Review Article
Volume 14:1, 2025

Journal of Material Sciences & Engineering

ISSN: 2169-0022 Open Access

Synthesis, Structural, Morphological, Optical and Biological Evaluation of Lanthanum Oxide Nanoparticles Using Co-Precipitation Methods

B. Ravindrana[1*], GK Kavi[2] and J Balaji[2]

[1]*Department of Physics, Thiru.Vi.Ka Govt. Arts College, Bharathidasan University, Thiruvarur, Tamil Nadu, India*

[2]*Department of Physics, University college of Engineering Panruti, Panruti, Tamil Nadu, India*

Abstract

Lanthanum nanoparticles have excellent photocatalytic, optical, physiochemical and biological properties and their applications are in modern society. Lanthanum nanoparticles were synthesized using a new and simple co-precipitation process. The structural and optical properties and the morphology of the produced nanocomposite were examined using X-Ray Diffraction (XRD) patterns, which confirm the development of hexagonal La_2O_3 nanoparticles with a structure. The presence of a LaO spectrum range of 4000 cm^{-1} to 400 cm^{-1} verifies the Fourier Transform Infrared (FTIR). Scanning Electron Microscopy (SEM) shows spherical-shaped particles in the 200 nm nano sized range. The optical characteristics of La_2O_3 nanoparticles were studied using UV-visible diffuse reflectance spectroscopy. The band gap value was determined to be 3.8 eV because, because of the metals, they can particularly target cancerous cells. Nanoparticles are increasing human exposure, particularly in medical applications and are currently being researched for their possible antibacterial and anticancer characteristics. The cytotoxicity of La_2O_3 was investigated using human cervical cancer cells (HeLa). The study also highlighted the potential use of La_2O_3 nanoparticles in cancer treatment due to their specific toxicity to cancer cells. Lanthanum has an IC_{50} value of 149.22 µg/ml for anticancer activity against the HeLa cell line.

Keywords: Nanoparticles • Optical properties • Cytotoxicity • Anticancer

Introduction

In recent days, nanocomposite substances underpinned on oxides of rare earth metals like lanthanum have been practiced in several technical fields and pharmaceuticals. Biomedical fields, especially medley of this kind, are identified by the special physicochemical properties of nanoparticles, which are used in various medical applications such as anticancer and antibacterial activity [1]. Nanostructured rare earth metal oxides allure a profusion of heed due to their chemical and physical properties. The emanation of nanotechnology has enticed researchers in many fields of industry and technology [2]. Nanoparticles connect the gap between the structure of the molecules and bulk fabrics [3]. Seldom-found oxides of rare earth metals include Sm_2O_3, CeO_2, Gd_2O_3, La_2O_3, Nd_2O_3 and Lu_2O_3. La_2O_3 is one of these rare-earth metal oxides; it is a p-type semiconductor with a large energy band gap, low lattice energy and high dielectric constant [4-6]. Lanthanides tend to accumulate in large amounts in the spleen, kidneys, bones and liver. Other organs imbibe significantly less Ln [7]. The quantity of Ln that agglomerates in other organs changes greatly depending on developmental stage [8]. Among the rare earth oxides, Lanthanum Oxide (La_2O_3) has the potential to become a more useful material in a broad range of optical and electronic utilizations. Nanoparticles have been used in dentistry, pharmacy and other fields due to their unique chemical and physical properties, such as conductance, magnetic, mechanical and optical. Exorbitant use of antibiotics has led to microbial resistance, due to which copious researchers have concentrated on the betterment of novel and powerful antimicrobial retainers [9-10]. Lanthanides have achieved a lot of curative properties, in contrast to MRNs, as biocides [11] and in wound healing. They are widely studied for their anti-viral and anti-cancer properties, etc. Lanthanum-holding complexes as diagnostic tools for therapeutic and biological applications have been discussed [12]. The absorbents used in medical applications must be innocuous, economical and biocompatible. Lanthanum oxide, zirconium and aluminium are the most felicitous, for curative applications.

