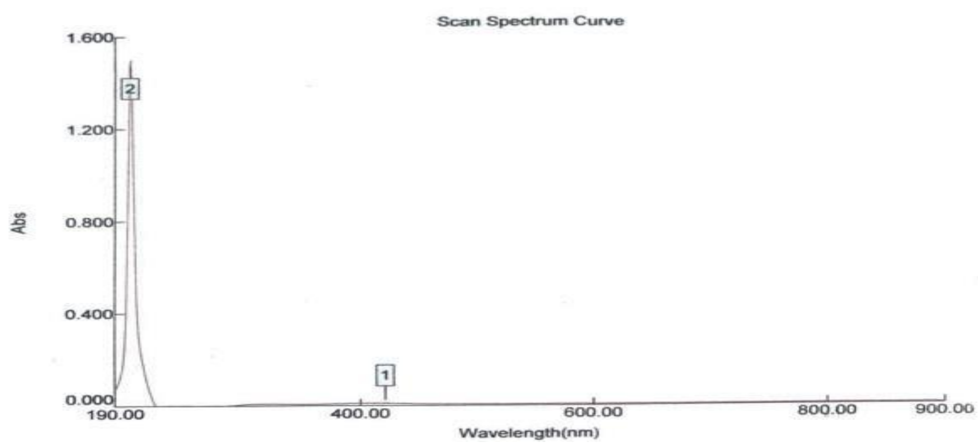


Figure 5: UV spectra for CdO nanoparticles from Banana peels

UV–Visible spectroscopic analysis for NiO nanoparticles:

These nanoparticles were synthesized from pomegranate peel extract shows high intensity absoption peak at 206 nm and a small peak at 358nm(**Figure 6**), which correspond to NiO nanoparticle peaks green synthesized from orange peel extract, pomegranate peel extract and other biological sources, as in literature.

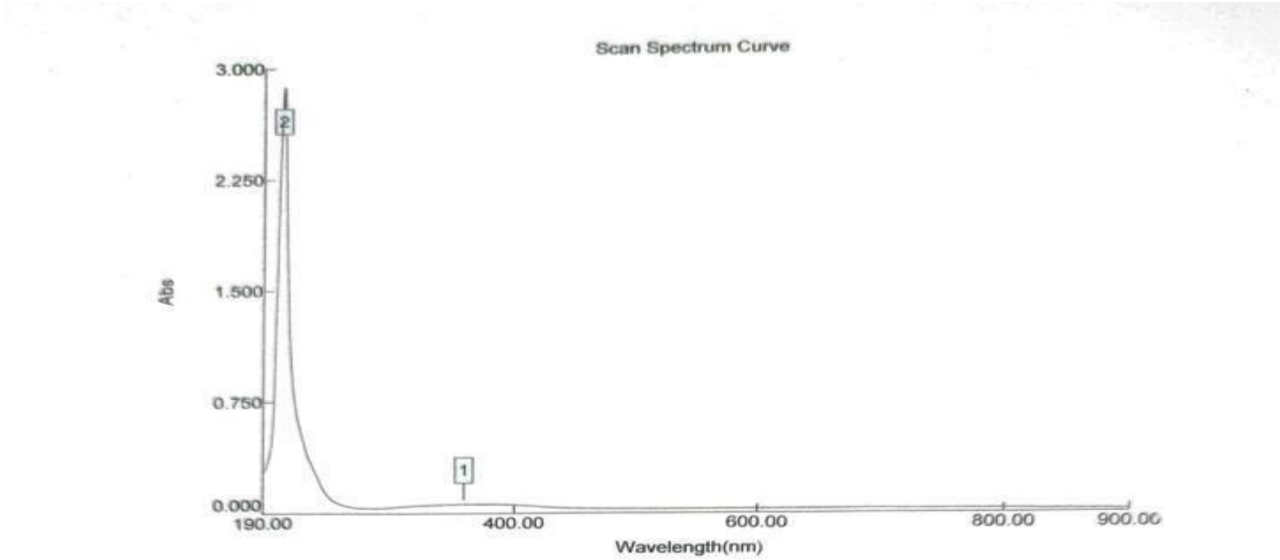


Figure 6: UV spectra for NiO nanoparticles from pomegranate peels

FTIR Analysis

FTIR analysis of ZnO nanoparticles:

ZnO nanoparticles were synthesized from orange peels show vibration band at around 450 cm^{-1}, which are assigned to stretching vibrations of Zn-O bond(**Figure 7**). Other peak was obtained at around 1100 cm^{-1} can be related to stretching vibrations of C-O bond of alcohols and phenols (Alwash, 2020).

