Synthesis of Chromium Oxide Nanoparticles and Tuning to Optimize Magnetic and Bactericidal Properties

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Abstract

In recent decades, scientists have been tailoring desirable nanostructure to unveil the potential of nanomaterials (NMs) in biomedical, energy, and environmental applications. This research discussed novel synthesis of chromium oxide (Cr_2O_3) nanoparticles (NPs), studied the impact of sintering at different temperatures and evaluated its magnetic and bactericidal properties. However, synthesized material initially confirmed by the colour of precipitate and then characterizes X-ray diffraction (XRD) which represents highly crystalline structure without any traces of impurities. Cr_2O_3 NPs has shown rhombohedral phase with average crystallite sizes that increases from 31.5 to 47.70 nm on increasing the temperature from 500 to 800 °C respectively. Furthermore, FE-SEM and TEM recorded of prepared samples which confirm the spherical shape at 500 °C. However, with the increasing sintering temperature up to 800 °C, the size and morphology turned into pentagonal and hexagonal shape. Similarly, the coercivity and retentivity of Cr_2O_3 NPs are calculated decreasing order 0.6784 Oe, 0.6579 Oe, 0.478 Oe, 0.4022 Oe and 1.5065×10^{-3} emu/g, 1.4290×10^{-3} emu/g, 1.3967×10^{-3} emu/g, 0.9638×10^{-3} emu/g with increasing the sintering temperature respectively. This signify that increase the

sintering temperatures paramagnetic property of Cr_2O_3 NPs transform into anti-ferromagnetic nature, which might be associated with induced exchange interaction of oxygen defects. The potential antibacterial efficacy was tested against Escherichia coli (Gram-negative), Klebsiella pneumonia (Gram-negative), and Salmonella typhi (Gram-negative). Optimized better MIC (minimum inhibition concentration) was observed for sintered at 500 °C as S. typhi (0.68 mg/ml), K. pneumoniae (0.387 mg/ml), and E. coli (0.532 mg/ml), and better results were found for Cr_2O_3 NPs. The present study entails Cr_2O_3 NPs can be used to develop potential antibacterial agent for effective treatment of antibiotic-resistant bacteria, and cure for previously incurable diseases.

Author keywords

Bactericidal; Chromium oxide; Magnetic retentivity; Nanostructure; Sintering; Tuning

Indexed keywords

Engineering controlled terms

Chemical shift; Coercive force; Crystallite size; Grain boundaries; High resolution transmission electron microscopy; Nanomagnetics; Nanoparticles; Salmonella; Sintering

Engineering uncontrolled terms

Bactericidal; Bactericidal properties; Biomedical applications; Chromium oxides; Energy applications; Environmental applications; Magnetic retentivity; Oxide nanoparticles; Sintering temperatures; Tuning

Engineering main heading

Escherichia coli

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Abstract

Author keywords

Indexed keywords

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Sustainable Water Management and Treatment: Systems, Processes and Technologies

Environmental Science and Engineering • Book Chapter • 2025 • DOI: 10.1007/978-3-031-85327-2_7

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Abstract

Global water resources are rapidly diminishing, driven by population growth, climate changeClimate change, and expanding industrialization. Experts estimate that by 2050, 52% of the projected 9.7 billion people worldwide will reside in areas experiencing water stress or scarcity. The global challenge of accessing clean, potable water will persist as sustainable solutions remain elusive. Water sustainabilitySustainability involves meeting the current generation's water needs without jeopardizing future generations' ability to meet their own. Water is the cornerstone of sustainable developmentSustainable development, serving as a common thread linking global challenges such as energy, food securityFood security, health, peace, security, and poverty eradication. Our survival and well-being depend heavily on effective water resource systems. However, with growing development pressures on land in watersheds and increasing demands for water in streams, rivers, lakes, and aquifers, it is unrealistic to expect these water systems to return to or maintain their pristine, most productive states. Sustainable water managementWater management (SWM) is crucial for addressing these pressures and achieving sustainable development goalsSustainable Development Goals (SDGs). SWM ensures that current water needs are met for all users without compromising the ability of future generations to meet their own needs. This concept aligns with broader sustainability principlesSustainability principles, addressing both present and future water challenges. Enhancing the efficiency of conventional membrane technologies for water treatment is now crucial to minimizing their environmental impactEnvironmental impact.

WastewaterWastewater treatmenttreatmentWastewater treatment removes pollutants, coarse particles, and toxic substances while killing pathogens and producing bio-methaneMethane (CH_4) and manure for agricultureAgriculture. It is crucial in reducing water waste, easing pressure on natural water sources, and supporting clean energy, forming the foundation for sustainable waste managementWaste management. Membrane technologies are increasingly favored forSustainable wastewater treatmentwastewater treatmentWastewater treatment due to their sustainabilitySustainability advantages, including cost-effectiveness, operational ease, and safety. Sustainable water treatment technologies utilize innovative methods such as membrane filtrationMembrane filtration, advanced oxidation processesAdvanced Oxidation Processes (AOPs), and nanotechnologyNanotechnology. Techniques like reverse osmosisReverse osmosis and ultrafiltration are highly effective in removing contaminantsContaminants, microorganisms, and nanoparticles from water. Sustainable water technologies include wastewater treatmentWastewater treatment plants, intelligent irrigation systems, fog catchers, rainwater harvestingRainwater harvesting, tap aerators, seawater desalinationDesalination, portable filters, and solar-powered desalinationDesalination units.

Author keywords

Electro deionization; Membrane technology; Water management; Water pollution; Water scarcity; Water Stress Index; Waterborne diseases

Indexed keywords

Engineering controlled terms

Agriculture; Cost effectiveness; Environmental technology; Microfiltration; Population statistics; Potable water; River pollution; Sustainable development; Sustainable development goals; Wastewater treatment; Water conservation; Water filtration; Waterworks

Engineering uncontrolled terms

Electro-deionization; Future generations; Global challenges; Sustainable water; Sustainable water management; Water needs; Water scarcity; Water stress indices; Water-borne disease; Waters managements

Engineering main heading

Membrane technology

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Abstract

Author keywords

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Phytochemistry and Potential Pharmacological Properties of Morus alba Plant for Health Benefits: A Comprehensive Review

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Abstract

Morus alba L. is a fast-growing shrub or moderate height tree and considered as Ayurvedic medicinal plant due to its medicinal uses. M. alba has high concentrations of phenols, tannins, steroids, flavonoids, alkaloids, terpenoids, and carbohydrates. In this review, approximately 200 papers were reviewed, and finally 96 papers were used to explore the phytochemistry and pharmacological properties of the Morus alba plant. The aim of this study is to provide an insightful exploration of biologically active compounds present in the bark, leaves, flowers, and fruits of the M. alba plant, and its potential pharmacological effects include anti-inflammatory, antidiabetic, antihyperlipidemic, hepatoprotective, neuroprotective, anthelmintic, anti-obesity, anxiolytic, hypocholesterolemic, antioxidant, antimicrobial, and nephroprotective activity. Phytocompounds present in M. alba extracts also have various biological activities, including blood coagulation factors, vasodilation, cytotoxic responses, cytokine storming, sympathetic responses, oxidative stress, cardiovascular, skin, gastrointestinal, skin whitening, and fibrosis, among others. The findings of this review paper showed that different parts of M. alba have various pharmacological and therapeutic potential and hence can be used in various herbal formulations as well as health care products. Published by Oriental Scientific Publishing Company © 2024.

Author keywords

Antioxidant; Flavonoids; Hepatoprotective; Neuroprotective; Pharmacology; Phytochemistry

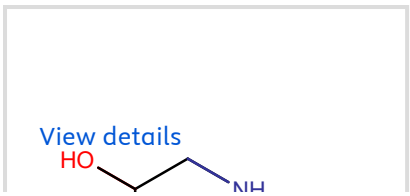
Indexed keywords

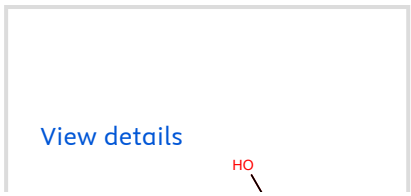
EMTREE drug terms

alkaloid; anthelmintic agent; antioxidant; blood clotting factor; carbohydrate; flavonoid; phenol derivative; steroid; tannin derivative; terpenoid

EMTREE medical terms

antimicrobial activity; bark; drug analysis; drug therapy; medicinal plant; Morus alba; neuroprotection; nonhuman; oxidative stress; pharmacology; phytochemistry; plant leaf; review; shrub; vasodilatation





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MiRNA-3163 limits ovarian cancer stem-like cells via targeting SOX-2 transcription factor

Non-coding RNA Research • Article • *Open Access* • 2024 • DOI: 10.1016/j.ncrna.2024.06.012

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Abstract

Cancer stem cells (CSCs) are pivotal in both cancer progression and the acquisition of drug resistance. MicroRNAs (miRNAs) play a crucial role in modulating CSC properties and are being explored as potential targets for therapeutic interventions. MiR-3163 is primarily known for its tumor suppressive properties in various human malignancies, with lower expression reported across different cancer types. However, its role in regulating the ovarian CSC phenotype and the underlying mechanism remain largely unknown. Here, we report a remarkable downregulation of miR-3163 in ovarian cancer stem-like cells (CSLCs). Enforced expression of miR-3163 in ovarian adherent and CSLCs, significantly disrupts the stemness phenotype. Moreover, downregulation of miR-3163 expression in ovarian cancer cells (OV2008 and OVCAR-3) inhibits the stem-like cells characterized by CD44+CD117+ expression. Sphere formation assay results reveal that overexpression of miR-3163 in ovarian cancer cells significantly inhibits spheroid formation ability, confirming the regulatory properties of miR-3163 on ovarian CSLCs. Mechanistic investigation reveals that miR-3163 depletes ovarian CSLCs via targeting SOX-2. Furthermore, we establish SOX-2 as a direct target of miR-3163 through dual-luciferase assay. Taken together, our study demonstrates that overexpression of miR-3163 could be a promising strategy for efficiently eradicating

the CSC population to prevent chemoresistance and tumor relapse in ovarian cancer patients. © 2024 The Authors

Author keywords

Cancer stem-like cells; MicroRNA; Migratory potential; Ovarian cancer

Indexed keywords

EMTREE drug terms

Hermes antigen; microRNA; microRNA 3163; stem cell factor receptor; transcription factor Sox2; unclassified drug

EMTREE medical terms

3' untranslated region; Article; bioinformatics; cancer patient; cancer prognosis; cancer staging; cancer stem cell; cell culture; cell migration; cell stemness; down regulation; female; flow cytometry; gene amplification; gene expression; gene mutation; gene overexpression; genetic transfection; human; human cell; luciferase assay; molecular cloning; OV-2008 cell line; ovary cancer; OVCAR-3 cell line; phenotype; protein expression; real time polymerase chain reaction; survival analysis; tumor spheroid; Western blotting; wound healing; wound healing assay

Device trade names

Commercial names given to devices, used for branding and differentiation in the market, commonly referenced in scientific and clinical research.

Tradename	Country	Manufacturer
Graphpad PRISM 8		Graphpad
LSRFortessa		Becton Dickinson
ImageJ		
Pierce	United States	Thermo

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MiRNA-3163 limits ovarian cancer stem-like cells via targeting SOX-2 transcription factor

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Chatterjee, Bilash [a, b]; Bose, Subhankar [a, b]; Singh, Richa [c]; Dixit, Amit Kumar [d]; Puia, Lalrin [d]; +1 author

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the CSC population to prevent chemoresistance and tumor relapse in ovarian cancer patients. © 2024 The Authors

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Graphpad PRISM 8		Graphpad

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CSIR - Indian Institute of Chemical Biology See opportunities by CSIR-IICB		CSIR-IICB
Ministry of AYUSH, Government of India See opportunities	761/2022-23	

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Advancing health monitoring with cognitive IoT, rapid machine learning, and mechanical systems

Trends and Applications in Mechanical Engineering, Composite Materials and Smart Manufacturing • Book Chapter • 2024 • DOI: 10.4018/979-8-3693-1966-6.ch019

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Abstract

Enhancing health monitoring for diabetes patients requires routine surveillance. Integrating IoT, embedded software, data analytics, intelligent systems, and smart devices can alleviate healthcare costs. Improved communication technologies enable remote exercise therapies. An intelligent healthcare infrastructure and expanded network packages are crucial for evolving e-health applications. Integration with 5G ensures higher bandwidth and energy efficiency. Real healthcare programs need seamless integration. In this study, an intelligent infrastructure for diabetes patient tracking using machine learning, smart gadgets, sensors, mobile phones, and mechanical systems ensure comprehensive data collection. Machine learning algorithms analyze patient data for efficient monitoring and prediction. Rigorous testing confirms system effectiveness.

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Abstract

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Spectroscopic investigations of green synthesized zinc oxide nanoparticles (ZnO NPs): antioxidant and antibacterial activity

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Ajay Kumar Tiwari, Saket Jha, Sharad Kumar Tripathi, Rohit Shukla, Ram Raseele Awasthi, Abhishek Kumar Bhardwaj, Abhimanyu Kumar Singh & Anupam Dikshit

Abstract

In the recent decade, zinc oxide nanoparticles (ZnO NPs) have been widely explored owing to their versatile properties and prodigious demands in the drug delivery, medical, energy storage, cosmetics, and the healthcare sectors. Therefore, the current work opts for an environmentally

benign method to prepare ZnO NPs. The leaf extract of *Calendula officinalis L.* acts as a reducing agent for the metal ions; therefore, in the current research, ZnO NPs were prepared via green route by using *Calendula officinalis* leaf extract. Furthermore, the ZnO NPs were analysed with different spectroscopic techniques to confirm the structure and stability of nanomaterials. The prepared ZnO NPs were characterized by XRD, FE-SEM, FT-IR and UV–Vis studies. Also, the antioxidant and antimicrobial properties of the synthesized ZnO NPs were investigated. The XRD result of synthesized ZnO NPs showed the crystalline size 28.23 nm with wurtzite hexagonal structure along with the most intense peak (101). Following preliminary confirmations of the intended ZnO NPs, both big and small agglomerated forms were observed in the FE-SEM, which is often used to determine their exterior assembly. Further, the results of Fourier transform infrared spectroscopy (FT-IR) indicated the formation of pure ZnO NPs with an absorption peak of the Zn–O bond between 4000 cm^{-1} and 500 cm^{-1} and no discernible peak in the monitoring range. The UV–Vis spectrum of the green synthesized ZnO NPs were revealed two prominent absorption peaks at 355 nm and 370 nm with energy band gap of 2.986 eV. Using the 1, 1-di phenyl-2-picrylhydrazyl (DPPH) test, the antioxidant activity of the described ZnO NPs was assessed. It demonstrated how, ZnO NPs significantly increased their antioxidant activity by scavenging 1, 1-di phenyl-2-picrylhydrazyl (DPPH) free radicals. It could be seen that synthesis of the naturally occurring plant product ZnO NPs have been acting as an alternate of chemical antioxidant. The antimicrobial analysis was also performed with the help of disk diffusion method where three multi-drug resistant human pathogens namely *Staphylococcus aureus, Klebsiella pneumoniae and E.coli* were used. The Zone of Inhibition diameter values are 35.2 mm ± 0.9, 23.6 mm ± 0.1 and 13.5 mm ± 0.1, respectively, which showed that the ZnO NPs was highly effective against *S. aureus.* Thus, the green synthesis method of ZnO NPs using leaf extract of *Calendula officinalis* is evidence that it is superior and environmentally friendly method for the preparation of ZnO NPs and hence it can be utilized in various nano-medicine approaches.

Article Highlights

- Green synthesis (hydrothermal method) of ZnO-NPs using leaf extract of *Calendula officinalis L.* and its spectroscopic investigation.
- Found effective Antioxidant activities of green synthesised ZnO that can be employed as skin care and cosmetics.
- Green synthesized ZnO NPs having a significant bactericidal activity observed against bacteria *S. aureus*, *K. pneumonia* and *E. coli.*

1 Introduction

Metal oxide nanoparticles (NPs) have opened a new horizon in the fields of drug delivery, gene delivery, nanomedicine, and biosensing in the twenty-first century [1, 2]. Nanoparticles are also applicable in environmental protection, sensing, communication, cosmetics, medical industry etc. [3]. The magnetic and catalytic properties of nanoparticles, along with their improved surface to volume ratio, can be enhanced by some unique modified processes [4, 5]. Nanoparticles can be synthesized by using an array of physical, chemical, and biological methods. The hydrothermal processes, physical vapor deposition, microemulsion, precipitation, ultrasonic irradiation, chemical reduction, plasma, and sol–gel methods are the best examples of the above methods [6]. But these methods required a variety of hazardous chemicals and a huge amount of energy to synthesize the nanoparticles. The above methods also utilize very high temperatures and pressures, which are very harmful to the environment. Accordingly, the product cast gets very high due to the higher order of the equipment used in these methods [7]. As a result, an environmentally friendly method is required to synthesize the nanoparticles without utilizing any toxic components. Recently, many

scholars have taken an interest in preparing the nanoparticles via green route. In medical science, especially in the diagnosis and treatment of several diseases, the biological method via the green route is comparatively more advantageous than the physical and chemical methods. Thus, the biological method via green route has replaced the physical and chemical methods for the synthesis of nanoparticles due to the high energy consumption, low cost, environmental impact, and production of more stable and biocompatible nanoparticles [8, 9]. Moreover, this method controls the morphology of nanoparticles, including nanorods, nanospheres, nanoporous structures, and nanowires, crucial for various emerging potentials applications [10].

Microorganisms [11], enzymes [12], fungi [13], and plant extracts [14] are used to prepare metal and metal oxide nanoparticles. Nevertheless, it is challenging to develop an effective and environment friendly method to prepare nanoparticles with absolute sizes, shapes, and compositions. Nontoxic and environment friendly nanoparticles are prepared by a variable phyto-chemistry based process using biological entities [15, 16]. There are several harmful compounds including radiation, smoke, and pollution; which pose serious effect to human health concern. Antioxidants are being used more frequently in an effort to mitigate the negative effects of these free radicals. Determining the reactive oxygen species (ROS) reaction requires examining the physical and chemical characteristics of nanoparticles, such as their size, surface charge, and chemical makeup. This is important because ROS generation can be control due to the intrinsic properties of nanoparticles. Numerous studies have demonstrated the ability of metal or metal oxide nanoparticles produced with plant extracts to scavenge radicals. These extracts phytochemicals have two functions: they stabilize the nanoparticles and function as antioxidants to combat free radicals [17, 18].