***Address for Correspondence:** B. Ravindrana, Department of Physics, Thiru. Vi. Ka government Arts College, Thiruvarur, Tamil Nadu, India, Tel:+491786143623; E-mail: khanteymoori@gmail.com*

Received: 22 March, 2024, Manuscript No. JME-24-130461; **Editor assigned:** 25 March, 2024, PreQC No. JME-24-130461 (PQ); **Reviewed:** 10 April, 2024, QC No. JME-24-130461; **Revised:** 20 March, 2025, Manuscript No. JME-24-130461 (R); **Published:** 27 March, 2025, DOI: 10.37421/2169-0022.2025.25.695

But some studies show that aluminium can beget damage of neurological and bone diseases in kidney failure patients. But lanthanum also satisfied all the criteria of absorbents most satisfactorily and did not cause any toxicity to the neurological, bone or any other parts of the body and here lanthanum stated that it had no hepatotoxic effects [13-15]. The research is based on the preparation and analysis of nanosized composites based on lanthanum oxide nanoparticles and their practical usage in medicine, such as their antimicrobial and anticancer properties, using cell line methods.

Materials and Methods

Chemicals used

$La(NO_3)_3.6H_2O$, hexahydrate of lanthanum (III) nitrate (433.007 g/mol; 99.9% purity) NaOH (Sodium Hydroxide; 40.00 g/mol, 99.9% pure) La_2O_3 NPs were made using ethanol and double-distilled water. It was mostly employed in the washing and solvent processes. The entire AR-grade chemical that was put to use was procured from Merck in India.

Synthesis of La_2O_3 nanoparticles

Using lanthanum (III) nitrate hexahydrate and 10 M NaOH, lanthanum nanoparticles were created. In double-distilled water, 0.1 M L(III) nitrate hexahydrate is present. 10 ml of lanthanum were mixed with 10 M NaOH in the following ratios: 100, 50, 20, 10 and 2 µl. Because it exhibits a larger production than other ratios, the 100 ml concentration in this different ratio concentration was chosen for the bulk preparation. 100 ml of 0.1 M Lanthanum (III) nitrate hexahydrate was used to titrate 10 M NaOH. A magnetic stirrer was used to stir 1 ml of 10 M NaOH at 800 rpm after it had been titrated. Within an hour, the mixture took on a milk white hue. The entire reaction took place in the dark. 15 minutes were spent centrifuging the acquired suspension at 15,000 rpm. To get rid of contaminants, nanoparticles were cleaned using deionized water. The precipitate was dried using a muffle furnace. Nanoparticles were stowed in a dry, dark and cool place and further characterization was performed.

Characterizations

Debye-Scherrer formula: the structural behaviour of the synthesised La_2O_3 has been studied by the X-ray diffraction method with (λ=1.5418A^0) as the source. The morphological properties and composition of elements were analyzed by the CARELZEISS model: EVO18 and EDAX analysis (Zeiss Sigma VP 300). A scanning electron microscope was also used to identify the surface morphology, structure and size. Identification of functional groups on the synthesized La_2O_3 samples was taken from FTIR (Spectrum 100; PerkinElmer, USA). Perkin Elmer Model: A Lambda 35 UV spectrometer is used to determine optical transmission and absorbance spectra within a range of 190 nm to 1100 nm.

Results and Discussion

Structural analysis

Using Bragg's law, the phase purity and crystalline nature of the shown La_2O_3 nanoparticles were studied by choosing the 2θ value between the 100 and 800 ranges. Figure 1 shows the XRD pattern of multiple peaks of grown nanoparticles of La_2O_3. From the obtained XRD pattern, it was observed that the maximum intensity occurred at (002) planes and some well-extended peaks were recorded at (101), (011), (003),(113) and (200). The size reduction and polycrystalline nature were confirmed from the above-mentioned extended peaks and weakly extended peaks were also studied and recorded along with the extended intensity peaks. The JCPDS software (73-2141) confirms the identified peaks and finds good agreement with the reported values [16-17]. The hexagonal structure formation was confirmed clearly by the synthesized La_2O_3 nanoparticles. The average size of the crystal (D) was confirmed by Debye-Scherrer [18].

$$D=K\lambda/\beta COS\theta$$

Where, β indicates Full Width at Half Maximum (FWHM), λ shows the wavelength of the X-ray (λ=1.5418A^0), θ is the diffraction angle for the peak, D is the crystallite size of the samples. and K is a constant (0.89). Undertaking into account instrumental broadening, the average crystallite size of La_2O_3 nanoparticles was also analyzed by using Williamson-Hall plot analysis [19]. The crystalline parameters verified the formation of the hexagonal structure of La_2O_3, in addition to the crystallographic parameters which include micro strain and dislocation density of the La_2O_3 nanoparticles and were computed from the XRD data using the following equations [20]. The outcome suggests that the phase structure of La_2O_3 is hexagonal.