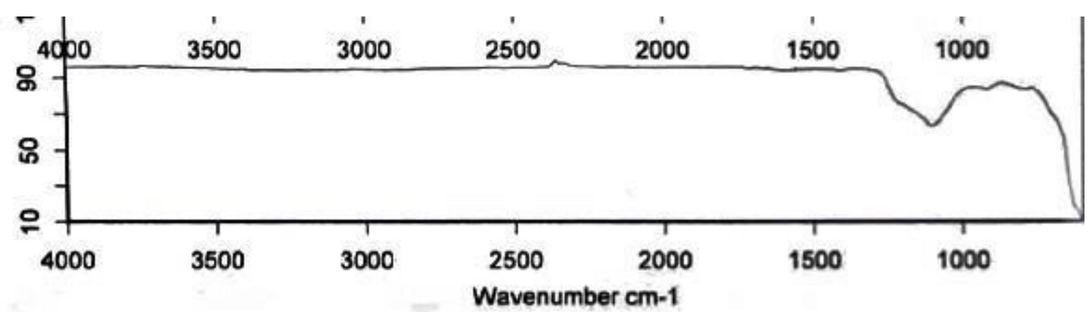


Figure 7: FTIR spectra for ZnO nanoparticles from orange peels

FTIR spectra of CdO nanoparticles:

CdO nanoparticles were synthesized from pomegranate peel extract reveals a characteristic absorption at 550 cm^{-1}, which confirms the synthesis of CdO nanoparticles(**Figure 8)** (*Alaa Z Skheel et al. 2021).*

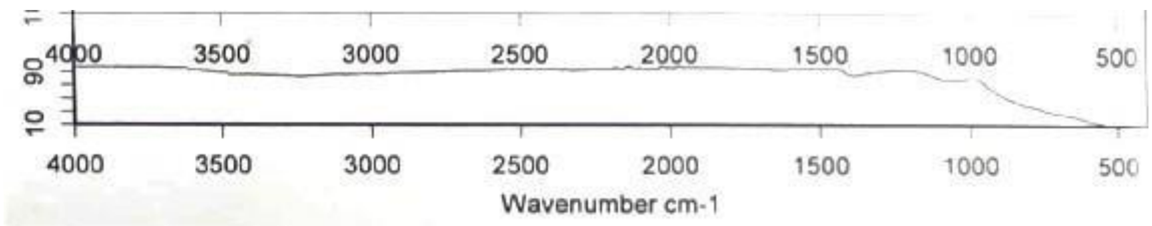


Figure 8: FTIR spectra for CdO nanoparticles

FTIR spectra of NiO nanoparticles:

NiO nanoparticles synthesized from pomegranate peels extract(Figure 9) show that a prominent peak is obtained at 550 cm^{-1} which confirms the presence of NiO nanoparticles and second peak obtained at 1100 cm^{-1} is characteristic of oxide groups another broad peak in between 3000-3500 cm^{-1} wavelength are due to O-H stretching vibrations (Israa Muzahem Rashid et al.2022).