Among the various metal oxide nanoparticles, zinc oxide nanoparticles (ZnO NPs) are one of the most cost-effective metal oxide nanoparticles with minimal toxicity and the highest biocompatibility. Nowadays ZnO NPs are used in photo-thermal therapy, antibacterial and anticancer drug distributions, cell imaging, and in bio-sensing by making them a promising tool in the field of biomedical sciences [19, 20]. Various methods of synthesis are utilized to improve both the crystal size and their properties for the production of ZnO NPs [21]. Among them, green synthesis method for the preparation of ZnO NPs are widely accepted due to its non-toxicity, environmental friendliness, and wide range of applications viz. antimicrobial properties, antioxidants, anti-aging, anticancer and so on. In the green synthesis method, secondary metabolites trap the metal ions and act as capping agents that help stabilize the nanoparticles in terms of electrostatic, steric, hydration forces, depletion, and Vander-Waals forces [22, 23]. The interactions of ZnO NPs with microbial cells are possible due to the smaller surface area and higher charge density [24, 25].

Researchers have used a variety of physico-chemical [26, 27] and biological or plant-mediated [28, 29] methods to synthesize the ZnO NPs. Green synthesis becomes more preferable technique in recent decades for producing the metallic nanoparticles because of cost effectiveness, lesser toxicity, and additional environmental suitability [30]. Plant extracts are used by researchers to create ZnO NPs through a green synthesis process. For example, several kind biological extracts including algal seaweeds [31], *Hibiscus sabdariffa* [32] *Limonium pruinosum* [33], *Laurus nobilis* [34], *Rosa indica* [35] *Parthenium hysterophorus* [36], *Thymus spp.* [37], *Solanum nigrum* [38], *Lawsonia inermis* [39], *Syzygium cumini* [40], and *Agathosma betulina* [41]. These natural extracts having stabilizing and reducing agents, play a significant role in the production of ZnO NPs. This chemical free approach of synthesizing nanoparticles is in line with the worldwide movement toward sustainability and is a viable substitute for traditional techniques that mainly rely on hazardous chemicals and energy-intensive procedures.

Calendula officinalis is a flowering plant which belongs to the family of Asteraceae. A wide range of pharmacological effects can be observed in the extract of *Calendula officinalis* due to which it can be utilized as an antiseptic, stimulant, diaphoretic, antispasmodic, and anti-pyretic agent [42, 43]. It has been observed that the leaf extracts of the *Calendula officinalis* have anti-cancerous, antiviral anti-genotoxic, anti-oxidant, anti-microbial and anti-inflammatory properties [44, 45].

The present study is focused on the synthesis of ZnO NPs via the green route by using *Calendula officinalis* leaf extract. The prepared ZnO NPs are further characterized by XRD, FE-SEM, UV–Vis and FT-IR spectroscopy for the size, shape, optical properties and stability of the ZnO NPs, respectively. The study also emphasizes the application approach of these nanoparticles towards medicinal area due to their effectiveness in antimicrobial and antioxidant properties. The antimicrobial study was done against multi-drug resistant human pathogens. Also an antioxidant activity was analyzed against DPPH free radical scavenging properties.

2 Method and reagents

2.1 Chemical products

Zinc acetate dihydrate ($C_4H_6O_4Zn.2H_2O$) (219 g/mol, purity 98.5%), and sodium hydroxide (NaOH) (39.997 g/mol, purity 97%) were supplied by Merck Life Science Pvt. Ltd. Mumbai. Nutrient agar (NA), Mueller Hinton Broth (MHB), Mueller Hinton Agar (MHA) and 2, 2-diphenyl-1-picrylhydrazyl (DPPH) (394.32 g/mol, purity 95%) were procured from Himedia Pvt. Ltd. Mumbai for antibacterial assay. As a solvent deionized water was employed. All the chemicals used in this experiment, are analytical grade.

2.2 Leaves procurement and processing

The fresh *Calendula officinalis* leaves were collected from the Roxburgh Botanical Garden, University of Allahabad, Prayagraj, Uttar Pradesh, India. The *Calendula officinalis* plants were identified by Prof. Anupam Dikshit, Department of Botany, University of Allahabad. Leaves were cleaned three times to get rid of the dust and other contaminants, and left in the shade for a week to dry. Leaves were chopped into small pieces to prepare the leaf extract.

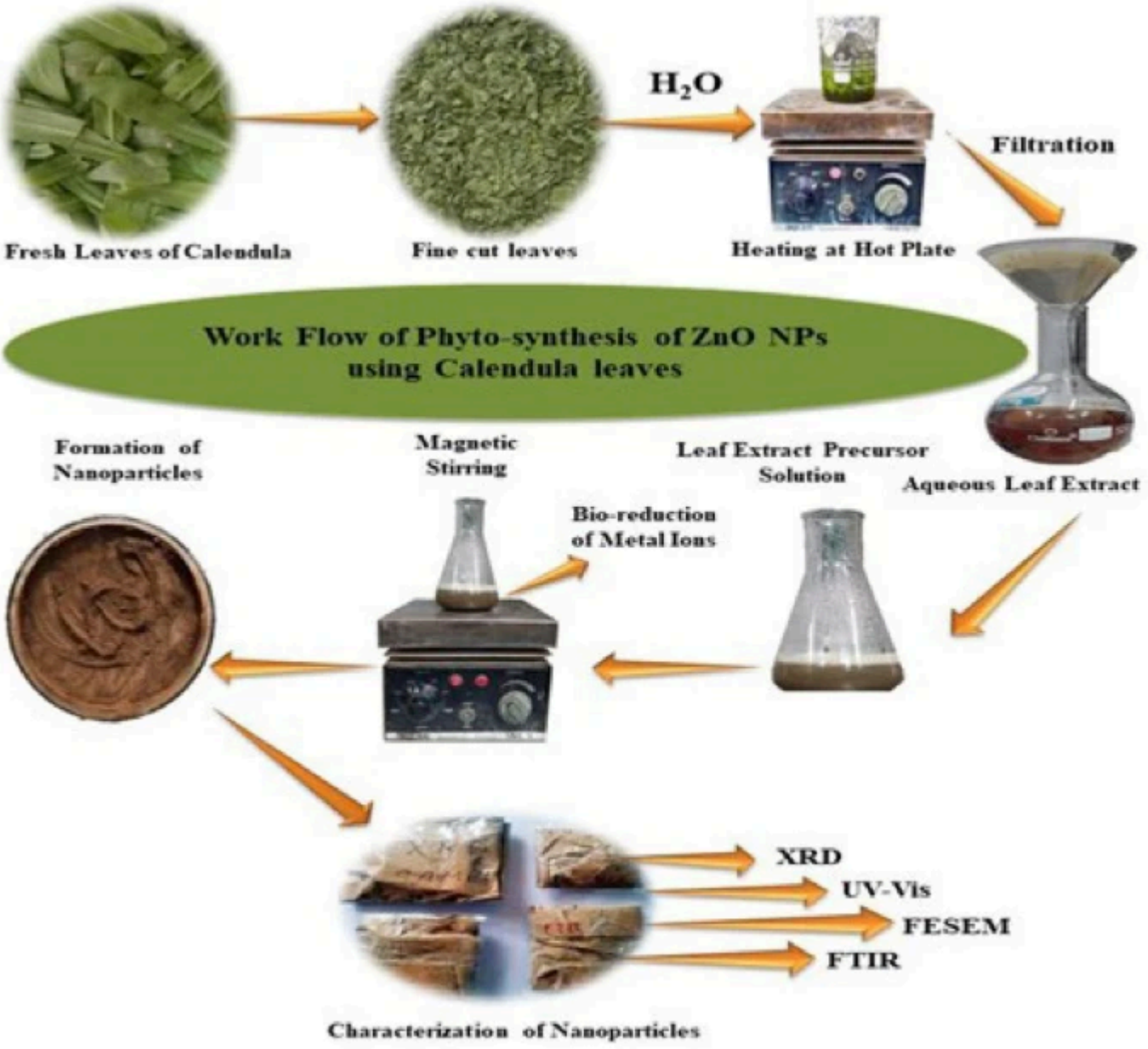
2.3 Preparation of the leaf extract

Chopped *Calendula officinalis* leaves (25 g) were added in 100 ml deionized water and kept on magnetic stirrer for 6 h at 60^0C for 1200 rpm [46]. The aqueous solution was filtered using filter paper and kept for 24 h at 4^0C. The zinc ions which are supportive to form the ZnO NPs, were reduced from the fused aqueous extract and zinc acetate.

2.4 Green synthesis of ZnO NPs

A beaker of *Calendula officinalis* leaf extract (50 ml) was kept on magnetic stirrer (1200 rpm) at 60^0C temperature. The aqueous solution of $ZnC_4H_6O_4.2H_2O$ (0.45 M of 50 ml) was dropped continuously and stirring it for two hours with constant stirring (1200 rpm). The colour of the reaction mixture started converting in to brown precipitate. The resulting precipitate was centrifuged at 6000 rpm for 15 min. It was washed twice with deionized water before spending the entire night at 100^0C [47]. Figure 1 shows the systematic procedure of synthesis of ZnO NPs.

Fig. 1



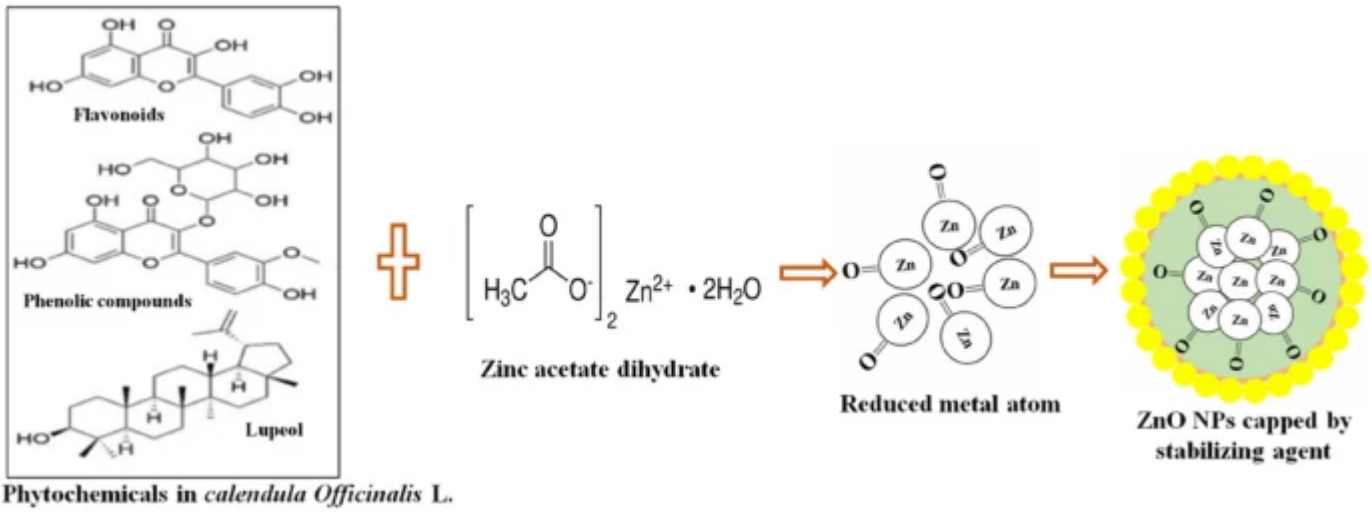
Flow diagram of synthesis of ZnO NPs using leaf extract of *Calendula officinalis*

2.4.1 Mechanism for the green synthesis of ZnO NPs

Phytochemicals in plant extracts can reduce metal precursors to nanoparticles, acting as both reducing and stabilizing agents. *Calendula officinalis* leaf extract contains numerous phytochemicals including triterpenes, Flavonoids, Phenolic compounds, coumarins, and carotenoids, which play a significant role in the reduction of metal ions. The concentration of these phytochemical reducing agents varies in different plant extracts, significantly influencing the composition of leaf extract in the process of the formation of nanoparticles. Apart from it various factor such as pH, temperature, contact time, metal salt concentration, and the phytochemical profile of the plant extract impact the synthesis, stabilization, and quantity of nanoparticles produced. Jaychandran et al. [48] suggested that metal ions undergo encapsulation with an organic covering in three steps for stabilization after reduction by plant extracts: 1) Activation phase,

involving metal ion reduction and nucleation, 2) Growth phase, ensuring nanoparticle stability, 3) Termination phase, determining the shape of nanoparticles. Metals like copper, silver, gold, titanium, zinc, iron, and nickel form metal oxides through phytochemical activity. Phytochemicals enable metal ions to reach growth and stabilization, ultimately linking metal ions and defining their shape [48]. The clear cut mechanism of green synthesis of ZnO NPs using *calendula officinalis* leaf extract, is represented in Fig. 2.

Fig. 2



Mechanism for the synthesis of ZnO NPs using *Calendula officinalis* leaf extract

2.5 Spectroscopic investigation of ZnO NPs

2.5.1 X-Ray powdered diffraction (XRD) analysis

The X-Ray powder diffraction technique was used to investigate the crystalline structure, size and formation of the compounds. ZnO NPs which were synthesized via the green route using *Calendula officinalis* leaf extract were analyzed using single crystal X-Ray Diffractometer (Rikagu, Ultima IV Japan) with Cu-Kα radiation (λ = 1.54020 Å). The scanning was done in the region of 2θ from 20° to 70°.

2.5.2 Field emission-scanning electron microscopy (FE-SEM)

The surface morphology of synthesized ZnO NPs were further analyzed by FE-SEM (JEOL India Pvt. Ltd., Delhi India) for superficial phenotype. A very small amount of nano-powder was kept on the carbon coated copper grid, and then FE-SEM grid was dried with a fine layer of sample and fixed with gold for 5 min.

2.5.3 Fourier transform infra-red (FT-IR) spectroscopy

The Perkin-Elmer Bucking Hamashire, UK FT-IR spectroscopy was used to investigate bond and functional groups existing in the green synthesized ZnO NPs. During the analysis, the band and fictional group were identified by using FT-IR spectra with a resolution of 4.0 cm^{-1} in order to 4000–450 cm^{-1}.

2.5.4 Ultraviolet–Visible (UV–Vis) spectroscopy

The optical properties of the green synthesized ZnO NPs were investigated using UV–Vis spectroscopy. The shape and size of the synthesized ZnO NPs, affect the sharpness of the absorption peak. In order to check the optical properties of green synthesized ZnO NPs, 0.05 g of ZnO NPs was dispersed in 4 mL of double ionized water. The absorption spectrum was recorded using an UV–Vis spectrophotometer (Spectra Max, San Jose, CA, USA) in a wavelength range of 350–460 nm.

2.6 Free radical scavenging activity

Brand William conducted a comprehensive investigation into the free radical scavenging activity of ZnO nanoparticles (NPs) synthesized through green methods, with adaptations made to the protocol outlined by a prior study [49]. The 2, 2-diphenyl-1-picrylhydrazyl (DPPH) radical, known for its stable purple color and characteristic absorption peak at 517 nm, served as the substrate for this assessment. Upon exposure to antioxidants present in the medium, the purple hue of DPPH underwent a discernible transition to transparency, indicative of radical scavenging activity. To prepare the solution for the antioxidant assay, 39.44 mg of DPPH was dissolved in 100 ml of methanol, yielding a concentration of 0.14 mM. Similarly, stock solutions of green-synthesized ZnO NPs and standard ascorbic acid were prepared in methanol, followed by appropriate dilutions to achieve the desired working concentrations. Ascorbic acid, employed as the standard, underwent evaluation at concentrations spanning 2–6 μg/ml to establish a calibration curve. In a controlled environment within a darkened laboratory, 140 μl of freshly prepared 1 mM DPPH was combined with 860 μl of test samples. To minimize the influence of ambient light, all test tubes were carefully wrapped in aluminum foil. A comparative analysis was conducted using a control sample comprising 1 ml of DPPH solution mixed with 3 ml of methanol. Data interpretation involved calculating the percent inhibition of DPPH free radicals relative to the control, with further determination of IC50 values derived from the descending order of test sample readings. This meticulous approach enabled a thorough assessment of the antioxidant potential of the green-synthesized ZnO NPs and facilitated valuable insights into their free radical scavenging capabilities. The percentage of scavenging free radical values was calculated by the following formula-[50]

$$\% {\mathbf{Radicals}}\,\,{\mathbf{cavenging}}\,\,{\mathbf{activity}} = \frac{{{\text{Absorbance of blank}} - {\text{absorbance of sample}}}}{{{\text{Absorbance of blank}}}} \times 100$$

2.6.1 Antioxidant radical power

The antioxidant radical power of the green synthesized ZnO NPs and Ascorbic acid can be evaluated by the given formula [51]

$$\text{ARP}=\frac{1}{{\text{EC}}_{50}}$$

(1)

2.7 Antibacterial activities

The antibacterial assessment employed the widely recognized disc diffusion method to discern the efficacy of green-synthesized ZnO nanoparticles (NPs) against three distinct bacterial strains: *Staphylococcus aureus* (Gram positive), *Escherichia coli* (Gram negative), and *Klebsiella pneumoniae* (Gram negative). These bacterial strains represent diverse microbial morphologies and pathogenic profiles, allowing for a comprehensive evaluation of the nanoparticles' antibacterial potential across different bacterial types. Prior to testing, the green-synthesized ZnO NPs were meticulously dissolved in dimethyl sulfoxide (DMSO) to facilitate the creation of standardized stock solutions, ensuring consistency and accuracy in subsequent analysis. This step is crucial in maintaining the stability and reproducibility of the experimental conditions, thereby enhancing the reliability of the results obtained. In a controlled laboratory environment, cultures of the respective bacterial strains were inoculated into separate batches of nutrient broth and then subjected to an incubation period of 12 h at 37°C. This incubation duration allows for optimal bacterial growth, ensuring that the cultures reach a logarithmic phase of growth before further experimentation. Following incubation, 100 μL of each bacterial culture was uniformly spread onto sterile Muller-Hinton agar (MHA) plates using sterile swabs. The choice of MHA as the growth medium is deliberate, as it provides a standardized and optimal environment for bacterial growth, enabling accurate assessment of antibacterial activity. Subsequently, discs impregnated with varying concentrations (50, 75, and 100 μg/ml) of green-synthesized ZnO NPs were carefully placed onto the agar plates, with sterile water discs serving as negative controls. This setup allows for the assessment of dose-dependent antibacterial effects, elucidating the relationship between NP concentration and inhibitory activity. The plates were then incubated at 37°C for a period of 24 h to allow for bacterial growth and subsequent assessment of inhibition zones [47]. The formation of clear zones of inhibition around the NP-loaded discs indicates the antibacterial activity of the synthesized nanoparticles against the respective bacterial strains. To ensure the reliability and robustness of the experimental data, each

assay was performed in triplicate, minimizing experimental variability and enhancing the statistical significance of the findings [47]. The inhibition zone diameters were meticulously measured, and the data were expressed as mean values ± standard deviation, providing a comprehensive understanding of the antibacterial efficacy of the green-synthesized ZnO NPs.