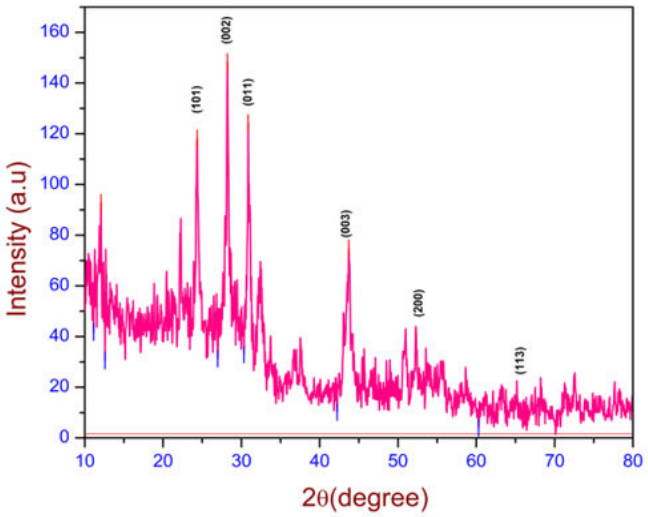

Figure 1. XRD Pattern W-H Plot of the La_2O_3 nanoparticles.

Morphology analysis

The powerful augmentation device for determining the size, structure and surface morphology of nanoparticles is the Scanning Electron Microscope (SEM). Figure 2 displays the synthesized La_2O_3 nanoparticles' obtained SEM micrographs. It was evident that the La_2O_3 nanoparticles' surface has a uniform size distribution and a spherical shape. In addition, some particle agglomerations were seen in the SEM pictures. There was good agreement in the obtained morphology. It was difficult to determine the precise particle size because of the existence of particle agglomerations. Using the Image J program, an approximate value of 36 nm for the average particle size was discovered.

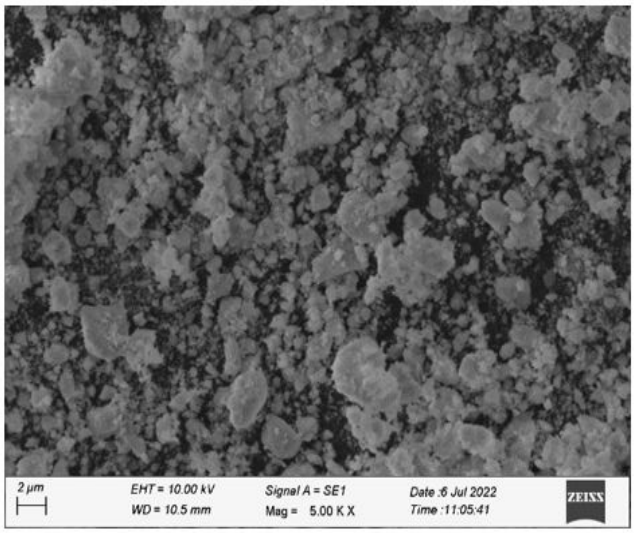

Figure 2. SEM Analysis of La_2O_3.

FTIR spectra analysis

The FTIR spectra in the wavenumber range between 4000 and 400 cm^{-1} are illustrated in Figure 3. The broad absorption peak found at 3425 cm-1 and the O-H stretching vibration of water molecules can be allocated. The minuscule peak at 2917 cm^{-1} suggests that vibrations attributed to the stretching of CH_2 occur. C-O bending vibrations are associated with sharp bands at 841 cm^{-1}, while C-O stretching vibrations are correlated with another band observed at 1055 cm^{-1}. The small, sharp absorption peak observed at 718 cm^{-1} was caused by the La-O stretching vibrations. Another minor absorption peak at 510 cm^{-1} can be attributed to La-O bending vibrations. The stretching and bending vibrations of the La-O bands provide evidence of La_2O_3 phase formation in the nanostructure samples.