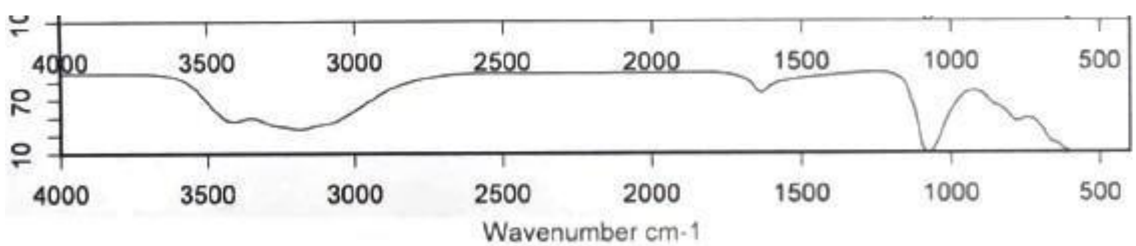


Figure 9: FTIR spectra for NiO nanoparticles from pomogranate peels

SUMMARY OF RESULTS

XRD Analysis (2θ)	ZnO	31.85, 34.48, 36.1, 47.6, 56.6, 62.7, 67.8
	CdO	33.03, 38.32, 55.30, 65.95, 69.26
	NiO	28.77, 31.54, 32.83, 37.23, 43.12, 51.40, 62.86

UV Analysis	ZnO	327 nm and 204 nm.
	CdO	203 nm
	NiO	206 nm

FTIR Analysis	ZnO	450 cm^{-1}
	CdO	550 $cm^{-1.}$
	NiO	550 $cm^{-1.}$

CONCLUSIONS AND FUTURE PROSPECTS

This work effectively synthesised green nanoparticles derived from biowastes such as orange peel, pomegranate peel, and banana peel. These biowastes were collected from a fruit juice vendor located on the campus, demonstrating an effective approach of using the manufacture of environmentally friendly nanoparticles. Nanoparticles were characterized by XRD method, FTIR and UV–visible spectroscopic method. Results obtained were comparable with results obtained from other literature articles. The green synthesis approach described herein presents a viable alternative to conventional chemical or physical methods employed in the creation of nanoparticles. The synthesis of environmentally acceptable and cost-effective green nanoparticles may be efficiently conducted on a large scale in industrial settings, making them suitable for a wide range of applications. Nanoparticles synthesised by green methods have demonstrated efficacy as antibacterial and antifungal agents, as well as exhibiting anticancer capabilities. Additionally, these nanoparticles have shown potential for application in the absorption and destruction of hazardous chemical dyes, as well as in the treatment of wastewater. There exist several potential applications for green synthesised nanoparticles that can contribute to the well-being of humanity and the environment on a broad scale.

REFERENCES

Adnan Alnehia, Abdel-Basit Al-Odayni, Annas Al-Sharabi, A. H. Al-Hammadi, Waseem Sharaf Saeed, "*Pomegranate Peel* Extract-Mediated Green Synthesis of ZnO-NPs: Extract Concentration-Dependent Structure, Optical, and Antibacterial Activity", *Journal of Chemistry*, vosl. 2022, Article ID 9647793, 11 pages, 2022. https://doi.org/10.1155/2022/9647793

Alaa Z Skheel , Muneer H Jaduaa, Ahmed N. Abd, 2021, green synthesis of cadmium oxide nanoparticles for biomedical applications. Materialstoday vol45(part 6); https://doi.org/10.1016/j.matpr.2021.03.168

Ali Ibrahim, T., A. Salman, T., & al-Rudha Abbas, S. (2021). Biosynthesis of zinc oxide nanoparticles using orange peels extract for biological applications. *Plant archives*,*21*(Suppliment-1),329–332. https://doi.org/10.51470/plantarchives.2021.v21.s1.052

Alqarni, L. S., Alghamdi, M. D., Alshahrani, A. A., & Nassar, A. M. (2022). Green Nanotechnology: Recent Research on Bioresource-Based Nanoparticle Synthesis and Applications. *Journal of Chemistry*, *2022*. https://doi.org/10.1155/2022/4030999

Al-Qasmi, N., Al-Gethami, W., Saleh, D., & Abuziad, A. (2020). A Sustainable Approach for the Synthesis of Metallic Nanoparticles and its Application as Antimicrobial Agents. *Journal of Materials Research and Technology*, *9*(6), 13036–13042. https://doi.org/10.1016/j.jmrt.2020.09.053

Alwash, A. (2020). The green synthesize of zinc oxide catalyst using pomegranate peels extract for the photocatalytic degradation of methylene blue dye. *Baghdad Science Journal*, *17*(3), 787–794. https://doi.org/10.21123/bsj.2020.17.3.0787

Bakayoko, M., Sackey, J., Razanamahandry, L. C., Ngom, B. D., & Ntwampe, S. K. O.