3 Results and discussion

3.1 X-ray diffraction analysis of green synthesized ZnO NPs

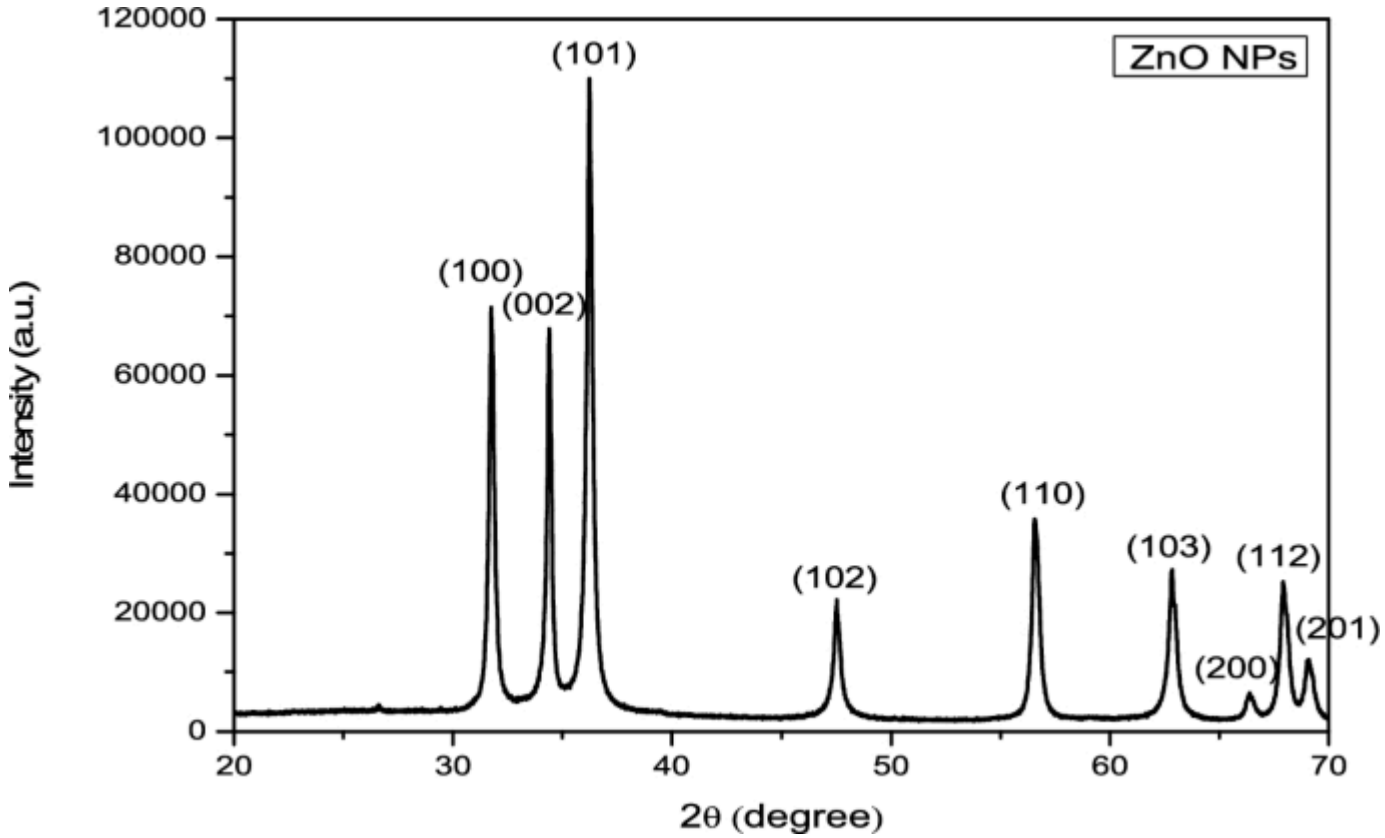
The recorded X-ray diffraction pattern shows the phase and crystallinity of the produced ZnO NPs. The produced ZnO NPs XRD patterns are displayed in Fig. 3. Lattice planes (hkl) of (100), (002), (101), (110), (200), (112), and (201) could be responsible for the diffraction peaks at 31.6^0, 34.3^0, 36.1^0, 47.4^0, 56.4^0, 62.7^0, 66.2^0, 67.8^0, and 69^0 (Table 1) for the hexagonal wurtzite ZnO phase (JCPDS-file: 36–1451) [52]. Furthermore, the complete conversion of the Zn precursor into ZnO NPs is shown by the lack of an impurity peak in the diffraction pattern. *Calendula officinalis* leaf extracts phenols and flavonoids work as reducing agents and shield the zinc acetate molecule's outermost surface, they promote the development of ZnO NPs. Diffraction peaks that are both conspicuous and narrow indicate that the product's particles have a distinct crystalline structure. The strong peak intensity indicates the high crystalline nature of the produced ZnO NPs. The Debye-Scherer equation is used to further estimate the diameter of the produced ZnO NPs [53].

$$D=\frac{K\lambda }{\beta Cos\theta }$$

(2)

where: D = Average crystallite size of the particles, K = Debye-Scherer's constant (= 0.94), λ = Wavelength of the Cu Kα-radiation (= 0.1540 nm), β = Full width at half maximum (FWHM) in radian, θ = Bragg's diffraction angle.

Fig. 3



XRD pattern of green synthesized ZnONPs

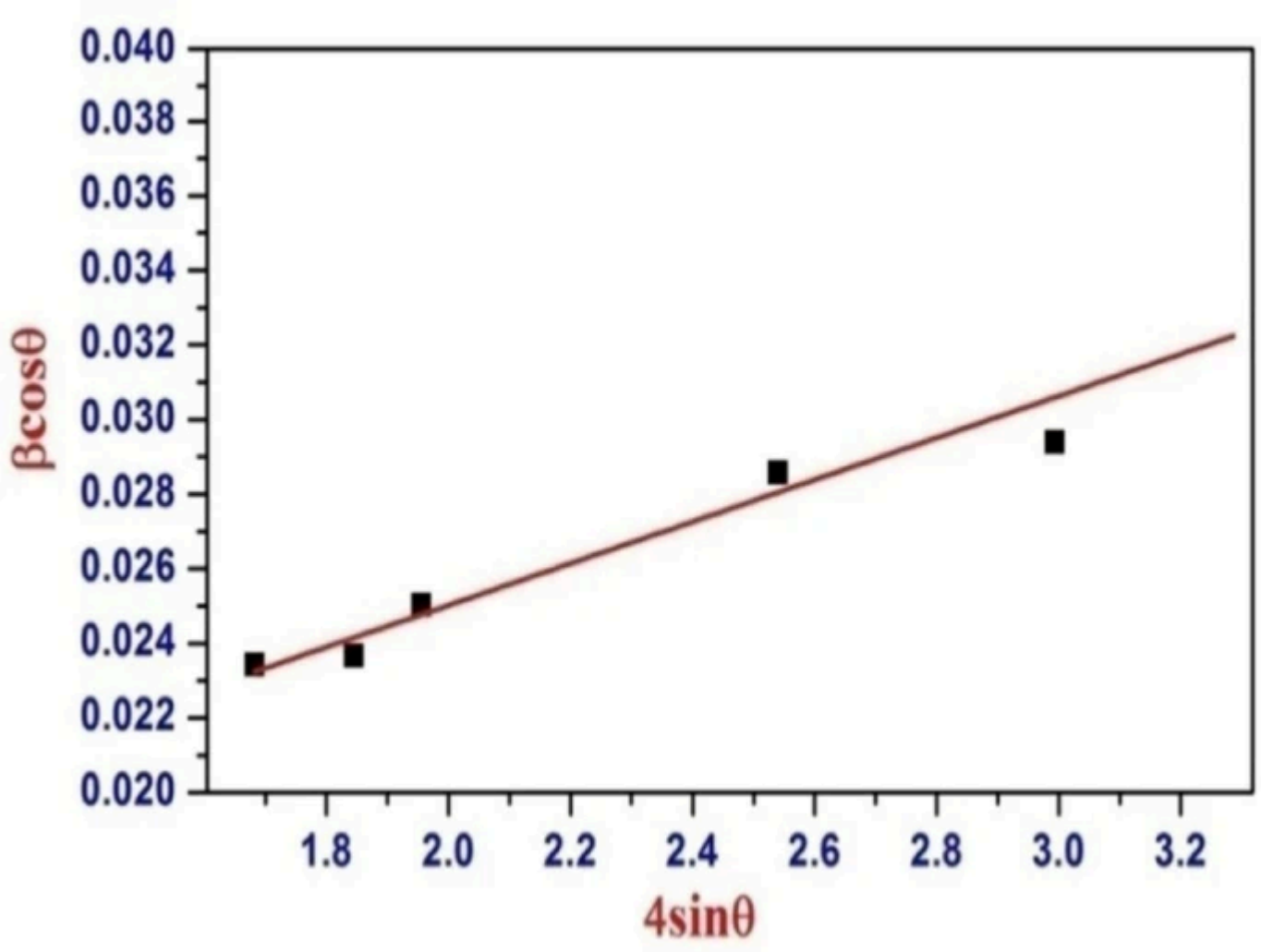
Table 1 XRD analysis at various diffraction angles

The XRD analysis proves that the *Calendula officinalis* leaves are the effective reducing agents for the green synthesis of ZnO NPs.

The FWHM of the most intense peak, which corresponded to the (101) plane located at 36.1°, was used to compute the crystallite diameter of the generated ZnO NPs, which came out to be 28.23 nm. ZnO NPs were found to have a well-crystalline character and a hexagonal wurtzite crystal structure. After calculations, it was discovered that the lattice has dimensions of (a = b) = 3.2535 Å and (c = 5.2151 Å).

The change in crystallographic properties can also be understood with the help of W–H plot between βCosθ versus 4Sinθ. Figure 4 depict W–H plots from mathematical relations-

Fig. 4



Williamson-Hall (W–H) Plot for green synthesized ZnO NPs

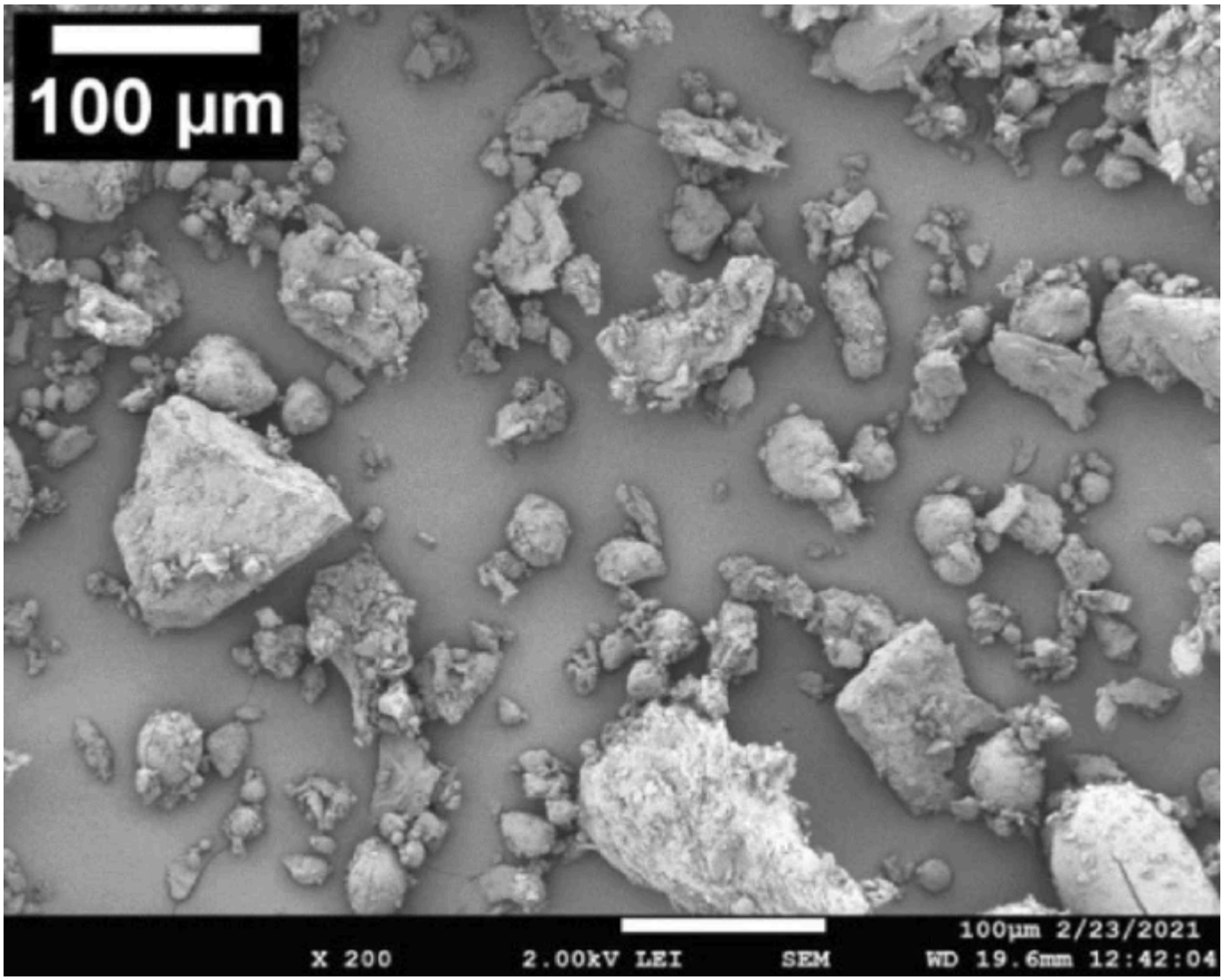
$\beta Cos\theta = \frac{k\lambda }{D}+4\mu_s Sin\theta$ (2).

Strain is determined from the slope of straight line. The values of micro-strain have been calculated and found to be 0.00451. The reciprocal of intercept reveals the grain size of the sample. The variations of grain sizes calculated from both Debye-Scherer's as well as W–H plot are approximately the same.

3.2 FE-SEM analysis of green synthesized ZnO NPs

The generated ZnO NPs FE-SEM images are displayed in Fig. 5. The surface morphology displays the aggregated particulates. FE-SEM provides the microstructure and surface morphology of samples and XRD provides the sample's crystallite size. From FE-SEM image of ZnO NPs, it is revealed that most of the particles are spherical in shape. Surface morphology also provides evidence that ZnO NPs were formed in their agglomerated state [54]. The microstructures have varying sizes, as seen by the FE-SEM image (Fig. 5).

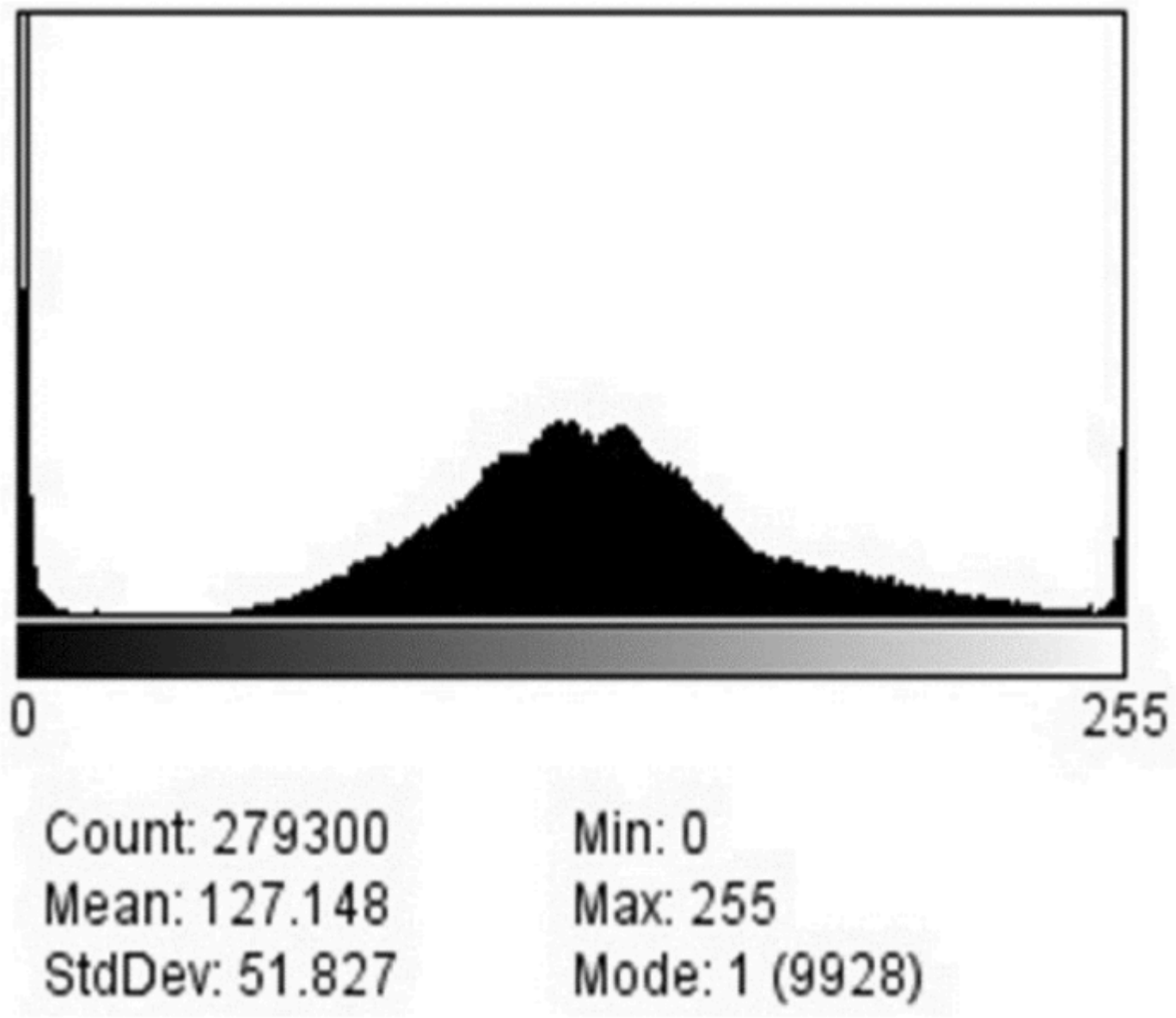
Fig. 5



FE-SEM micrographs of green synthesized ZnO NPs

The histogram of the FE-SEM image is formed by IMAGE-J software. The histogram gives statistics about the distribution of pixel values in the whole image. Histogram of FE-SEM images is made by IMAGE-J. The software program Image J (version 1.46r) was used for FE-SEM image analysis. The observed standard deviations and mean deviations of ZnO NPs using Image-J software were found to decrease with increasing the magnification from × 200 to × 1100 (Fig. 6). The standard deviation (51.287) revealed that pixels spread out around the mean of the crystallite of ZnO NPs. The mean deviation (127.148) was measured as the closest alternative to the standard deviation.