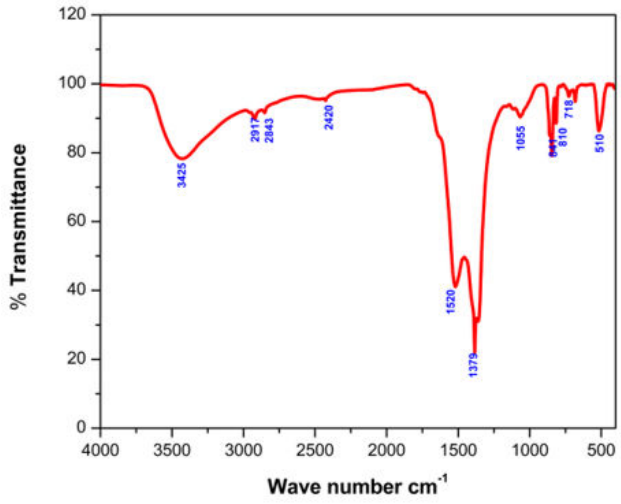

Figure 3. FTIR spectrum of La_2O_3.

UV-visible spectra analysis

The optical properties of the La_2O_3 nanoparticles were analyzed using UV-visible diffuse reflectance spectroscopy. Figure 4 shows the acquire reflectance spectra of in the wavelength range of 200-1100 nm found in the La_2O_3 nanoparticles.

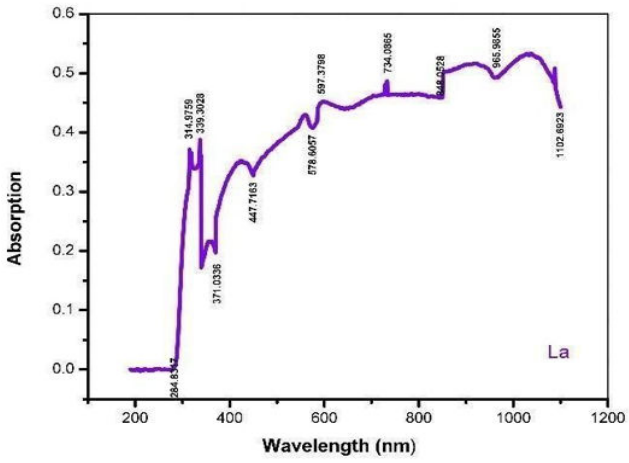

Figure 4. UV-visible spectra analysis of La_2O_3.

The refraction spectra of the indirect band gap value of La_2O_3 nanoparticles determined using Tau's plot is as follows: (hυ F(R))1/2=A (hυ-Eg). Where, F(R)=(1-R)1/2/2R, h is a Planks constant, μ is the light frequency, A is the absorption coefficient and Eg is the band gap energy. The K-M plot was drawn between (hυF(R))1/2vshυ as shown in Figure 5. A tangent of a straight line is drawn to the interaction point with the hυ axis, which is indirect bandgap energy and is predicted to be 3.8 eV. The desired Eg value shows that there is a shift observed in the synthesized nanoparticles. The recoded Eg value was in good agreement.

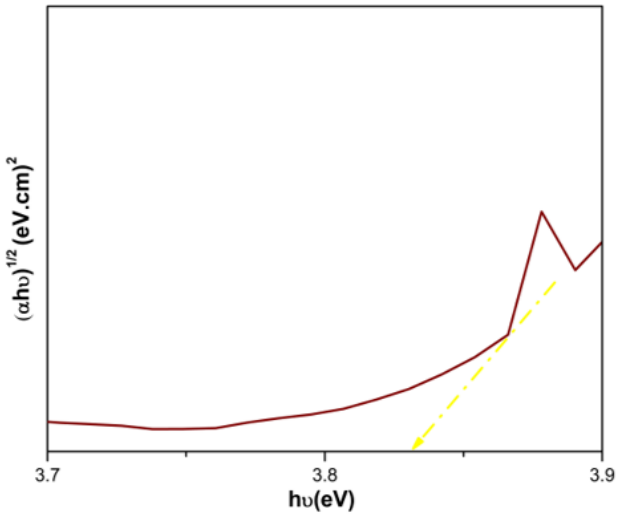

Figure 5. Energy bandgap (eV) by Tau's Plot.

Energy Dispersive Spectroscopic–(EDS)

Analysis using Energy Dispersive Spectroscopy (EDS) La_2O_3 nano powder that had been calcined at 800°C for three hours had its chemical composition determined in atomic percentages and these measurements showed that it was roughly identical to the stoichiometric composition of La_2O_3. According to EDS measurements, the material contains 81.59% oxygen and 18.41% lanthanum atoms, which is nearly equal to the metal amount added during synthesis (Figure 6).