(2019). Bio-synthesis and characterization of nanoscaled CdO using corn husk extract via green nano-chemistry. *Materials Today: Proceedings*, *36*, 534–539. https://doi.org/10.1016/j.matpr.2020.05.32

Baraa Y. Hussein, Ahmed Mishaal Mohammed ; 'Biosynthesis and characterization of nickel oxide nanoparticles by using aqueous grape extract and evaluation of their biological applications' Results in Chemistry, Volume 3, January 2021; https://doi.org/10.1016/j.rechem.2021.100142.

Doan Thi, T. U., Nguyen, T. T., Thi, Y. D., Ta Thi, K. H., Phan, B. T., & Pham, K. N. (2020). Green synthesis of ZnO nanoparticles using orange fruit peel extract for antibacterial activities. *RSC Advances*, *10*(40), 23899–23907. https://doi.org/10.1039/d0ra04926c

Enyioma C. Okpara et al, 2020 , green wastes mediated ZnO naoparticle synthesis , chatracterisation and electrochemical studies.*Materials* **2020**, *13*(19), 4241;

Hager R Ali , Mohammad A Hassan ,2017 ,applications of biowaste materials as green synthesis of nanoparticles and water purification, Advance in materials 2017; 6(5): 85-101, doi: 10.11648/j.am.20170605.16

ISRAA MUZAHEM RASHID*, SAMI DAWOD SALMAN, ALAA KAREEM MOHAMMED & YASMIN SALIH MAHDI Green Synthesis of Nickle Oxide Nanoparticles for Adsorption of Dyes ; Sains Malaysiana 51(2)(2022): 533-546 http://doi.org/10.17576/jsm-2022-5102-17

J. Xu, Y. Huang, S. Zhu, N. Abbes, X. Jing, and L. Zhang, "A review of the green synthesis of ZnO nanoparticles using plant extracts and their prospects for application in antibacterial textiles," *Journal of Engineered Fibers and Fabrics*, vol. 16, Article ID 155892502110462, 2021.

Karthik, K., Dhanuskodi, S., Gobinath, C., Prabukumar, S., & Sivaramakrishnan, S. (2017). Andrographis paniculata extract mediated green synthesis of CdO nanoparticles and its electrochemical and antibacterial studies. *Journal of Materials Science: Materials in Electronics*, *28*(11), 7991–8001. https://doi.org/10.1007/s10854- 017-6503

M. Naseer, U. Aslam, B. Khalid, and B. Chen, "Green route to synthesize zinc oxide nanoparticles using leaf extracts of cassia fistula and melia azadarach and their antibacterial potential," *Scientific Reports*, vol. 10, pp. 1–10, 2020.

Patra, J. K., & Baek, K. H. (2014). Green Nanobiotechnology: Factors Affecting Synthesis and Characterization Techniques. *Journal of Nanomaterials, 2014*. https://doi.org/10.1155/2014/417305

Rashid, I. M., Salman, D., Mohammed, A. K., & Mahdi, Y. S. (2022). Green Synthesis of Nickle Oxide Nanoparticles for Adsorption of Dyes. *Sains Malaysiana*, *51*(2), 533–546. https://doi.org/10.17576/jsm-2022-5102-17

Sadhiyha Yasir Offi Al Jubory ,2020, Banana fruit peels as capping and reducing agents to creating cadmium oxide nanoparticles and evaluation of its activity against ecoli and candida albicans. Plant Archives Vol. 20, Supplement 2, 2020 pp. 2046-2050

Singh, J., Dutta, T., Kim, K. H., Rawat, M., Samddar, P., & Kumar, P. (2018). "Green synthesis of metals and their oxide nanoparticles: Applications for environmental remediation. *Journal of Nanobiotechnology*, *16*(1). https://doi.org/10.1186/s12951-018-0408-4

Xu, J., Huang, Y., Zhu, S., Abbes, N., Jing, X., & Zhang, L. (2021). A review of the green synthesis of ZnO nanoparticles using plant extracts and their prospects for application in antibacterial textiles. *Journal of Engineered Fibers and Fabrics*, *16*. https://doi.org/10.1177/15589250211046242