Fig. 6



Histogram of SEM images by IMAGE-J gives the information of microstructure particle distribution in the pixel values

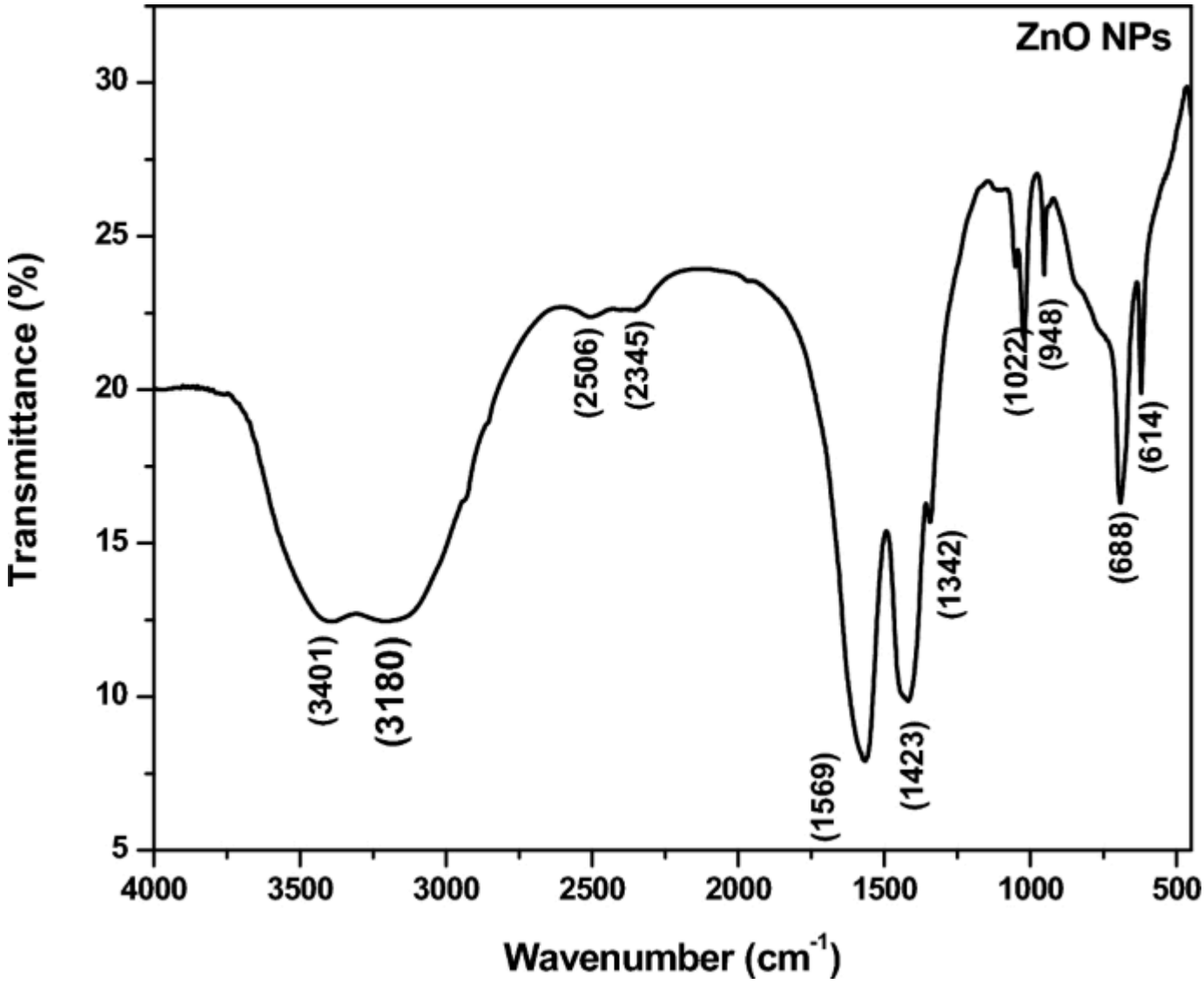
Thus, the instability of the FE-SEM micrograph was expressed as the significance of the standard deviation. The observed irregular-shaped nanoparticles in FE-SEM images indicated that green synthesized nanoparticles using leaf extract contained a large volume-to-surface ratio. The histogram of the FE-SEM image showed that the ZnO NPs at different magnifications had a uniform particle size distribution on the surface of the cluster.

3.3 FT-IR analysis of green synthesized ZnO NPs

Figure 7 shows the FT-IR spectrum of the green synthesized ZnO NPs. From the spectrum it is clear that the compositional and functional groups are present in the green synthesized ZnO NPs. The spectroscopic grade KBr was utilized in the form of a pallet to record the FT-IR spectrum in the wave number range of 4000–500 cm^{-1} in the different reflectance modes. FT-IR spectrum has

shown the numerous bands at various absorption peaks (Table 2, Fig. 7) which are similar to the ones earlier reported [55, 56]. To be more precise, an extensive band at 3401 cm^{-1} is assigned to the O–H stretching mode of the hydroxyl group present in the green synthesized ZnO NPs. The peak of 3080 cm^{-1} is due to the C-H stretching vibration of alkenes functional groups. The peaks detected in spectrum (Fig. 7) at 2345 cm^{-1} assign the C = C alkane/C = N stretching.

Fig. 7



FT-IR spectra of green synthesized ZnO NPs

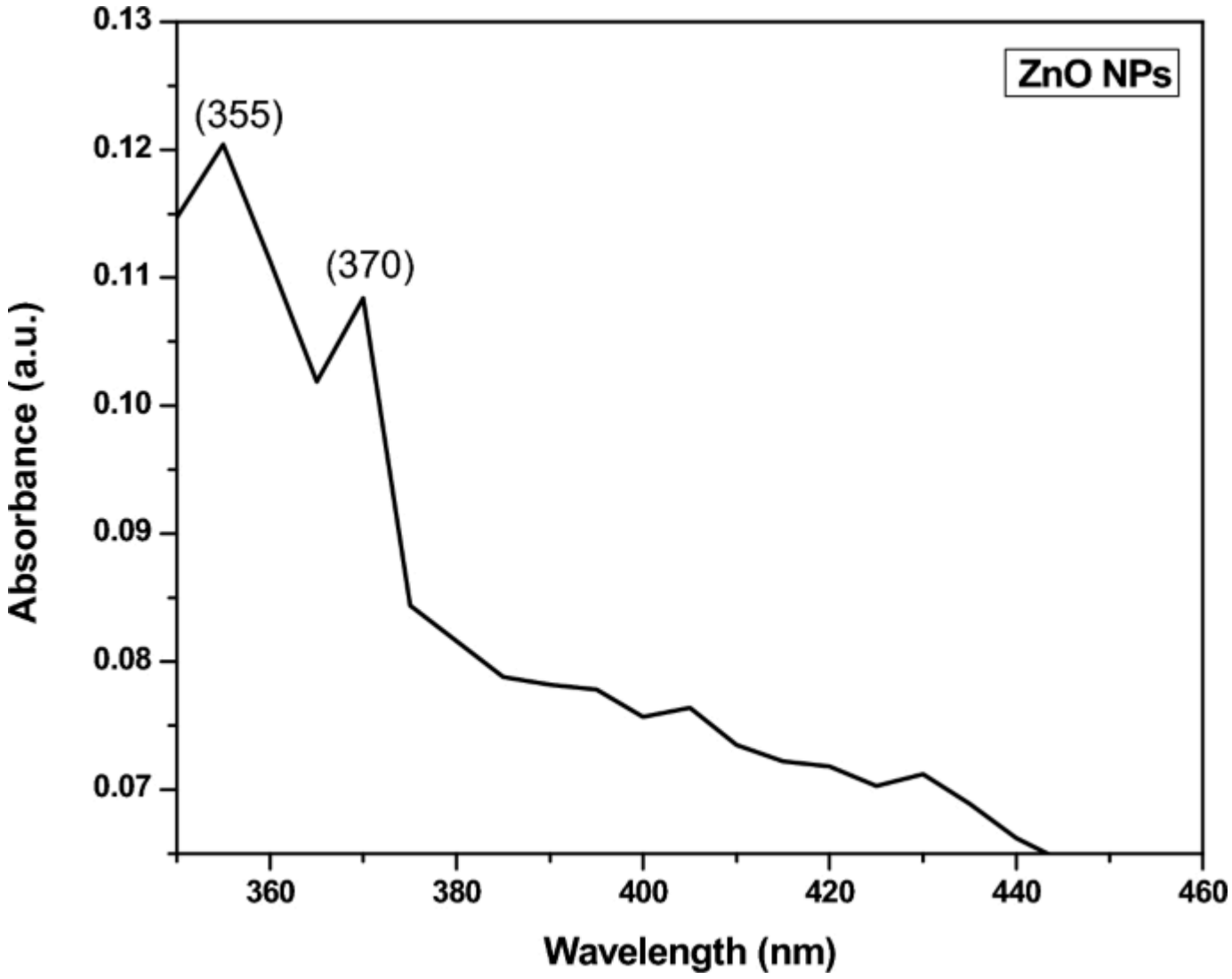
Table 2 Bond and functional group present in FTIR spectra

However, the peak at the 1569 cm^{-1} is assigned to the (N–H) stretching of the amine functional group and 1423 cm^{-1} is assigned to the (C-O), C-F, alkyl halide strong groups present in the green synthesized ZnO NPs. Probably 1022 cm^{-1}, 948 cm^{-1}, 773 cm^{-1}, 688 cm^{-1} is assigned the C-N stretching amine functional group which are present synthesized ZnO NPs [57]. The FT-IR spectrum confirms the formation of chemical bonding due to functional groups present in the green synthesized ZnO NPs.

3.4 UV–Visible analysis of green synthesized ZnO NPs

The leaves extract not only acts as a reducing agent but also a stabilizing agent. The zinc ions are reduced in the zinc oxide solution by the secondary metabolite of the plants. This was studied by taking the UV-Vis spectrum in between 350 nm and 460 nm. Figure 8 showed the absorption spectrum of green synthesized ZnO NPs. Two strong absorption peaks were visualized at 355 nm and 370 nm which confirmed the formation of ZnO at nanoscale [58]. For the formation of ZnO NPs, the absorbance peak was found in the previous report in the range of 300–360 nm [59]. The smaller size particles were also visualized at FE-SEM image (Fig. 5) that also supported the above statement and bump around 370 nm. This was because of more interaction of Zn ions with secondary metabolites. Bioactive constituents of plant extract interacted with the Zn ions and acted as stabilizing as well as abbreviating agents in the reduction of the metal size [60, 61]. The band gap energy was evaluated by equation-

Fig. 8



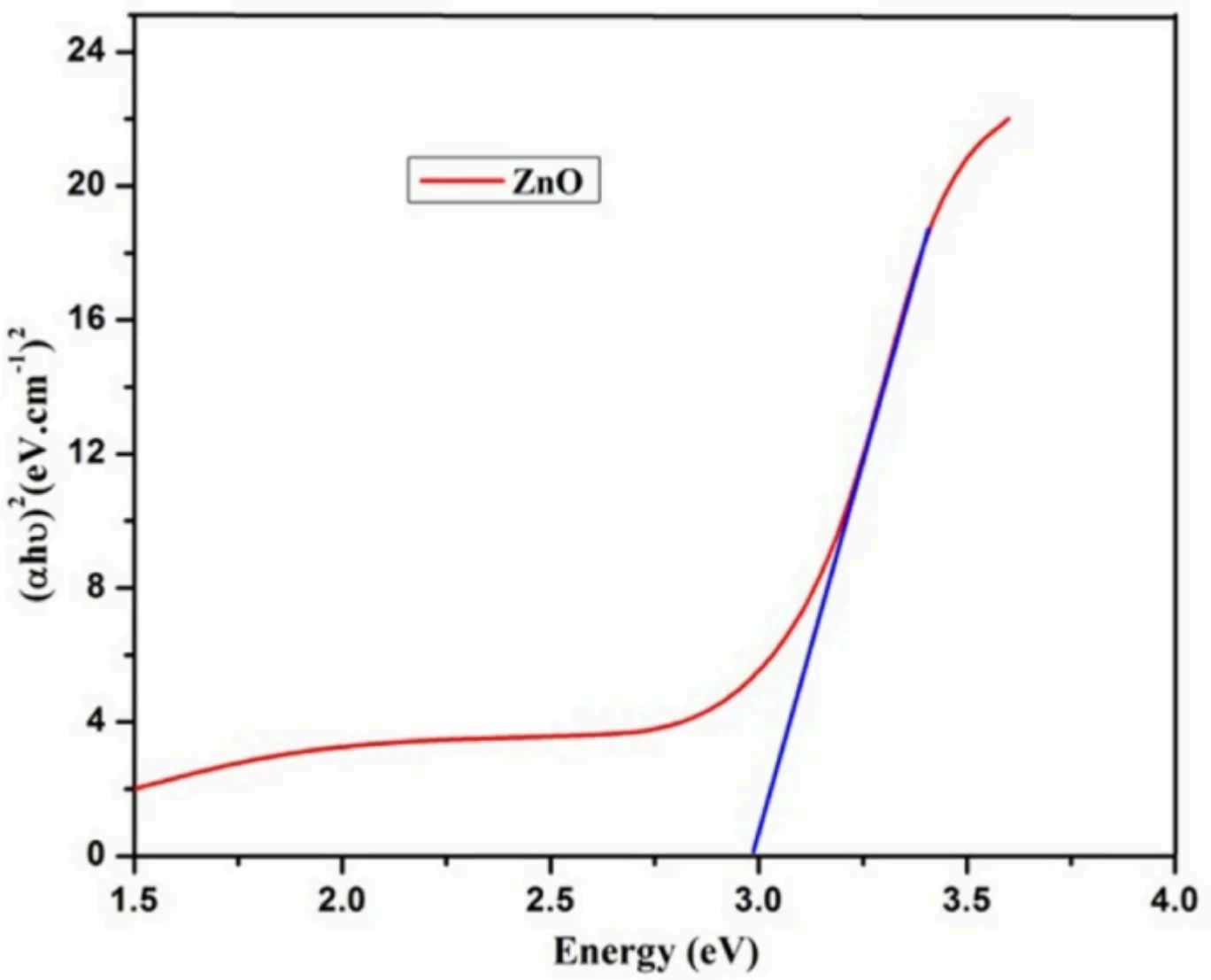
UV–Visible Spectrum of green synthesized ZnO NPs

$${E}_{g}=\frac{1240}{\lambda }eV$$

(3)

The optical band gap energy of green synthesized ZnO NPs were observed 2.986 eV (Fig. 9) which was comparable to the previously reported one [62, 63]. As ZnO is a direct wide band-gap (2.986 eV) semiconductor material at a room temperature, it has gained widespread research interest for a variety of applications such as, optical and opto-electronic devices because of its intriguing features including non-toxicity, non-expensive, large electron mobility and various novel morphological features.

Fig. 9



Optical band gap of green synthesized ZnO NPs

3.5 Free radical scavenging activity:

The evaluation of antioxidant activity entailed assessing the DPPH-mediated free radical scavenging capability of ZnO NPs. DPPH, a stable nitrogen-centered free radical, readily undergoes electron or proton transfer, converting into a stable diamagnetic free radical. Consequently, the purple color of the DPPH solution diminishes in proportion to the electrons received from antioxidant agents like ZnO NPs, resulting in the formation of 1, 1-diphenyl-2-picryl-hydrazine with a light yellowish colour. The remarkable antioxidant prowess of green-synthesized ZnO NPs arises from their ability to transfer electrons from oxygen to the electron density of nitrogen within DPPH, effectively neutralizing its unpaired electron. This electron transfer process engenders an electronegative force, which is particularly pronounced in ZnO NPs and hinges upon the structural configuration and oxygen moiety.A pivotal aspect of green-synthesized NPs lies in the electrostatic interaction between negatively charged bioactive compounds sourced from plant extracts and positively charged metal ions within the NPs. This interaction enhances the antioxidant activity

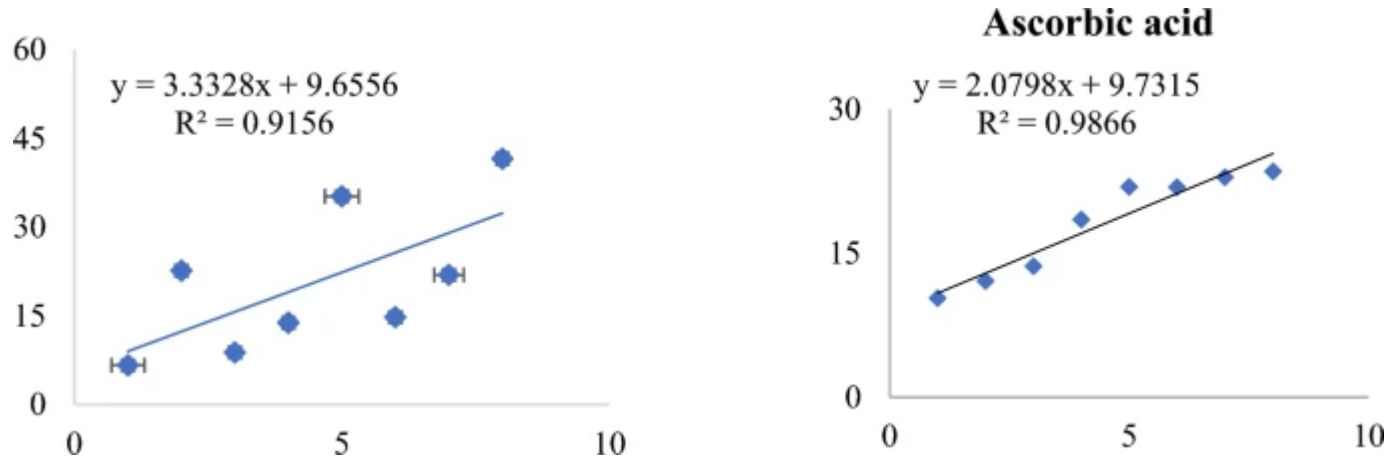
manifold compared to chemically synthesized counterparts. In this context, the IC_{50} value, derived from the mediated antioxidant assay, stands at 6600 µl/ml. Discrepancies in the antioxidant activity of ZnO NPs originating from different sources can be attributed to variations in size and surface characteristics due to the synthesis process and the botanical origins. Previous studies have underscored that smaller-sized ZnO NPs exhibit the highest percentage of radical scavenging activity, a trend paralleled in gold nanoparticles as well. This emphasizes the nuanced interplay between nanoparticles properties and antioxidant efficacy, thereby highlighting the significance of synthesis methodologies and precursor materials in dictating the antioxidant potential of nanomaterials. Over all, the utilization of nano-sized ZnO particles represents a strategic approach to bolstering antioxidant activity through synergistic interactions, enhanced reactivity, and size-dependent effects. In recent study green synthesized dual doped Co–Cu from plant *Tinospora cordifolia* exhibited a remarkable antioxidant activity against DPPH, HO and NO free radicals [64]. In another study Cu-doped hematite nanoparticles was created through green synthesis from the plant *Azadirachta indica* leaves extract used to examine the antioxidant activities and doped hematite nanoparticles contains high amount of free radical scavenging activity against DPPH free radicals [65]. In some advanced study iron oxide nanoparticles (Fe_2O_3-NPs) were synthesized by chemical and green precipitation methods had been tested against photo-catalytic and antioxidant activities was significantly high of green synthesized nanoparticles of *Azadirachta indica* [66].The green synthesized nanoparticles from *A. indica* used to create hematite nanoparticles with varied Co/Cu dopant concentrations. Methyl orange and Methylene blue industrial wastes can be degraded by using Co/Cu doped hematite nanoparticles. It also possessed remarkable photo-catalytic and antioxidant activities [67]. Incorporating these nanoparticles into antioxidant formulations holds immense potential for developing novel therapeutics and functional materials aimed at combating oxidative stress-related diseases and promoting overall health and well-being [68].