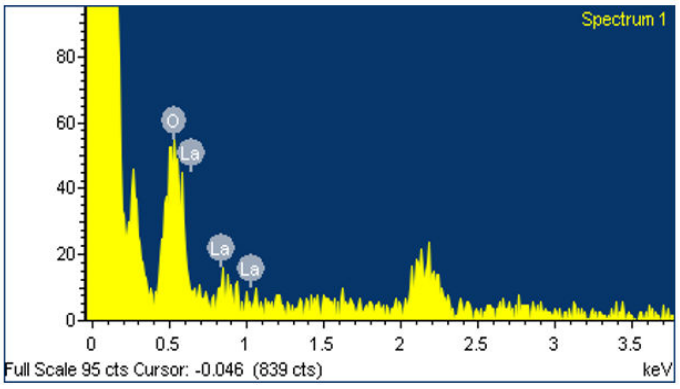

Figure 6. EDS of La_2O_3.

Biological studies

Anticancer: The growth of body cells in an uncontrolled manner is said to be a cancer disease. The name cancer is always labelled for the organ of the body where it begins; even later, it extends its infection to other organs of the body. Cancer is one of the leading causes of death worldwide, ranking second only to heart disease. It arises from the imperfections of a natural cell because of DNA genetic mutations. The reproduction of abnormal cells in an unusual way by asexual reproduction, that is, it violates the signals that are responsible for regulating the cell's growth around it, obtaining annexing characteristics and causing variation in its tissue surroundings. According to the WHO's report, cancer will be a major cause of death worldwide. It is noted that 13 percent of deaths were almost equal to 7.6 million people in the world in 2008. From the survey, it is estimated that the death rate is likely to improve to over 11 million by 2030. Normally, cervical cancer in women starts earlier at the cervix and it is named so. In the year 2018, it was diagnosed that a number of 570,000 women were found to have cervical cancer. Among those, 311,000 people died due to the disease. 99 percent of cervical cancer cases are due to the virus named HPV, which is the most common virus spread by sexual transmission. In developing countries such as India, the number of cases of cervical cancer is disproportionate. Although most HPV infections were cured spontaneously with persistent infection and no symptoms, which can cause cervical cancer in women, one of the most successful curable forms of cancer is cervical cancer, which can be diagnosed and certified by WHO in 2020. Clinically, beneficial effects of chemotherapeutic agents in cancer treatment were recorded. But some drugs and fatal bone marrow depression were exhibited due to their chemical compounds, which lead to alopecia. Even though several researchers are going on to develop anticancer agents with no adverse effects along with cost-effective trends, this is a potential area of research in the field of pharmaceutical applications worldwide. Various experiments also proved that the chemical showed anticancer activity with respect to a variety of cell lines. Investigation of novel chemical compounds along with tumour cell effects is used to study some new therapeutic applications by means of cell lines. To diagnose *in vitro* cytotoxicity, cell lines are used as cancer samples, which acts as a primary step in the field of anticancer compound research. HeLa is the eternal cell line used in research science. It is the most commonly used human cell line and is named after the derivation of the cervical infected cell of cancer, which was taken on February 8, 1951, from Henrietta Lack, an African American 31-year-old and five children who died due to cervical cancer on October 4, 1951. Thus, this study aimed at evaluating the *in vitro* anticancer activity of lanthanum in cervical cancer cells (HeLa cell line).

MTT assay determination of *In-vitro* cytotoxic effect: To determine the cytotoxicity effect of test compound on HeLa cell line by MTT assay. Cell line was first obtained from NCCS (National Center for Cell Science), Pune, India and keep alive Dulbecco's modified Eagles medium. The USA banned DMEM located at sigma Aldrich was utilized. The cell line in 25 cm^2 flask tissue culture with DMEM was cultured and supplemented with 10% FBS, sodium bicarbonate (Merck, Germany), L-glutamine and antibiotic solution containing amphotericin B (2.5 µg/ml), penicillin (100 U/ml) and streptomycin (100 µg/ml). In a CO_2-humidified incubator, a 5% tissue culture cell line was preserved at 370°C (NBS Eppendorf, Germany) using an inverted phase contrast microscope. Tissue cell viability was estimated by direct observation and followed by the MTT assay method.

Seeding of cells using 96 well plate: A monolayer of confluent two-day-old cells was trypsinized and the same were suspended in 10% growth medium. A 100-µl suspension of 100 µl cell (5×10^3 cells /well) was seeded at 96-well culture tissue plate and incubated in a 5% humidified CO_2 incubator at 370C

Compound stock preparation: Using a cyclomixer, a sample of 1 mg was taken and dissolved in 1 ml of DMEM. To ensure stability, the obtained solution was filtered using a microscope syringe (0.22 µm).