3.6 Antioxidant reducing power

The antioxidant values also evaluated in terms of ARP values showed 50% scavenging concentration of both the ascorbic acid and ZnO NPs (Table 3 Fig. 10). Approximately the values of 50% scavenging of free radical are equal to ascorbic acid which showed that the ZnO NPs are also potent scavengers of antioxidants [69]

Table 3 Antioxidant reducing power (ARP)

Fig. 10



Free radical scavenging activity of ZnO NPs and Ascorbic acid against DPPH

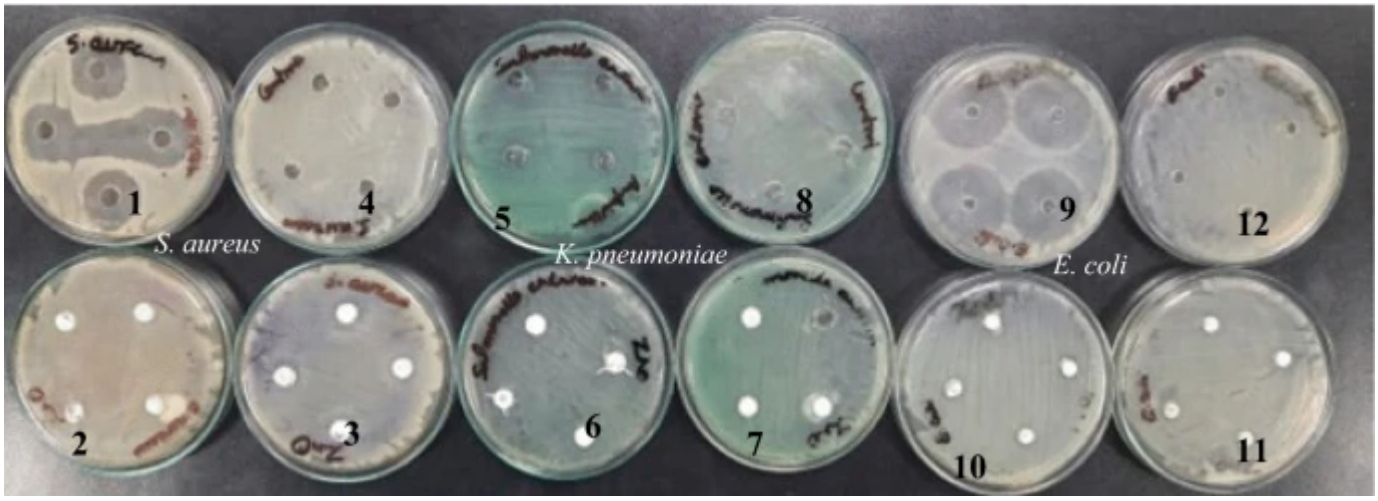
3.7 Antibacterial activity

The antibacterial activities were performed using the disc diffusion method. The disc diffusion method has several limitations such as: 1. It provides primary confirmation of the antibacterial activity but fails to provide accurate cytotoxicity. 2. It is not able to provide the exact minimum inhibitory concentration (MIC) of targeted nanoparticles. 3. It is also not able to depict mechanistic cytotoxicity against the pathogens. Thus our study is only focused to confirm the antibacterial property of ZnO NPs. Apart from these limitations this method have positive approach such as simple, effective and convenient method to check the antibacterial property of a test sample. It also provide effective concentration or lethal concentration (not accurately) of a test sample [70]. The different concentrations of green synthesized ZnO NPs were tested against the pathogenic bacteria, i.e., *S. aureus* (Gram + ve) *E. coli* (Gram -ve), and *K. pneumoniae* (Gram -ve). The green synthesized ZnO NPs were observed against these bacteria, as indicated in Table 4 and Fig. 10. For the standard drug, amoxicillin was taken for reference and for the comparison of the activity of ZnO NPs. Double-distilled water was used as a negative control. ZnO NPs showed maximum inhibition against *Staphylococcus aureus* (35.2 mm ± 0.9) and minimum inhibition against *Klebsiella pneumoniae* (23.6 mm ± 0.1) and *E. coli* (13.5 mm ± 0.1). The efficacy of inhibition percentage is directly proportional to concentration, which means increasing concentration will increase the zone of the diameter [71]. The results reveal that the diameter of the inhibitory zone increases with increasing nanoparticles concentration for all tested strains [71]. It is also observed that the green synthesized ZnO NPs showed better inhibition against Gram + ve in comparison to gram-ve. This may be, the size of nanoparticles was less than 22 nm. which increase its cell membrane penetration property and cause severe cell toxicity (antibacterial property). It is reported that, in

metal oxide nanoparticles such as ZnO NPs, the size of nanoparticles is inversely proportional to effective antibacterial property which means lesser the size of nanoparticles couses more antibacterial property [72] This might be because the cell wall of gram-negative bacteria is more complex than that of gram-positive bacteria [2]. Here, the presence of ZnO NPs leads to damage the cell wall of *S. aureus* (Fig. 11). This effect can be explained by the strong direct interactions with the bacterial membrane surface and antibacterial agents like ZnO NPs. For the ZnO NPs to penetrate the bacteria's cells, the bacteria's membrane has small pores [71]. ZnO NPs cause cell harm by encouraging microorganisms to emit reactive oxygen species once they have broken through a membrane [71]. The antibacterial efficacy can be explained based on literature by free radical formations like singlet oxygen, H_2O_2, hydroxyl radicals, and Zn^{2+} ions which are released from the surface of ZnO NPs and damage the cell wall, they damage DNA, and create pores in the membrane where bacteria's can't survive [72]. UV and visible rays can activate ZnO and form electron–hole pairs (e-/h +). It has also been reported that the presence of both these findings demonstrate that ZnO NPs are hazardous to the tested bacterial strains [73, 74]. This means that they have great potential as an antibacterial agent in commercial and medical settings.

Table 4 Depicting the values of antibacterial analysis

Fig. 11



Bacterial cultures showing the inhibition zones of green synthesized ZnO NPs. against bacteria *S. aureus* (1–3), *K. pneumonia* (5–7) and *E. coli* (9–11) with control (4, 8, 12)

Green synthesized ZnO NPs using *Calendula officinalis* is found more effective than the previous studies. Hence green synthesized ZnO NPs can be utilized effectively in various biomedical applications including skin care, ointment, and cosmetics. The present study is focused on antioxidant and antibacterial analysis of the green synthesized ZnO NPs. The antibacterial assay done against *S. aureus, K. pneumonia,* and *E. coli* pathogenic bacteria which is supported by different researcher (Table 5).

Table 5 Comparative zone of inhibition from previously reported work

Conclusion

Several methods have been introduced to synthesize ZnO NPs, but recently, biological methods have been advanced over physico-chemical approaches due to their lower energy consumption, cost-effectiveness, and eco-friendliness. The present work enlightened the ZnO NPs using an aqueous greenery extract of *Calendula officinalis.* The secondary metabolites of plant extracts provide stabilizing agents for the synthesis. The optical prosperities, stability, structural characteristics, and morphology of the green synthesized ZnO NPs were analyzed. The FE-SEM micrograph showed that most of the synthesized ZnO NPs have a spherical in shape. The crystalline sizes of the synthesized ZnO NPs were evaluated using Debye-Scherer formula along the most intense peaks (101) and found to be 28.23 nm. FT-IR studies clearly showed the oxide of zinc and bioactive photochemical present in the synthesized nanomaterials which indicate the possibility of formation of ZnO NPs pore shell. The optical band gap energy was evaluated 2.986 eV which can be employed in various optical applications. Furthermore, ZnO NPs were analyzed as an antioxidant against DPPH and antibacterial properties against several multidrug resistance pathogens. The antioxidant reducing power (ARP) value of green-synthesized ZnO NPs was found to be less than that of ascorbic acid. However, despite having a lower ARP value, the experimental results indicate that green-synthesized ZnO NPs exhibit more antioxidant properties than the standard drugs. The antimicrobial activity of green-synthesized ZnO NPs against both Gram-positive (*S. aureus*) and Gram-negative bacteria (*K. pneumoniae* and *E. coli*) was positive. The above studies suggested that synthesized ZnO NPs can be employed in various fields including pharmaceuticals, cosmeceuticals, environmental industries, and biomedical applications. This study would be a promising avenue for further research and development.

Data availability

The experimental data and the results that support the findings of this study are available.

References

1. Ananthalakshmi R, Rajarathinam SR, Sadiq AM. Antioxidant activity of ZnO Nanoparticles synthesized using Luffa acutangula peel extract. Res J Pharm Technol. 2019;12(4):1569–72. https://doi.org/10.5958/0974-360X.2019.00260.9.

Article Google Scholar

2. Bhardwaj AK, Sundaram S, Yadav KK, Srivastav AL. An overview of silver nano-particles as promising materials for water disinfection. Environ Technol Innov. 2021;23: 101721. https://doi.org/10.1016/j.eti.2021.101721.

Article Google Scholar

3. Ijaz I, Gilani E, Nazir A, Bukhari A. Detail review on chemical, physical and green synthesis, classification, characterizations and applications of nanoparticles. Green Chem Lett Rev. 2020;13(3):223–45. https://doi.org/10.1080/17518253.2020.1802517.

Article Google Scholar

4. Tiwari AK, Jha S, Singh AK, Mishra SK, Pathak AK, Ojha RP, Dikshit A. Innovative investigation of zinc oxide nanoparticles used in dentistry. Crystals. 2022;12(8):1063. https://doi.org/10.3390/cryst12081063.

Article Google Scholar

5. Ramos AP, Cruz MA, Tovani CB, Ciancaglini P. Biomedical applications of nanotechnology. Biophys Rev. 2017;9(2):79–89. https://doi.org/10.1007/s12551-016-0246-2.

Article Google Scholar

6. Singh MP, Bhardwaj AK, Bharati K, Singh RP, Chaurasia SK, Kumar S, Vikram K. Biogenic and non-biogenic waste utilization in the synthesis of 2D materials (graphene, h-BN, g-C2N) and their applications. Front Nanotechnol. 2021;3:685427. https://doi.org/10.3389/fnano.2021.685427.

Article Google Scholar

7. Bhardwaj AK, Naraian R. Cyanobacteria as biochemical energy source for the synthesis of inorganic nanoparticles, mechanism and potential applications: a review. Biotech. 2021;11(10):445. https://doi.org/10.1007/s13205-021-02992-5.

Article Google Scholar

8. Mittal R, Sharma A, Bhardwaj AK, Bhateria R, Bansal S, Kashyap R, Bhukal S. Removal of chromium (VI) using spirulina assisted synthesized mesoporous iron oxide nanoparticles. Inorg Chem Commun. 2023. https://doi.org/10.1016/j.inoche.2023.110881.

Article Google Scholar

9. Debroy A, Joshi S, Yadav M, George N. Green synthesis of nanoparticles from bio-waste for potential applications: Current trends, challenges, and prospects. Bio-Based Mater Waste Energ Generation Res Manage. 2023. https://doi.org/10.1016/B978-0-323-91149-8.00009-0.

Article Google Scholar

10. Thakur N, Thakur N, Kumar K, Arya V, Kumar A. Encapsulation of Tinospora cordifolia plant in Ni doped TiO2 nanoparticles for the degradation of malachite green dye. Nanofabrication. 2023. https://doi.org/10.37819/nanofab.8.305.

Article Google Scholar

11. Jha AK, Prasad K, Kulkarni AR. Synthesis of TiO2 nanoparticles using microorganisms. Colloids Surfaces B Biointerfaces. 2009;71(2):226–9. https://doi.org/10.1016/j.colsurfb.2009.02.007.

Article Google Scholar

12. Yaraki MT, Zahed Nasab S, Zare I, Dahri M, Moein Sadeghi M, Koohi M, Tan YN. Biomimetic metallic nanostructures for biomedical applications, catalysis, and beyond. Indus Eng Chem Res. 2022;61(22):7547–93. https://doi.org/10.1021/acs.iecr.2c00285.

Article Google Scholar

13. Jain M, Kapadia R, Jadeja RN, Thounaojam MC, Devkar RV and Mishra SH. Traditional uses, phytochemistry and pharmacology of Tecomellaundulata–A review. Asian Pacific Journal of Tropical Biomedicine. 2012; 2 Issue: 3. S1918-S1923.https://doi.org/10.1016/S2221-1691(12)60521-8

14. Umaralikhan L, Jaffar MJM. Green synthesis of ZnO and Mg doped ZnO nanoparticles, and its optical properties. J Mater Sci Mater Electron. 2017;28:7677–85. https://doi.org/10.1007/s10854-017-6461-1.

Article Google Scholar

15. Ijaz M, Zafar M, Islam A, et al. A review on antibacterial properties of biologically synthesized zinc oxide nanostructures. J Inorg Organomet Polym. 2020;30:2815–26. https://doi.org/10.1007/s10904-020-01603-9.

Article Google Scholar

16. Khanuja M, Uma Varma A. Synthesis and Characterization of Pure and Doped ZnO Nanostructures for Antimicrobial Applications: Effect of Dopant Concentration with Their Mechanism of Action. In: Ghorbanpour, M., Manika, K., Varma, A. (eds) Nanoscience and Plant–Soil Systems. Soil Biology, vol 48. Springer, Cham. 2017; https://doi.org/10.1007/978-3-319-46835-8_6

17. Thakur N, Kumar A, Thakur N. Tinospora cordifolia and polyvinylpyrrolidone encapsulated dual doped Ni-Cu TiO2 emerging nanocatalyst for the removal of organic dyes from wastewater and its free radical assay activity. Hybrid Adv. 2023;4: 100086. https://doi.org/10.1016/j.hybadv.2023.100086.

Article Google Scholar

18. Kumar P, Thakur N, Tapwal A, Kumar S. Enhancing the adsorption capacity of green/chemical synthesized hematite nanoparticles by copper doping: removal of toxic Congo red dye and antioxidant activity. Appl Nanosci. 2023;13(9):6591–604. https://doi.org/10.1007/s13204-023-02943-x.

Article Google Scholar

19. Jiang J, Pi J, Cai J. The advancing of zinc oxide nanoparticles for biomedical applications. Bioinorg Chem Appl. 2018;2018:1–18. https://doi.org/10.1155/2018/1062562.

Article Google Scholar

20. El-Fallal AA, Elfayoumy RA, El-Zahed MM. Antibacterial activity of biosynthesized zinc oxide nanoparticles using Kombucha extract. SN Appl Sci. 2023;5:332. https://doi.org/10.1007/s42452-023-05546-x.

Article Google Scholar

21. Sirelkhatim A, Mahmud S, Seeni A, Kaus NHM, Ann LC, Bakhori SKM, Mohamad D. Review on zinc oxide nanoparticles: antibacterial activity and toxicity mechanism. Nano-micro Lett. 2015;7:219–42. https://doi.org/10.1007/s40820-015-0040-x.

Article Google Scholar

22. Ajitha B. Reddy, Y.A.K. Reddy, P.S. Jeon, H.J. and Ahn C.W.(2016). Role of capping agents in controlling silver nanoparticles size, antibacterial activity and potential application as optical hydrogen peroxide sensor. RSC advances. 6(42): 36171–36179. https://doi.org/10.1039/C6RA03766F

23. Tari O, Aronne A, Addonizio ML, Daliento S, Fanelli E, Pernice P. Sol–gel synthesis of ZnO transparent and conductive films: a critical approach. Solar Energ Mater Solar Cells. 2012;105:179–86. https://doi.org/10.1016/j.solmat.2012.06.016.

Article Google Scholar

24. Cao W, Zhang Y, Wang X, Li Q, Xiao Y, Li P, Xing X. Novel resin-based dental material with anti-biofilm activity and improved mechanical property by incorporating hydrophilic cationic copolymer functionalized nano-diamond. J Mater Sci Mater Med. 2018;29(10):1–13. https://doi.org/10.1007/s10856-018-6172-z.

Article Google Scholar

25. Bala N, Saha S, Chakraborty M, Maiti M, Das S, Basu R, Nandy P. Green synthesis of zinc oxide nanoparticles using Hibiscus subdariffa leaf extract: effect of temperature on synthesis, anti-bacterial activity and anti-diabetic activity. RSC Adv. 2015;7(5):4993–5003. https://doi.org/10.1039/C4RA12784F.

Article Google Scholar

26. Verma R, Dwivedi GK, Singh JP, Singh AP, Tamta N, Kumar A. Characterization of synthesized zinc oxide nanoparticles and their effect on growth, productivity and zinc use efficiency of wheat and field pea in the Indian Himalayan foothills. Curr Sci. 2023. https://doi.org/10.18520/cs/v124/i11/1319-1328.

Article Google Scholar

27. Mishra SK, Srivastava RK, Prakash SG. ZnO nanoparticles: Structural, optical and photoconductivity characteristics. J Alloys Compounds. 2012;539:1–6. https://doi.org/10.1016/j.jallcom.2012.06.024.

Article Google Scholar

28. Jha AK, Prasad K, Prasad K, Kulkarni AR. Plant system: nature's nanofactory. Colloids Surf B. 2009;73(2):219–23. https://doi.org/10.1016/j.colsurfb.2009.05.018.

Article Google Scholar

29. Pantidos N, Horsfall LE. Biological synthesis of metallic nanoparticles by bacteria, fungi and plants. J Nanomed Nanotechnol. 2014;5(5):1. https://doi.org/10.4172/2157-7439.1000233.

Article Google Scholar

30. Mittal AK, Chisti Y, Banerjee UC. Synthesis of metallic nanoparticles using plant extracts. Biotechnol Adv. 2013;31(2):346–56. https://doi.org/10.1016/j.biotechadv.2013.01.003.

Article Google Scholar

31. Sangeetha G, Rajeshwari S, Venckatesh R. Green synthesis of zinc oxide nanoparticles by aloe barbadensis miller leaf extract: structure and optical properties. Mater Res Bull. 2011;46(12):2560–6. https://doi.org/10.1016/j.materresbull.2011.07.046.

Article Google Scholar

32. Chemingui H, Moulahi A, Missaoui T, Al-Marri AH, Hafiane A. A novel green preparation of zinc oxide nanoparticles with Hibiscus sabdariffa L.: photocatalytic performance, evaluation of antioxidant and antibacterial activity. Environ Technol. 2024;45(5):926–44. https://doi.org/10.1080/09593330.2022.2130108.

Article Google Scholar

33. Naiel B, Fawzy M, Halmy MWA, Mahmoud AED. Green synthesis of zinc oxide nanoparticles using Sea Lavender (Limonium pruinosum L. Chaz) extract: characterization, evaluation of anti-skin cancer, antimicrobial and antioxidant potentials. Sci Rep. 2022;12(1):20370. https://doi.org/10.1038/s41598-022-24805-2.

Article Google Scholar

34. Chemingui H, Missaoui T, Mzali JC, Yildiz T, Konyar M, Smiri M, Yatmaz HC. Facile green synthesis of zinc oxide nanoparticles (ZnO NPs): antibacterial and photocatalytic activities. Mater Res Express. 2019;6(10):10504. https://doi.org/10.1088/2053-1591/ab3cd6.

Article Google Scholar

35. Yang Z, Xie C. Zn2+ release from zinc and zinc oxide particles in simulated uterine solution. Colloids Surf B Biointerfaces. 2006;47(2):140–5. https://doi.org/10.1016/j.colsurfb.2005.12.007.

Article Google Scholar

36. Datta A, Patra C, Bharadwaj H, Kaur S, Dimri N, Khajuria R. Green synthesis of zinc oxide nanoparticles using parthenium hysterophorus leaf extract and evaluation of their antibacterial properties. J Biotechnol Biomater. 2017;7(3):271–6. https://doi.org/10.4172/2155-952X.100027.

Article Google Scholar

37. Karam ST, Abdulrahman AF. Green synthesis and characterization of ZnO nanoparticles by using thyme plant leaf extract. Photonics. 2022. https://doi.org/10.3390/photonics9080594.

Article Google Scholar

38. Ramesh M, Anbuvannan M, Viruthagiri GJSAPAM. Green synthesis of ZnO nanoparticles using Solanum nigrum leaf extract and their antibacterial activity. Spectrochim Acta Part A Mol Biomol Spectr. 2015;136:864–70. https://doi.org/10.1016/j.saa.2014.09.105.

Article Google Scholar

39. Upadhyaya H, Shome S, Sarma R, Tewari S, Bhattacharya MK, Panda SK. Green synthesis, characterization and antibacterial activity of ZnO nanoparticles. Am J Plant Sci. 2018;9(6):1279–91. https://doi.org/10.4236/ajps.2018.96094.

Article Google Scholar

40. Sadiq H, Sher F, Sehar S, Lima EC, Zhang S, Iqbal HM, Nuhanović M. Green synthesis of ZnO nanoparticles from SyzygiumCumini leaves extract with robust photocatalysis applications. J Mol Liquids. 2021;335:116567. https://doi.org/10.1016/j.molliq.2021.116567.

Article Google Scholar

41. Thema FT, Manikandan E, Dhlamini MS, Maaza MJML. Green synthesis of ZnO nanoparticles via Agathosmabetulina natural extract. Mater Lett. 2015;161:124–7. https://doi.org/10.1016/j.matlet.2015.08.052.

Article Google Scholar

42. Butnariu M, Coradini CZ. Evaluation of biologically active compounds from *Calendula officinalis* flowers using spectrophotometry. Chem Central J. 2012;6:1–7. https://doi.org/10.1186/1752-153X-6-35.

Article Google Scholar

43. Perveen R, Shujaat S, Qureshi Z, Nawaz S, Khan MI, Iqbal M. Green versus sol-gel synthesis of ZnO nanoparticles and antimicrobial activity evaluation against panel of pathogens. J Mater Res Technol. 2020;9(4):7817–27. https://doi.org/10.1016/j.jmrt.2020.05.004.

Article Google Scholar

44. Wood M. The book of herbal wisdom: using plants as medicines. North AtlantiBooks. 2017. https://www.google.co.in/books/edition/The_Book_of_Herbal_Wisdom/Czw-DwAAQBAJ?hl=en&gbpv=0

45. Medina EJ, Angel LG, Paco L, Algarra I, Collado A, Garrido F. A new extract of the plant *Calendula officinalis* produces a dual in vitro effect. Cytotoxic anti-tumor activity and lymphocyte activation. BMC Cancer. 2006;6:1–4. https://doi.org/10.1186/1471-2407-6-119.

Article Google Scholar

46. Shahen MZ, Mahmud S, Rony MH, Sohana SN, Imran MAS, Al Maruf MA, Alam MS. Effect of antibiotic susceptibility and inhibitory activity for the control of growth and survival of microorganisms of extracts of Calendula officinalis. Eur J Med Health Sci. 2019;1(1):1–9.

Google Scholar

47. Tiwari AK, Jha S, Agrawal R, Mishra SK, Pathak AK, Singh AK, Awasthi RR. Anti-bacterial efficacy of phyto-synthesized zinc oxide nanoparticles using Murraya paniculata l. leaf extract. Sciences. 2022;13(4):864–71.

Google Scholar

48. Jayachandran A, Aswathy TR, Nair AS. Green synthesis and characterization of zinc oxide nanoparticles using Cayratiapedata leaf extract. Biochem Biophys Rep. 2021;26: 100995. https://doi.org/10.1016/j.bbrep.2021.100995.

Article Google Scholar

49. Kumar MP, Suresh D, Nagabhushana H, Sharma SC. Beta vulgaris aided green synthesis of ZnO nanoparticles and their luminescence, photocatalytic and antioxidant properties. Eur Phys J Plus. 2015;130(6):109. https://doi.org/10.1140/epjp/i2015-15109-2.

Article Google Scholar

50. Tripathi SK, Jha S, Dikshit A, Kumar R. Phytochemical and antioxidant assay of Ecliptaalba (L.) leaf extract. Int J Pharm Sci Res. 2021;12(4):2288–95.

Google Scholar

51. Benmehdi H, Behilil A, Memmou F, Amrouche A. Free radical scavenging activity, kinetic behaviour and phytochemical constituents of Aristolochiaclematitis L. roots. Arab J Chem. 2017;10:S1402–8. https://doi.org/10.1016/j.arabjc.2013.04.015.

Article Google Scholar

52. Mydeen SS, Kumar RR, Kottaisamy M, Vasantha VS. Biosynthesis of ZnO nanoparticles through extract from Prosopis juliflora plant leaf: Antibacterial activities and a new approach by rust-induced photocatalysis. J Saudi Chem Soc. 2020;24(5):393–406. https://doi.org/10.1016/j.jscs.2020.03.003.

Article Google Scholar

53. Muniz FTL, Miranda MR, Morilla dos Santos C, Sasaki JM. The Scherrer equation and the dynamical theory of X-ray diffraction. Acta Crystallographica Sec A Foundation Adv. 2016;72(3):385–90. https://doi.org/10.1107/S205327331600365X.

Article MathSciNet Google Scholar

54. Jha S, Singh R, Tiwari AK, Tripathi SK, Pandey A, Dikshit A. Microbial and physic-chemical analysis of palatable water samples from different localities of Prayagraj district. Biochem Cell Arch. 2021;21(2):5149–59.

Google Scholar

55. Peng X, Palma S, Fisher NS, Wong SS. Effect of morphology of ZnO nanostructures on their toxicity to marine algae. Aquat Toxicol. 2011;102(3–4):186–96. https://doi.org/10.1016/j.aquatox.2011.01.014.

Article Google Scholar

56. Rad SS, Sani AM, Mohseni S. Biosynthesis, characterization and antimicrobial activities of zinc oxide nanoparticles from leaf extract of Mentha pulegium (L.). Microb Pathog. 2019;131:239–45. https://doi.org/10.1016/j.micpath.2019.04.022.

Article Google Scholar

57. Narendra Kumar HK, Chandra Mohana N, Nuthan BR, Ramesha KP, Rakshith D, Geetha N, Satish S. Phyto-mediated synthesis of zinc oxide nanoparticles using aqueous plant extract of Ocimum americanum and evaluation of its bioactivity. SN Appl Sci. 2019;1:1–9. https://doi.org/10.1007/s42452-019-0671-5.

Article Google Scholar

58. Sasani Ghamsari M, Alamdari S, Han W, Park HH. Impact of nanostructured thin ZnO film in ultraviolet protection. Int J Nanomed. 2017. https://doi.org/10.2147/IJN.S118637.

Article Google Scholar

59. Babayevska N, Przysiecka Ł, Iatsunskyi I, Nowaczyk G, Jarek M, Janiszewska E, Jurga S. ZnO size and shape effect on antibacterial activity and cytotoxicity profile. Sci Rep. 2022;12(1):8148. https://doi.org/10.1038/s41598-022-12134-3.

Article Google Scholar

60. Nayagam V, Gabriel M, Palanisamy K. Green synthesis of silver nanoparticles mediated by Coccinia grandis and Phyllanthus emblica: a comparative comprehension. Appl Nanosci. 2018;8:205–19. https://doi.org/10.1007/s13204-018-0739-3.

Article Google Scholar

61. Pai S, Sridevi H, Varadavenkatesan T, Vinayagam R, Selvaraj R. Photocatalytic zinc oxide nanoparticles synthesis using Peltophorumpterocarpum leaf extract and their characterization. Optik. 2019;185:248–55. https://doi.org/10.1016/j.ijleo.2019.03.101.

Article Google Scholar

62. Tan ST, Chen BJ, Sun XW, Fan WJ, Kwok HS, Zhang XH, Chua SJ. Blueshift of optical band gap in ZnO thin films grown by metal-organic chemicalvapor deposition. J Appl Phys. 2005. https://doi.org/10.1016/j.ijleo.2019.03.101.

Article Google Scholar

63. Thakur N, Thakur N. Removal of organic dyes and free radical assay by encapsulating polyvinylpyrrolidone and Tinospora Cordifolia in dual (Co–Cu) doped TiO2 nanoparticles. Environ Pollut. 2023;335: 122229. https://doi.org/10.1016/j.envpol.2023.122229.

Article Google Scholar

64. Kumar P, Thakur N, Tapwal A, et al. Enhancing the adsorption capacity of green/chemical synthesized hematite nanoparticles by copper doping: removal of toxic Congo red dye and

antioxidant activity. Appl Nanosci. 2023;13:6591–604. https://doi.org/10.1007/s13204-023-02943-x.

Article Google Scholar

65. Kumar P, Kumar S, Thakur N. Azadirachta indica and polyvinylpyrrolidone encapsulated Fe2O3 nanoparticles to enhance the photocatalytic and antioxidant activity. Inorg Chem Commun. 2023;155:111084. https://doi.org/10.1016/j.inoche.2023.111084.

Article Google Scholar

66. Kumar P, Kumar S, Tapwal A, et al. Chemical/green synthesized cobalt/copper-doped α-Fe2O3 nanoparticles: potential for environmental remediation. J Mater Res. 2024;39:836–49. https://doi.org/10.1557/s43578-023-01274-5.

Article Google Scholar

67. Debanath MK, Karmakar S. Study of blueshift of optical band gap in zinc oxide (ZnO) nanoparticles prepared by low-temperature wet chemical method. Mater Lett. 2013;111:116–9. https://doi.org/10.1016/j.matlet.2013.08.069.

Article Google Scholar

68. Yakimovich NO, Ezhevskii AA, Guseinov DV, Smirnova LA, Gracheva TA, Klychkov KS. Antioxidant properties of gold nanoparticles studied by ESR spectroscopy. Russian Chem Bullet. 2008;57:520–3. https://doi.org/10.1007/s11172-008-0080-1.

Article Google Scholar

69. Stan M, Popa A, Toloman D, Silipas TD, Vodnar DC. Antibacterial and antioxidant activities of ZnO nanoparticles synthesized using extracts of Allium sativum, Rosmarinus officinalis and Ocimumbasilicum. Acta Metallurgica Sinica. 2016;29:228–36. https://doi.org/10.1007/s40195-016-0380-7.

Article Google Scholar

70. Hossain TJ. Methods for screening and evaluation of antimicrobial activity: a review of protocols, advantages and limitations. Adv Limitations (July 17, 2023).

71. MuthuKathija M, Badhusha MSM, Rama V. Green synthesis of zinc oxide nanoparticles using Pisonia Alba leaf extract and its antibacterial activity. Appl Surf Sci Adv. 2023;15: 100400. https://doi.org/10.1016/j.apsadv.2023.100400.

Article Google Scholar

72. Gudkov SV, Burmistrov DE, Serov DA, Rebezov MB, Semenova AA, Lisitsyn AB. A mini review of antibacterial properties of ZnO nanoparticles. Front Phys. 2021;9: 641481.

Article Google Scholar

73. Sirelkhatim A, Mahmud S, Seeni A, Kaus NHM, Ann LC, Bakhori SKM, Mohamad D. Review on zinc oxide nanoparticles: antibacterial activity and toxicity mechanism. Nano-micro Lett. 2015;7:219–42.

Article Google Scholar

74. Steffy K, Shanthi G, Maroky AS, Selvakumar S. Synthesis and characterization of ZnOphytonanocomposite using Strychnos nux-vomica L. (Loganiaceae) and antimicrobial activity against multidrug-resistant bacterial strains from diabetic foot ulcer. J Adv Res. 2018;9:69–77. https://doi.org/10.1016/j.jare.2017.11.001.

Article Google Scholar

75. Mahendra C, Chandra MN, Murali M, Abhilash MR, Singh SB, Satish S, Sudarshana MS. Phyto-fabricated ZnO nanoparticles from Canthiumdicoccum (L.) for antimicrobial, anti-tuberculosis and antioxidant activity. Process Biochem. 2020;89:220–6. https://doi.org/10.1016/j.procbio.2019.10.020.

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Contributions

The study's conception and design were contributed by all authors. Material preparation, data collection and writing were conducted by Ajay Kumar Tiwari, Saket Jha, and Rohit Shukla. The spectroscopic investigations were performed by Ajay Kaumr Tiwari, and Ram Raseele Awasthi. The antioxidant and antimicrobial activities were performed by Sharad Kumar Tripathi, Abhishek Kumar Bhardwaj, and Saket Jha. The initial draft of the manuscript was composed by Ajay Kumar Tiwari and Saket Jha. Review, Editing, and Supervision of the manuscript was composed by Abhimanyu Kumar Singh, and Anupam Dikshit. Authors have contributed feedback and approved for the final manuscript.

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Ethics approval and consent to participate

Not applicable.

Consent for publications

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Competing interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper. There is no conflict of interest in this manuscript. The authors declare that they have no known competing financial.

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Mannose-specific plant and microbial lectins as antiviral agents: A review

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Abstract

Lectins are non-immunological carbohydrate-binding proteins classified on the basis of their structure, origin, and sugar specificity. The binding specificity of such proteins with the surface glycan moiety determines their activity and clinical applications. Thus, lectins hold great potential as diagnostic and drug discovery agents and as novel biopharmaceutical products. In recent years, significant advancements have been made in understanding plant and microbial lectins as therapeutic agents against various viral diseases. Among them, mannose-specific lectins have being proven as promising antiviral agents against a variety of viruses, such as HIV, Influenza, Herpes, Ebola, Hepatitis, Severe Acute Respiratory Syndrome Coronavirus-1 (SARS-CoV-1), Middle Eastern Respiratory Syndrome Coronavirus (MERS-CoV) and most recent Severe Acute Respiratory Syndrome Coronavirus-2 (SARS-CoV-2). The binding of mannose-binding lectins (MBLs) from plants and microbes to high-mannose containing N-glycans (which may be simple or complex) of glycoproteins found on the surface of viruses has been found to be highly specific and mainly responsible for their antiviral activity. MBLs target various steps in the viral life cycle, including viral attachment, entry and replication. The present review discusses the brief classification and structure of lectins along with antiviral activity of various mannose-specific lectins from plants and microbial sources and their diagnostic and therapeutic applications against viral

diseases. Graphical abstract: (Figure presented.)

Author keywords

Antiviral agents; Mannose-specific lectins; Plant lectins; Viruses

Indexed keywords

MeSH

Antiviral Agents; Glycoproteins; Humans; Lectins; Mannose; Mannose-Binding Lectins; Plant Lectins; Polysaccharides; SARS-CoV-2; Virus Diseases

EMTREE drug terms

agglutinin; bacterial protein; BanLec; chitinase; cyanovirin N; hevein; jacalin; mannan binding lectin; microvirin; plant lectin; ricin B; scytovirin; unclassified drug; antivirus agent; glycoprotein; lectin; mannose; mannose binding lectin; plant lectin; polysaccharide

EMTREE medical terms

Agaricus bisporus; antiviral activity; Ebolavirus; Euonymus; Euonymus europaeus; Galanthus; Galanthus nivalis; glycosylation; hepatitis virus; Herpesviridae; human; Human immunodeficiency virus; Influenza virus; Nicotiana tabacum; nonhuman; Review; SARS coronavirus; Severe acute respiratory syndrome coronavirus 2; virus attachment; virus entry; virus replication; chemistry; metabolism; virus infection

Chemicals and CAS Registry Numbers

Unique identifiers assigned by the Chemical Abstracts Service (CAS) to ensure accurate identification and tracking of chemicals across scientific literature.

chitinase	9001-06-3
cyanovirin N	212132-87-1
mannose	31103-86-3

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Abstract

Energy is of the utmost importance to transact the world economy. Globally, there is a high demand for nonrenewable fossil fuels energy production for electricity, transportation, and manufacturing. Fossil fuels have various negative aspects such as the limited existence of fossil fuels, pollution, dangerous health effects, and threats to the natural environmental balance. The present energy scenario has encouraged the exploration of more efficient alternative sources of energy that provide an uninterrupted balanced energy supply. Biofuels are an environment-friendly alternative source for renewable bioenergy production. Economical biofuels can be produced from carbon-rich agricultural plant crop biowaste. Biofuels occur in the three states: solid wood charcoal, liquid in bioethanol, biodiesel and biogas in gas form. Generally, bioethanol and biodiesel are used as biofuels. Biodiesel is produced by esterifying triglycerides with methanol from plants and animal sources. Fermentative microorganisms obtain biofuels namely bioethanol biogas and biohydrogen by a biochemical procedure. Microbial strains have a significant role in fermentation and sustainable bioenergy production. This has motivated researchers to apply biotechnological approaches to produce high-volume biofuels through an economically viable potential microbial system. This chapter describes advances in microbial biotechnology

approaches used for economical, ecofriendly, toxic-free, renewable, and sustainable bioenergy production from waste. © 2025 Elsevier Inc. All rights reserved.