Cytotoxicity assay by MTT method: Without the influence of the test agent, the seed (200 µl) was suspended in the required cell density (20,000 cells per well) on a 96-well plate and allowed to glow for an hour overnight. Test agents with appropriate concentrations were added (12.5, 25, 50, 100, 200 µg/ml). The plate was incubated for about 72 hours in a CO_2 atmosphere at 370°C. take down the plate from the incubator for the incubation period and also remove the spent media to add the MTT regent for obtaining the final concentration of the total volume at 0.5 mg/ml. The plate was wrapped with aluminum foil to avoid light exposure. The incubator plates were reinserted and they were incubated for about 3 hours. 100 ml of solubilization solution (DMSC) was added after the removal of MTT regent. Using a gyratory shake, the dissolution was enhanced by gentle stirring. MTT formazan crystals were dissolved by pipetting up and down occasionally for dense culture. The absorbance was studied using a reference wavelength of 570 nm and 630 nm on an ELISA reader or a spectrophotometer. The IC_{50} value was predicted using the linear equation Y=MX+C and the value of the IC_{50} was determined. Where C and M values were obtained from the viability graph by taking Y=50.

Cytotoxicity investigation-Direct microscopic observation: Using Olympus CKX41 with Optika pro5CCD camera the following microscopic studied were observed and the image were recovered. Microscopical studies of phase contrast tissue culture and all microscopic studies were taken by 24 hours' treatment of entire plate. Some indicators such as shrinking of cells or rounding vacuolization and granulation in the cell's cytoplasm were the observed changes to predict the statistical cytotoxicity analysis.

Statistical analysis: Three separate tests were carried out to do triplicate experiments. MS Windows (version 3) graph pad Instat-based software was used to determine graphically the inhibition of cancer cell growth by 50% inhibition concentration (IC_{50}) exacts (Table 1 and Figure 7).

	HeLa (Cervical cancer cell line)						
Activity	**Cell control**	**12.5 (µg/mL)**	**25 (µg/mL)**	**50 (µg/mL)**	**100 (µg/mL)**	**200 (µg/mL)**	**Standa rd (Cisplatin) 15 µM**
Viability (%)	100	94.5	84.78	71.6	56.43	40.45	25.76
Cytotoxicity (%)	0	5.5	15.22	28.4	43.57	59.55	74.24
IC_{50} Value (µg/mL)	149.22						

Table 1. Effect of varying concentrations of Lanthanum on cell viability and cytotoxicity of HeLa (Cervical cancer) cell line as determined by MTT assay.

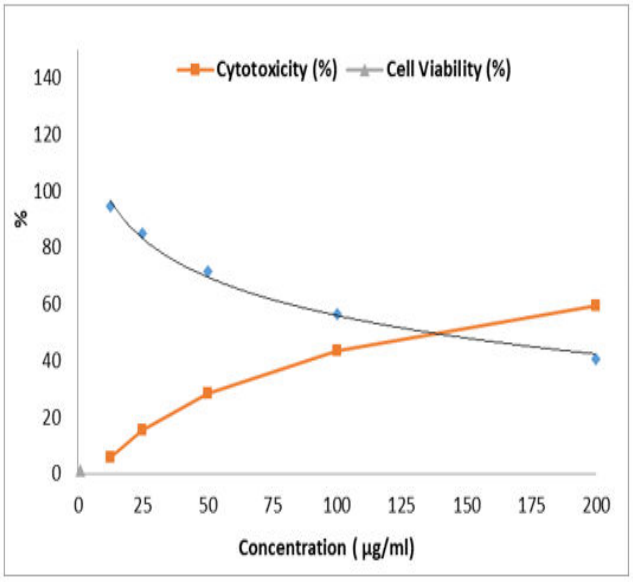

Figure 7. Effect of varying concentrations of Lanthanum on cell viability and cytotoxicity of HeLa (Cervical cancer) cell line as determined by MTT assay.