Author keywords

Biodiesel; bioethanol; biofuels; microbial biotechnology; renewable energy; sustainable bioenergy production

Abstract

Author keywords

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Metabolic Changes and Immunity Suppression Parameters as Biomarkers of Environmental Pollutants

Biomonitoring of Pollutants in the Global South • Book Chapter • 2024 •
DOI: 10.1007/978-981-97-1658-6_20

Mishra, Bharat [a]; Tiwari, Archita [b]; Mishra, Shrishti [c]

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Abstract

Pollution occurring in our surroundings is one of the most consequential challenges to health in the modern world. Any foreign material that occupies space in the environment and produces a hazardous effect on human health and their activities, comes under the category of environmental pollutants. These environmental pollutants are present in the environment through human activities as well as by nature which leads to pollution. These pollutants originate from the soil, air, water, noise, radioactive material, thermal, agriculture, light, etc. having unfavorable effects on human immunity and metabolic processes. Among all the pollutants, air pollutants play a vital role in immunity deficiency and metabolic disorders. Air pollution causes a range of metabolic diseases, including nonalcoholic fatty liver disease, stroke, cardiovascular disease, type-2 diabetes, chronic kidney disease, peripheral artery disease, skin diseases, neurological disorders, some types of cancer, etc. It also affects normal metabolic functioning and regulation. These metabolism-sensitive disorders usually result from disruptions to the major metabolic and molecular signaling pathways, which can be caused by hereditary and lifestyle factors, as well as exposure to pollutants such endocrine-disrupting chemicals (EDCs). The

metabolism of fatty acids, tryptophan, steroid hormone production, and tyrosine can be triggered by air pollution, leading to a variety of disorders. The metabolism of fatty acids, tryptophan, steroid hormone production, and tyrosine can be triggered by air pollution, leading to a variety of disorders. Cardiopulmonary diseases like CVD, COPD, and Metsyn, which are characterized by abdominal obesity, hypertriglyceridemia, and low HDL, can be initiated by air pollution, which directly increases the levels of the cytokines IL-6, TNF-α and indirectly activates the NF-κB, AP-1 inflammatory pathways. Environmental pollutants also have a mutant effect on immunity responses that can evoke toxicity to the immune system. Immune responses triggered by on exposure to air pollutants immune responses are triggered, which are mediated by specific NLR-and TLR-dependent mechanisms. Air pollutants directly interacting with the receptor or indirectly by producing secondary mediators like DAMP or PAMP alter the activation of TLR signaling, and altered TLR signaling results in modified cytokines profiles and an increment in proinflammatory responses. Various immune cells can be affected by environmental pollutants, including macrophages, neutrophils, dendritic cells that give notification to alter immune responses, and lymphocytes that enact them. Diseases like autoimmune diseases, asthama, cardiovascular diseases, neural ailment, bronchitis, 2[SARS-CoV-2], connective tissue diseases, inflammatory bowl diseases, skin diseases and cancer etc are caused due to immunity suppression. In this chapter we aim to summarize the effect of ambient pollutants on the immune system and metabolic processes is vital to understanding how pollution leads to diseases and how that pathology could be abrogated.

Author keywords

Air pollutants; Cardiovascular diseases; Environmental pollutants; Immunity suppression; Metabolic disorders; Respiratory diseases

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Livestock Manure Application Causes the Spread of Antibiotic- resistant Genes in Agricultural Lands

Antimicrobials in Agriculture • Book Chapter • 2024 • DOI: 10.1201/9781003268895-4

Kumar, Dileep [a]; Aslam, Anam [b]; Gautam, Ranjana [b]; Gupta, Ankita [b]; Yadav, Anurag [c]; +1 author

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Abstract

Livestock manure has long been valued as an agricultural fertilizer, but its significance is now overshadowed by a serious concern - the widespread presence of antibiotic-resistant genes (ARGs). These ARGs, found abundantly in manure, soil, and water, pose a direct threat by contributing to the emergence of antibiotic-resistant bacteria due to the extensive use of antibiotics in livestock farming. This research article delves into the scientific evidence linking the application of livestock manure to the dissemination of ARGs in agricultural lands and the grave consequences for public health and the environment. The problem of antibiotic and ARG pervasiveness extends beyond manure, evident in surface water, sewage treatment plant effluent, soils, and animal waste. Unregulated antibiotic use in animal feed has led to a global health crisis as antibiotic-resistant bacteria become increasingly prevalent. Applying manure to agricultural soils creates a breeding ground for these pathogenic entities, posing a significant threat to human well-being. Over half of the veterinary antibiotics released into the environment end up in the soil, where they undergo complex processes, impacting soil microorganisms. The article highlights the potential transfer of resistance DNA from animal manure to the soil, further emphasizing the risks associated with the propagation of antibiotic resistance. The research stresses the need for a proactive and responsible approach to agricultural practices as the quest for sustainable solutions becomes crucial to safeguarding human health and the environment. Understanding the intricate complexities of this pressing

issue is essential in addressing the challenges of antibiotic resistance and its potential consequences. © 2024 selection and editorial matter, Arti Gupta and Ram Prasad; individual chapters, the contributors.

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Abstract

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Sustainable Numerical Analysis of Diabetes Mellitus with Comprehensive Study

2024 1st International Conference on Sustainability and Technological Advancements in Engineering Domain, SUSTAINED 2024 • Conference Paper • 2024 • DOI: 10.1109/SUSTAINED63638.2024.11074173

Awasthi A.K. [a] ; Koyyana, Koshika [a] ; Sharma, Minakshi [b] ; Singh, Raghvendra [c] ; Sharma, Garima [d] ; +1 author

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Abstract

Latest approach for diabetes mellitus based on numerical analysis is proposed. This paper is based on the glucose-insulin interactions with time delay factor also. It has number of steps, firstly, based on the analysis of diabetes; A mathematical model is formed then by comparing and based on numerical solutions the theoretical results confirmed. The effectiveness of proposed work is checked by computer simulations. The results based on time delay shows the best results by this model. © 2024 IEEE.

Author keywords

Diabetes; Glucose-Insulin; numerical analysis; sustainability; time delay

Indexed keywords

Engineering controlled terms

Artificial intelligence; Information systems; Information use; Sustainable development

Engineering uncontrolled terms

Delay factors; Diabetes mellitus; Glucose-insulin; Glucose-insulin interactions; Numerical solution; Time-delays

Engineering main heading

Numerical analysis; Time delay

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Sustainable Water Management and Treatment: Systems, Processes and Technologies

Environmental Science and Engineering • Book Chapter • 2025 • DOI: 10.1007/978-3-031-85327-2_7

Mishra, Bharat [a] ; Tiwari, Archita [b]

[a] Shakuntala Misra National Rehabilitation University, Lucknow, India

Abstract

Global water resources are rapidly diminishing, driven by population growth, climate changeClimate change, and expanding industrialization. Experts estimate that by 2050, 52% of the projected 9.7 billion people worldwide will reside in areas experiencing water stress or scarcity. The global challenge of accessing clean, potable water will persist as sustainable solutions remain elusive. Water sustainabilitySustainability involves meeting the current generation's water needs without jeopardizing future generations' ability to meet their own. Water is the cornerstone of sustainable developmentSustainable development, serving as a common thread linking global challenges such as energy, food securityFood security, health, peace, security, and poverty eradication. Our survival and well-being depend heavily on effective water resource systems. However, with growing development pressures on land in watersheds and increasing demands for water in streams, rivers, lakes, and aquifers, it is unrealistic to expect these water systems to return to or maintain their pristine, most productive states. Sustainable water managementWater management (SWM) is crucial for addressing these pressures and achieving sustainable development goalsSustainable Development Goals (SDGs). SWM ensures that current water needs are met for all users without compromising the ability of future generations to meet their own needs. This concept aligns with broader sustainability principlesSustainability principles, addressing both present and future water challenges. Enhancing the efficiency of conventional membrane technologies for water treatment is now crucial to minimizing their environmental impactEnvironmental impact.

WastewaterWastewater treatmenttreatmentWastewater treatment removes pollutants, coarse particles, and toxic substances while killing pathogens and producing bio-methaneMethane (CH_4) and manure for agricultureAgriculture. It is crucial in reducing water waste, easing pressure on natural water sources, and supporting clean energy, forming the foundation for sustainable waste managementWaste management. Membrane technologies are increasingly favored forSustainable wastewater treatmentwastewater treatmentWastewater treatment due to their sustainabilitySustainability advantages, including cost-effectiveness, operational ease, and safety. Sustainable water treatment technologies utilize innovative methods such as membrane filtrationMembrane filtration, advanced oxidation processesAdvanced Oxidation Processes (AOPs), and nanotechnologyNanotechnology. Techniques like reverse osmosisReverse osmosis and ultrafiltration are highly effective in removing contaminantsContaminants, microorganisms, and nanoparticles from water. Sustainable water technologies include wastewater treatmentWastewater treatment plants, intelligent irrigation systems, fog catchers, rainwater harvestingRainwater harvesting, tap aerators, seawater desalinationDesalination, portable filters, and solar-powered desalinationDesalination units.

Author keywords

Electro deionization; Membrane technology; Water management; Water pollution; Water scarcity; Water Stress Index; Waterborne diseases

Indexed keywords

Engineering controlled terms

Agriculture; Cost effectiveness; Environmental technology; Microfiltration; Population statistics; Potable water; River pollution; Sustainable development; Sustainable development goals; Wastewater treatment; Water conservation; Water filtration; Waterworks

Engineering uncontrolled terms

Electro-deionization; Future generations; Global challenges; Sustainable water; Sustainable water management; Water needs; Water scarcity; Water stress indices; Water-borne disease; Waters managements

Engineering main heading

Membrane technology

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Abstract

Author keywords

Indexed keywords

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Phytochemistry and Potential Pharmacological Properties of Morus alba Plant for Health Benefits: A Comprehensive Review

Biomedical and Pharmacology Journal • Review • *Open Access* • 2024 • DOI: 10.13005/bpj/3014

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Abstract

Morus alba L. is a fast-growing shrub or moderate height tree and considered as Ayurvedic medicinal plant due to its medicinal uses. M. alba has high concentrations of phenols, tannins, steroids, flavonoids, alkaloids, terpenoids, and carbohydrates. In this review, approximately 200 papers were reviewed, and finally 96 papers were used to explore the phytochemistry and pharmacological properties of the Morus alba plant. The aim of this study is to provide an insightful exploration of biologically active compounds present in the bark, leaves, flowers, and fruits of the M. alba plant, and its potential pharmacological effects include anti-inflammatory, antidiabetic, antihyperlipidemic, hepatoprotective, neuroprotective, anthelmintic, anti-obesity, anxiolytic, hypocholesterolemic, antioxidant, antimicrobial, and nephroprotective activity. Phytocompounds present in M. alba extracts also have various biological activities, including blood coagulation factors, vasodilation, cytotoxic responses, cytokine storming, sympathetic responses, oxidative stress, cardiovascular, skin, gastrointestinal, skin whitening, and fibrosis, among others. The findings of this review paper showed that different parts of M. alba have various pharmacological and therapeutic potential and hence can be used in various herbal formulations as well as health care products. Published by Oriental Scientific Publishing Company © 2024.

Author keywords

Antioxidant; Flavonoids; Hepatoprotective; Neuroprotective; Pharmacology; Phytochemistry

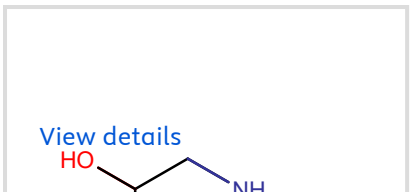
Indexed keywords

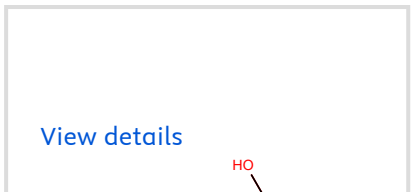
EMTREE drug terms

alkaloid; anthelmintic agent; antioxidant; blood clotting factor; carbohydrate; flavonoid; phenol derivative; steroid; tannin derivative; terpenoid

EMTREE medical terms

antimicrobial activity; bark; drug analysis; drug therapy; medicinal plant; Morus alba; neuroprotection; nonhuman; oxidative stress; pharmacology; phytochemistry; plant leaf; review; shrub; vasodilatation





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Journal of Biomolecular Structure and Dynamics ›

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Research Articles

An *in vitro* approach to unveil the structural alterations in D-ribose induced glycated fibrinogen

Afreen Khanam, Sultan Alouffi, Shahnawaz Rehman, Irfan Ahmad Ansari, Uzma Shahab & Saheem Ahmad

Pages 5209-5223 | Received 17 Apr 2020, Accepted 14 Jun 2020, Published online: 08 Aug 2020

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Abstract

Plasma proteins persistently bear non-enzymatic post-translational modifications (NEPTM) that proceeds with nucleophilic addition between free amino groups of proteins, and carbonyl group of reducing sugars. Glycation, a prevalent NEPTM rush by the high availability of reducing sugars results in the generation of advanced glycation end products (AGEs). Plasma proteins are more vulnerable to glycation because of the presence of multiple glycation sites and are widely studied. However, fibrinogen glycation is less studied. Therefore, it was

designed as an *in vitro* study to elucidate D-ribose mediated glycative damage suffered by fibrinogen protein at secondary and tertiary structure level. The glycation induced structural alterations were analyzed by UV-vis, fluorescence, circular dichroism, scanning electron microcopy and Fourier transform infrared spectroscopy. Glycation induced protein aggregation and fibrils formation was confirmed by thioflavin T and congo red assay. Moreover, molecular docking study was performed to further validate physicochemical characterization. Structural alterations, increased ketoamines, protein carbonyls and HMF contents were reported in D-ribose glycated fibrinogen against their native analogues. The results validate structural perturbations, increased glycoxidative stress and AGEs formation, which might influence normal function of fibrinogen especially blood coagulation cascade. Thus, we can conclude that under diabetes induced hyperglycemic state in physiological systems, D-ribose induced fibrinogen glycation might play a crucial role in the onset of micro- and macro-vascular complications, thereby worsen the diabetes associated secondary disorders. Moreover, this *in vitro* study might pave a path to choose fibrinogen as a future biomarker for the early detection of diabetes mediated vascular complications.

Communicated by Ramaswamy H. Sarma

Keywords:

Fibrinogen D-ribose glycation advanced glycation end products (AGEs)

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Disclosure statement

The authors declare that they have no conflicts of interest with the contents of this article.

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Published online: 29 Nov 2017

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Pandemic and Brand Communication in India

International Handbook of Disaster Research • Book Chapter • 2023 •
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Dang, Tanu

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Abstract

The recent Covid-19 pandemic, which shocked the entire world by its spread and devastation, has changed the way brands sell and people buy. There has been a transformative change in how brands connect and communicate with the audience. The pandemic outbreak and subsequent lockdown coupled with the increased risk of health and hygiene made the brands rethink about their strategy and performance. During the pandemic, brand attitude and brand reputation gained greater relevance over brand positioning. Consumers not only evaluated the ways in which brands dealt with the pandemic but also shifted loyalty if their brands failed to act responsibly during the crisis. Brand communications evolved new ways to humanize their brand in order to make it more relatable to their consumers. The crisis made the brands more focused on consumer experiences. Successful brands were quick to adapt, innovate, and ramp up experiences and safety measures for their consumers thereby enabling trust and promoting business recovery. Through various examples from India, this chapter attempts to analyze brand communication during the pandemic. It attempts to make an important contribution to literature by providing evidence of the various strategies that some brands adopted at the time of disaster. By analyzing these strategies, this chapter attempts to guide brands in strengthening their communications and adding more meaning to their message.

Author keywords

Brand communication; Consumer behavior; COVID-19; CSR

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Deep Learning-based Covid and Pneumonia Classification

2023 2nd International Conference on Smart Technologies for Smart Nation, SmartTechCon 2023 • Conference Paper • 2023 • DOI: 10.1109/SmartTechCon57526.2023.10391490

Ali, Mohd Mohsin [a] ; Ranjan, Vibhav [a] ; Farid, Amina [b] ; Raj, Manish [a]

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Abstract

Internal images of the body may be captured using X-ray technology, which helps doctors diagnose and treat a wide range of medical issues. Recent studies have focused on optimizing the usage of deep learning algorithms to boost medical imaging's accuracy and productivity. Deep learning AI makes use of massive datasets to train computer algorithms to recognize patterns, which are then used to make predictions or classifications about fresh data. This method has shown promise in facilitating quicker and more accurate detection of conditions including lung cancer and bone fractures using X-ray images. Patient outcomes may improve with the use of deep learning algorithms in medical imaging. Healthcare systems may be strengthened, and the effects of health crises lessened by facilitating faster and more accurate diagnosis. Investing in initiatives that promote the use of deep learning in medical imaging will help get us there. A bespoke deep learning model was able to classify 70% of a dataset evenly between the healthy, COVID, and pneumonia patients, yielding an astonishing 97.96% accuracy. Applying deep learning algorithms to the analysis of X-ray images has shown great potential for improving the efficiency and precision of medical diagnoses. Better health outcomes may result from this enhanced ability to identify abnormalities and illnesses such as lung cancer and bone fractures. The healthcare industry stands to benefit greatly from adopting programs that encourage the integration of deep learning in medical imaging and might even save lives by doing so. © 2023 IEEE.

Author keywords

Artificial intelligence; Computer-aided diagnostics; Convolutional neural networks; Deep learning; Dermatologists; Digital dermatology; Skin cancer; Transfer learning

Indexed keywords

Engineering controlled terms

Biological organs; Classification (of information); Computer aided diagnosis; Computer aided instruction; Convolutional neural networks; Deep learning; Dermatology; Diseases; E-learning; Image classification; Image enhancement; Learning algorithms; Learning systems; Transfer learning

Engineering uncontrolled terms

Bone fracture; Computer aided diagnostics; Convolutional neural network; Deep learning; Dermatologist; Digital dermatology; Lung Cancer; Skin cancers; Transfer learning; X-ray image

Engineering main heading

Medical imaging

Abstract

Author keywords

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Volume XXI | Issue 2
Environment

Covid-19 lockdown effect on aerosol optical depth in Delhi National Capital Region, India

Sharma Vipasha[1], Ghosh Swagata[2], Shahnawaz[3], Rai Kumar Praveen[4], Singh Sultan[5]

Abstract: Coronavirus cases in India have been steadily increasing since March 2020. COronaVIrus Disease 2019 (COVID-19) has been managed by a variety of preventative measures. A prominent measure by the Government of India to prevent the spread of Coronavirus Disease 2019 (COVID-19) began on March 25, 2020, with a complete suspension of all outdoor activities throughout the country. Such complete lockdown has resulted in a decrease in anthropogenic emissions, which is partly due to restrictions on human activities. Delhi National Capital Region (NCR), a landlocked area, suffers from high amounts of aerosols due to both natural and anthropogenic sources. The present research focuses on changes in Aerosol Optical Depth (AOD) prior to and during lockdown (initial and second lockdown phases) around satellite cities (Faridabad, Ghaziabad, Gautam Budh Nagar and Gurugram) of Delhi using high-resolution MODIS AOD product. With the implementation of lockdown measures in phase I and phase III of the current study region, AOD decreased dramatically, while phase II and phase IV lockdown phases had a higher concentration of aerosol. An unexpected increase in AOD occurred during the second lockdown compared with the initial lockdown and before the lockdown. Overall, the average percentage change from 2019 to 2020 during first lockdown is -4.44%, while the average percentage change from 2020 to 2021 is 27.63%.

Keywords: MAIAC, COVID-19, lockdown, satellite cities, aerosol optical depth
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Author contributions: Conceptualization, S.G; methodology, X.X.; formal analysis, V.S.; investigation, V.S.; S.G. writing—original draft preparation, V.S.; writing—review and editing, S.G.; S; P.K.R.; Resources provision: S.; P.K.R.; S.S. All authors have read and agreed to the published version of the manuscript.Declaration of interests: The authors declare no conflict of interest.
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available at Level-1 Atmosphere Archive & Distribution System (LAADS) (https://ladsweb.modaps.eosdis.nasa.gov/). Authors are thankful to NASA AERONET federation, AERONET scientific team and principal investigators for establishing, maintaining the sites, and providing AERONET data at https://aeronet.gsfc. nasa. gov/.