Morphological examination: Figure 8 shows the structural changes that happened at the HeLa cells under treatment with various concentration of lanthanum. Drastic changes in the structural characteristics were observed for the sample concentration increases (up to 200 µg/ml) of tested cell line which was proportionate with repeat to the applied concentration. Exhibition of anticancer effects found HeLa in samples are due to the inclusion of cell migration inhibition cell cycle arrest and apoptosis. Moreover, cells appeared to float completely in comparison to the control morphology and seems to be rounded at the highest applied concentration. To destroy the cancer cells in the primary goal of chemotherapeutic anticancer drugs. Highly programmed and systematic cell death is said to be apoptosis, where the adjacent cells do the phagocytosed activities in the debris cells. A notable increase in cytotoxicity and decrease in cell viability were recorded with increasing concentration of the Lanthanum by MTT assay was shown Figure 6. The IC_{50} values of Lanthanum in HeLa was found to be 149.22 µg/ml respectively. The lowest IC_{50}. value has the higher anticancer activity. The order of anticancer activity of samples were found to be lanthanum.

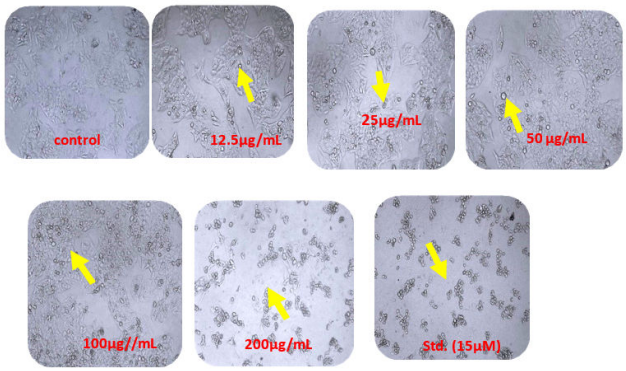

Figure 8. Effect of varying concentrations of Lanthanum on cell viability and cytotoxicity of HeLa (Cervical cancer) cell line as determined by MTT assay (Arrow marks indicate representative apoptotic cells).

Conclusion

The synthesis of nanoparticles was performed by the Co-precipitation methods. The nanoparticles were confirmed by X-ray powder diffraction analysis, which indicates the clear formation of a hexagonal structure. The existence of metal-oxygen bonding and other functional groups of uncalcined La_2O_3 nanoparticles were examined using FTIR spectroscopy. Optical transmission studies show that the grown crystal is optically transparent and that the lower threshold wavelength occurs at 200 nm. The optical band gap is 3.8 eV in the UV-vis absorption spectrum. In conclusion, Lanthanum acts as an anticancer activity against the HeLa cell line in a dose-dependent manner after 72 hours with an IC_{50} value of 149.22 µg/ml and the anticancer property of Lanthanum may be responsible for the cytotoxicity via apoptosis induction toward cervical cancer cells. We laid out that this lanthanum could potentially be employed therapeutically in the treatment of cancer. Besides, clinical trials are required to endorse their therapeutic functionality.

Acknowledgments

Not applicable.

Funding

Not applicable.

Ethics Declarations

Not applicable.

Consent for Publication

Not applicable.

Competing Interests

The author declares that they no known competing financial interests or personal relationship that could have appeared to influence the work reported in this paper.

Author Information

Department of Physics, Thiru Vi. Ka. Government Arts College, Thiruvarur,610 003 Tamil Nadu, India. (Affiliated to Bharathidasan University, Tiruchirappalli).

Author Contributions

All authors made substantial contributions to conception and design, acquisition of data or analysis and interpretation of data; took part in drafting the article for important intellectual content; and agreed to be accountable for all aspects of the work.