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Covid-19 lockdown effect on aerosol optical depth in Delhi National Capital Region, India

[Rezumat. Efectul lockdown-ului din perioada Covid-19 asupra adâncimii optice a aerosolilor în regiunea capitalei naționale Delhi, India]

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Vipasha, Sharma [a]; Swagata, Ghosh [b]; Shahnawaz [c]; Kumar Praveen, Rai [d]; Sultan, Singh [e]

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Abstract

Coronavirus cases in India have been steadily increasing since March 2020. COronaVIrus Disease 2019 (COVID-19) has been managed by a variety of preventative measures. A prominent measure by the Government of India to prevent the spread of Coronavirus Disease 2019 (COVID-19) began on March 25, 2020, with a complete suspension of all outdoor activities throughout the country. Such complete lockdown has resulted in a decrease in anthropogenic emissions, which is partly due to restrictions on human activities. Delhi National Capital Region (NCR), a landlocked area, suffers from high amounts of aerosols due to both natural and anthropogenic sources. The present research focuses on changes in Aerosol Optical Depth (AOD) prior to and during lockdown (initial and second lockdown phases) around satellite cities (Faridabad, Ghaziabad, Gautam Budh Nagar and Gurugram) of Delhi using high-resolution MODIS AOD product. With the implementation of lockdown measures in phase I and phase III of the current study region, AOD decreased dramatically, while phase II and phase IV lockdown phases had a higher concentration of aerosol. An unexpected increase in AOD occurred

during the second lockdown compared with the initial lockdown and before the lockdown. Overall, the average percentage change from 2019 to 2020 during first lockdown is -4.44%, while the average percentage change from 2020 to 2021 is 27.63%.

Author keywords

aerosol optical depth; COVID-19; lockdown; MAIAC; satellite cities

Indexed keywords

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India

GEOBASE Subject Index

aerosol; COVID-19; MODIS; pollutant source; spatiotemporal analysis; urban area; viral disease

Funding details

Details about financial support for research, including funding sources and grant numbers as provided in academic publications.

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Funding text 1
This research was funded by Science & Engineering Research Board (SERB), Department of Science & Technology (DST), Government of India (Project File No. ECR/2017/000331). It is also partially supported for mobility activity by the ERASMUS+ Programme of the European Union.

Funding text 2
The corresponding author acknowledges the Science & Engineering Research Board (SERB), Department of Science & Technology (DST), Government of India for funding this work through Project File No. ECR/2017/000331. Present research is partially supported for mobility activity by the ERASMUS+ Programme of the European Union. This research was funded by Science & Engineering Research Board (SERB), Department of Science & Technology (DST), Government of India (Project File No. ECR/2017/000331). It is also partially supported for mobility activity by the ERASMUS+ Programme of the European Union. MODIS AOD products were available at Level-1 Atmosphere Archive & Distribution System (LAADS) (https://ladsweb.modaps.eosdis.nasa.gov/). Authors are thankful to NASA AERONET federation, AERONET scientific team and principal investigators for establishing, maintaining the sites, and providing AERONET data at https://aeronet.gsfc. nasa. gov/.

Funding text 3
The corresponding author acknowledges the Science & Engineering Research Board (SERB), Department of Science & Technology (DST), Government of India for funding this work through Project File No. ECR/2017/000331. Present research is partially supported for mobility activity by the ERASMUS+ Programme of the European Union.

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Effect of non-enzymatic glycosylation in the epigenetics of cancer

Seminars in Cancer Biology • Review • 2022 • DOI: 10.1016/j.semcancer.2020.11.019

Rehman, Shahnawaz [a]; Aatif, Mohammad [b]; Rafi, Zeeshan [c]; Khan, Mohd Yasir [a]; Shahab, Uzma [d]; +2 authors

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Abstract

The non-enzymatic glycosylation or non-enzymatic covalent modifications (NECMs) or glycation of cellular proteins result in the generation and accumulation of advanced glycation end products (AGEs) that are associated with the epigenetics of cancer. Epigenetic modifications are inheritable changes without alterations in the sequences of DNA. Glycation-mediated epigenetic mechanisms change the accessibility of transcriptional factors to DNA via rearrangement or modification in the chromatin structure and collaborate with gene regulation in the pathogenesis of cancer. Epigenetic mechanisms play a critical role in sustaining the tissue-specific gene expression. Distraction from normal epigenetic mechanism results in alteration of gene function, initiation and progression of cancer, and cellular malignant transformation. Epigenetic modifications on DNA and histones control enzymatic expressions of corresponding metabolic pathways, which in turn influence epigenetic regulation. Glycation of histones due to persistent hyperglycemia results in histone-histone and histone-DNA cross-linking in chromatin by compromising the electrostatic interactions, that affect the dynamic architecture of chromatin. Histone proteins are highly prone to glycation due to their basic nature and long half-lives, but the exact role of histone glycation in the epigenetics of cancer is still in the veil. However, recent studies have suggested the role of histone glycation mediated epigenetic modifications that affect cellular functioning by altering the gene expressions of related metabolic pathways. Moreover, dicarbonyls-induced NECMs of histones perturb the architecture of chromatin and transcription of genes via multiple mechanisms. Contrary to the genetic causes of cancer, a possible reversal of glycation-mediated epigenetic modifications might open a new realm for therapeutic interventions. In this review, we have portrayed a mechanistic link between histone glycation and cancer epigenetics. © 2020 Elsevier Ltd

Author keywords

AGEs; Cancer; Epigenetics; Glycosylation; Histone

Indexed keywords

MeSH

Cell Transformation, Neoplastic; Chromatin; DNA Methylation; Epigenesis, Genetic; Glycosylation; Histones; Humans; Neoplasms

EMTREE drug terms

advanced glycation end product; advanced glycation end product receptor; DNA; histone; RNA; histone

EMTREE medical terms

chromatin structure; deacetylation; DNA glycation; epigenetics; glycation; histone acetylation; histone deacetylation; histone demethylation; histone glycation; histone methylation; histone modification; human; malignant neoplasm; nonhuman; protein function; regulatory mechanism; Review; RNA glycation; transcription factor glycation; cell transformation; chromatin; DNA methylation; genetic epigenesis; genetics; glycosylation; metabolism; neoplasm

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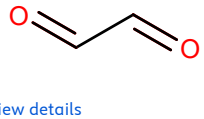

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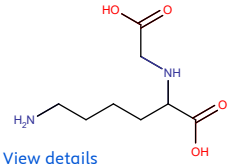

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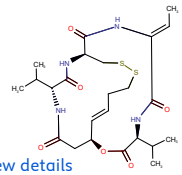

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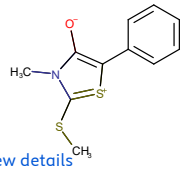

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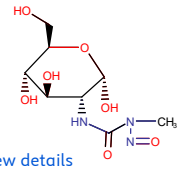

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DNA	9007-49-2
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RNA	63231-63-0

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An in vitro approach to unveil the structural alterations in d-ribose induced glycated fibrinogen

Journal of Biomolecular Structure and Dynamics • Article • 2021 • DOI: 10.1080/07391102.2020.1802339

Khanam, Afreen [a]; Alouffi, Sultan [b,c]; Rehman, Shahnawaz [a]; Ansari, Irfan Ahmad [a]; Shahab, Uzma [d]; +1 author

[a] IIRC-1, Laboratory of Glycation Biology and Metabolic Disorder, Department of Biosciences, Faculty of Sciences, Integral University, Lucknow, Uttar Pradesh, India

Abstract

Plasma proteins persistently bear non-enzymatic post-translational modifications (NEPTM) that proceeds with nucleophilic addition between free amino groups of proteins, and carbonyl group of reducing sugars. Glycation, a prevalent NEPTM rush by the high availability of reducing sugars results in the generation of advanced glycation end products (AGEs). Plasma proteins are more vulnerable to glycation because of the presence of multiple glycation sites and are widely studied. However, fibrinogen glycation is less studied. Therefore, it was designed as an in vitro study to elucidate d-ribose mediated glycative damage suffered by fibrinogen protein at secondary and tertiary structure level. The glycation induced structural alterations were analyzed by UV-vis, fluorescence, circular dichroism, scanning electron microcopy and Fourier transform infrared spectroscopy. Glycation induced protein aggregation and fibrils formation was confirmed by thioflavin T and congo red assay. Moreover, molecular docking study was performed to further validate physicochemical characterization. Structural alterations, increased ketoamines, protein carbonyls and HMF contents were reported in d-ribose glycated fibrinogen against their native analogues. The results validate structural perturbations, increased glycoxidative stress and AGEs formation, which might influence normal function of fibrinogen especially blood coagulation cascade. Thus, we can conclude that under diabetes induced hyperglycemic state in physiological systems, d-ribose induced fibrinogen glycation might play a crucial role in the onset of micro- and macro-vascular complications, thereby worsen the diabetes associated secondary disorders. Moreover, this in vitro study might pave a path to choose fibrinogen as a future biomarker for the early detection of diabetes mediated vascular complications. Communicated by Ramaswamy H. Sarma.

Author keywords

advanced glycation end products (AGEs); d-ribose; Fibrinogen; glycation

Indexed keywords

MeSH

Circular Dichroism; Fibrinogen; Glycation End Products, Advanced; Glycosylation; Molecular Docking Simulation; Ribose

EMTREE drug terms

advanced glycation end product; aminoketone; arginine; carbonyl derivative; fibrinogen; lysine; ribose; thiol derivative; advanced glycation end product; fibrinogen

EMTREE medical terms

Article; diabetic microangiopathy; human; hydrophobicity; hyperglycemia; in vitro study; molecular docking; oxidative stress; protein aggregation; protein glycosylation; protein secondary structure; protein tertiary structure; spectrofluorometry; ultraviolet visible spectroscopy; circular dichroism; glycosylation; metabolism

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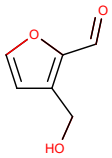
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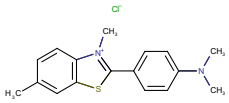
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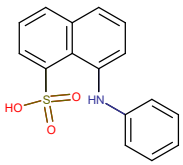
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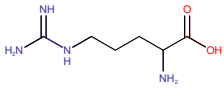
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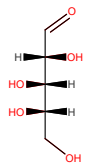
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lysine	56-87-1, 6899-06-5, 70-54-2
ribose	34466-20-1, 50-69-1, 93781-19-2

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Authors are thankful to DST for infrastructural support to the Department of Bio-Sciences, Integral University under FIST program. The MCN no. for this article is IU/R&D/2019-MCN000692.

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Polyethylene microplastics disrupt focal adhesion kinase (FAK) signaling and sertoli cell metabolism, compromising blood-testis barrier function and spermatogenesis

Toxicology • Article • 2025 • DOI: 10.1016/j.tox.2025.154240

Vigneshwaran G. [a]; Dubey, Itishree [a]; Kumar, Anand [b]; Lalruatmawii [a]; Hylalij, Aditya [a]; +6 authors

[a] Department of Pharmacology and Toxicology, National Institute of Pharmaceutical Education and Research, Raebareli, (NIPER-R), Uttar Pradesh, Lucknow, 226002, India

Abstract

Polyethylene microplastics (PE-MPs), used extensively in personal care applications, are non-biodegradable pollutants with demonstrated bioaccumulation potential and toxicological relevance. Recent studies have detected microplastics in human semen and testicular tissues, raising concerns about their effect on male reproductive health. This study investigates the toxicological effects of orally administered polyethylene microplastics (PE-MPs) at 20 µg/mL, 200 µg/mL, and 2000 µg/mL doses in rats for 56 days, with a focus on disruption of the blood-testis barrier (BTB) and destabilization of ectoplasmic specialization (ES), both essential for normal spermatogenesis. Western blot analysis showed a marked reduction in BTB-associated tight junction proteins occludin, claudin-11, N-cadherin, E-cadherin, and adaptor protein ZO-1, as well as the steroidogenic marker StAR in PE-MPs-treated rats, indicating disruption of barrier integrity and steroidogenic function. PE-MPs exposure significantly reduced p-FAK (Tyr407), could impair the F-actin organization, and lead to an open BTB. At the same time, increased p-FAK (Tyr397) expression resulted in decreased spermatid adhesion, disrupting apical ES dynamics and contributing to a leaky BTB with increased permeability. These alterations led to spermiation failure, premature germ cell exfoliation, and impaired spermatogenesis. Additionally, the Akt and mammalian rapamycin (mTOR) expression targets were explored to understand their potential role in PE-

MPs-induced testicular toxicity. The exposure to PE-MPs significantly altered 17 serum metabolites, indicating metabolic disturbances identified through ^{1}H NMR metabolomics. High doses of PE-MPs significantly elevated serum pyruvate and lactate levels in rats, possibly infiltrating the testis due to disruption of the BTB. Also, PE-MPs exposure significantly elevated the serum histidine-to-tyrosine ratio, indicating disrupted amino acid metabolism. These findings demonstrate that PE-MPs compromise BTB integrity, disrupt ES dynamics, impair spermatogenesis, and induce systemic metabolic alterations, highlighting their potential risk to male reproductive health. © 2025 Elsevier B.V.

Author keywords

Blood-testis barrier; Focal adhesion kinase signaling; Metabolomics; Polyethylene microplastics; Testicular toxicity

Indexed keywords

MeSH

Animals; Blood-Testis Barrier; Focal Adhesion Kinase 1; Focal Adhesion Protein-Tyrosine Kinases; Male; Microplastics; Rats; Rats, Sprague-Dawley; Sertoli Cells; Signal Transduction; Spermatogenesis; Testis

EMTREE drug terms

claudin 11; F actin; focal adhesion kinase; follitropin; glutathione; histidine; lactic acid; luteinizing hormone; malonaldehyde; mammalian target of rapamycin; microplastic; nerve cell adhesion molecule; occludin; polyethylene; protein Bax; protein bcl 2; protein kinase B; protein ZO1; pyruvic acid; reactive oxygen metabolite; superoxide dismutase; tight junction protein; tyrosine; uvomorulin; focal adhesion kinase; focal adhesion kinase 1; Ptk2 protein, rat

EMTREE medical terms

Akt/mTOR signaling; animal experiment; animal model; animal tissue; apoptosis; Article; blood testis barrier; cell adhesion; cell infiltration; cell metabolism; cell survival; comet assay; controlled study; DNA damage; DNA fragmentation; energy yield; germ layer; gonad; lactate blood level; male; metabolic disorder; metabolic regulation; mouse; multivariate analysis; nonhuman; oxidative stress; particle size; protein expression; proton nuclear magnetic resonance; quantitative analysis; radioimmunoprecipitation; scanning electron microscopy; semen parameters; seminiferous tubule; Sertoli cell; signal transduction; sperm count; sperm quality; sperm viability; spermatid; spermatogenesis; spermatogenic failure; spermatozoon motility; Sprague Dawley rat; testicular toxicity; testis tissue; toxicity; TUNEL assay; upregulation; Western blotting; animal; drug effect; metabolism; rat; signal transduction; testis

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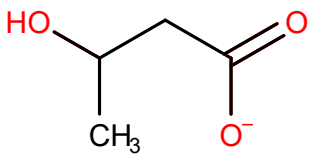

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Email address sapana.kushwaha@niperrbl.ac.in

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Physicochemical Characterization of in Vitro LDL Glycation and Its Inhibition by Ellagic Acid (EA): An in Vivo Approach to Inhibit Diabetes in Experimental Animals

BioMed Research International • Article • *Open Access* • 2022 • DOI: 10.1155/2022/5583298

Ahmad, Saheem [a] ; Alouffi, Sultan [a, b] ; Khan, Saif [c] ; Khan, Mahvish [d] ; Akasha, Rihab [a] ; +4 authors

[a] Department of Clinical Laboratory Sciences, College of Applied Medical Sciences, University of Hail, Saudi Arabia

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Abstract

Hundreds of millions of people around the globe are afflicted by diabetes mellitus. The alteration in glucose fixation process might result into hyperglycaemia and could affect the circulating plasma proteins to undergo nonenzymatic glycation reaction. If it is unchecked, it may lead to diabetes with increase in advanced glycation end products (AGEs). Therefore, the present study was designed to inhibit the diabetes and glycation by using natural antioxidant "ellagic acid"(EA). In this study, we explored the antidiabetes and antiglycation potential of EA in both in vitro (EA at micromolar concentration) and in vivo systems. The EA concentrations of 10 and 20 mg kg-1B.W./day were administered orally for 25 days to alloxan-induced diabetic rats, a week after confirmation of stable diabetes in animals. Intriguingly, EA supplementation in diabetic rats reversed the increase in fasting blood sugar (FBS) and hemoglobin A1c (HbA1c) level. EA also showed an inhibitory role against glycation

intermediates including dicarbonyls, as well as AGEs, investigated in a glycation mixture with in vitro and in vivo animal plasma samples. Additionally, EA treatment resulted in inhibition of lipid peroxidation-mediated malondialdehyde (MDA) and conjugated dienes (CD). Furthermore, EA exhibited an antioxidant property, increased the level of plasma glutathione (GSH), and also helped to decrease histological changes evaluated by histoimmunostaining of animal kidney tissues. The results from our investigation clearly indicates the antiglycative property of EA, suggesting EA as an adequate inhibitor of glycation and diabetes, which can be investigated further in preclinical settings for the treatment and management of diabetes-associated complications. © 2022 Saheem Ahmad et al.

Indexed keywords

MeSH

Animals; Antioxidants; Diabetes Complications; Diabetes Mellitus, Experimental; Ellagic Acid; Glutathione; Glycation End Products, Advanced; Glycosylation; Humans; Rats

EMTREE drug terms

alkadiene; alloxan; aminoguanidine; aminoketone; antidiabetic agent; antioxidant; C peptide; carbonyl derivative; ellagic acid; fluorescein isothiocyanate; fructosamine; glucose; glutathione; hemoglobin A1c; low density lipoprotein; malonaldehyde; advanced glycation end product; ellagic acid

EMTREE medical terms

absorption; alloxan-induced diabetes mellitus; animal experiment; animal model; animal tissue; Article; concentration (parameter); controlled study; diabetes mellitus; diabetic complication; enzyme linked immunosorbent assay; glucose blood level; glycation; high performance liquid chromatography; histopathology; human; hyperglycemia; immunohistochemistry; immunoreactivity; in vitro study; inhibitory concentration; lipid peroxidation; nonhuman; physical chemistry; rat; spectrofluorometry; spectrophotometry; ultraviolet visible spectroscopy; water solubility; animal; diabetic complication; experimental diabetes mellitus; glycosylation; metabolism

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aminoguanidine	1068-42-4, 2582-30-1, 79-17-4
C peptide	59112-80-0
ellagic acid	476-66-4

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