References

1. Zhou, Xiaohong, Yaoqi Pang, Zebang Liu and Evgeny I. Vovk, et al. "Active Oxygen Center in Oxidative Coupling of Methane on La_2O_3 Catalyst." *J Energy Chem* 60 (2021): 649-659.
2. Shabaninejad, Zahra, Fatemeh Yousefi, Ahmad Movahedpour and Younes Ghasemi, et al. "Electrochemical-Based Biosensors for Microrna Detection: Nanotechnology Comes into View." *Anal Biochem* 581 (2019): 113349.
3. Sovizi, Mohammad Reza and Somayeh Mirzakhani. "A chemiresistor Sensor Modified with Lanthanum Oxide Nanoparticles as a Highly Sensitive and Selective Sensor for Dimethylamine at Room Temperature." *New J Chem* 44 (2020): 4927-4934.
4. Kabir, Humayun, Sooraj Hussain Nandyala, M. Mahbubur Rahman and Alamgir Kabir, et al. "Influence of Calcination on the Sol-Gel Synthesis of Lanthanum Oxide Nanoparticles." *Appl Phys* 124 (2018): 1-11.
5. Gao, Gang, Lei Yang, Bing Dai and Fei Xia, et al. "Investigation of the Effect of Annealing Temperature on Optical Properties of Lanthanum-Oxide thin Films Prepared by Sol-Gel Method." *Surf Coat Technol* 365 (2019): 164-172.
6. Misra, Sudhindra N, Minaz A. Gagnani and Ram S. Shukla. "Biological and Clinical Aspects of Lanthanide Coordination Compounds." *Bioinorg Chem Appl* 2 (2004): 155.
7. Evans CH and CH Evans. "The Occurrence and Metabolism of Lanthanides." *Biochem Lanthanides* 8 (1990): 285-337.
8. Thombre, Rebecca S, Vinaya Shinde, Elvina Thaiparambil and Samruddhi Zende, et al. "Antimicrobial Activity and Mechanism of Inhibition of Silver Nanoparticles against Extreme Halophilic Archaea." *Front Microbiol* 7 (2016): 1424.
9. Belurkar, Roopa. "Synthesis And Characterization of Lanthanum Nanoparticles By *Anethum Graveolens* (Dill) Leaf Extract." *Orient J Chem* 37 (2021): 1205.
10. Wakabayashi, Tokumitsu, Ayumi Ymamoto, Akira Kazaana and Yuta Nakano, et al. "Antibacterial, Antifungal and Nematicidal Activities of Rare Earth Ions." *Biol Trace Elem Res* 174 (2016): 464-470.
11. Todorov, Lozan, Irena Kostova and Maria Traykova. "Lanthanum, Gallium and Their Impact on Oxidative Stress." *Curr Med Chem* 26 (2019): 4280-4295.
12. Mudge, David W, David W Johnson, Carmel M. Hawley and Scott B. Campbell, et al. "Do Aluminium-Based Phosphate Binders Continue to have a Role in Contemporary Nephrology Practice?." *BMC Nephrol* 12 (2011): 1-8.
13. Persy, Veerle P, Geert J Behets, Marc E. De Broe and Patrick C. D'Haese. "Management of Hyperphosphatemia in Patients with End-Stage Renal Disease: Focus on Lanthanum Carbonate." *Int J Nephrol Renovasc Dis* 2 (2009): 1-8.
14. Behets, Geert J, Kayawe Valentine Mubiana, Ludwig Lamberts and Karin Finsterle, et al. "Use of Lanthanum for Water Treatment a Matter of Concern?." *Chemosphere* 239 (2020): 124780.
15. Dhatchinamurthy L, P. Thirumoorthy, L. Arunraja and S. Karthikeyan. "Synthesis and Characterization of Cadmium Sulfide (Cds) Thin Film for Solar Cell Applications Grown by Dip Coating Method." *Mater Today: Proc* 26 (2020): 3595-3599.
16. Chang, Hung-Yi and Huey-Ing Chen. "Morphological Evolution for CeO_2 Nanoparticles Synthesized by Precipitation Technique." *J Cryst Growth* 283 (2005): 457-468.
17. Williamson GK and WH Hall. "X-ray Line Broadening from Filed Aluminium and Wolfram." *Acta Metallurgica* 1 (1953): 22-31.
18. Suresh, R, V Ponnuswamy and R Mariappan. "Effect of Annealing Temperature on the Microstructural, Optical and Electrical Properties of CeO_2 Nanoparticles by Chemical Precipitation Method." *Appl Surf Sci* 273 (2013): 457-464.
19. Pathan, Amanullakhan A, Kavita R Desai and CP Bhasin. "Synthesis of La_2O_3 Nanoparticles using Glutaric Acid and Propylene Glycol for Future CMOS Applications." *Int J Nanotechnol Chem* 3 (2017): 21-25.
20. Balusamy, Brabu, Yamuna Gowri Kandhasamy, Anitha Senthamizhan and Gopalakrishnan Chandrasekaran, et al. "Characterization and Bacterial Toxicity of Lanthanum Oxide Bulk and Nanoparticles." *J Rare Earths* 30 (2012): 1298-1302.

How to cite this article: B. Ravindrana, GK Kavi and J Balaji. "Synthesis, Structural, Morphological, Optical and Biological Evaluation of Lanthanum Oxide Nanoparticles Using Co-Precipitation Methods." *J Material Sci Eng* 14 (2025):695.