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SYNTHESIS AND CHARACTERIZATION OF BIOGENIC ZINC OXIDE NANOPARTICLES PHOTOCATALYSTS AND EVALUATION OF ITS ANTIOXIDANT, ANTIBACTERIAL AND NANOTOXICITY PROPERTIES

LAU GEE EEN

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By

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During the process of dyeing and printing in textile industry, more than 8000 chemicals are taking part. Methyl orange (MO) and Methylene blue (MB) are synthetic dyes commonly used in the dyeing process. Inappropriate usage and disposal of these synthetic dye may lead to negative impacts on the environment. Photocatalysis of nanoparticles is a pioneering wastewater treatment technique, notably for those containing organic compounds which are difficult to remove. The fascinating physical and chemical properties made zinc oxide nanoparticles (ZnONPs) famous in nanotechnology. The research highlights the potential of new nano-agents on antioxidant and photocatalytic activity. The roselle flower and oil palm leaf extracts act as reducing agents, while Sodium hydroxide (NaOH) is used as a precipitating agent during the synthesis of ZnONPs. Synthesis of ZnONPs without the addition of plant extracts, ZnO (B) was used as blank control of the study. Characterization and analytical studies were conducted on the synthesized ZnONPs. GC-MS discovered that saturated and unsaturated fatty acids were the main constituents in both extracts. EDX revealed the synthesized ZnONPs constituent two elements, Zn and O. The FTIR analysis showed the presence of phenolic compounds and Zn-O stretching bond in green synthesized products. In terms of morphology, the size of the synthesized ZnONPs was 10–15 nm. They are found in agglomerated spherical-shaped. XRD spectra revealed the ZnONPs have 20-30 nm crystallite size. ZnONPs have wurtzite structure in Raman spectrum. UV Vis discovered that ZnONPs have relatively large band gap, which are 2.9 eV and 3.2 eV. TGA proved high thermal stability of ZnONPs. ESR revealed the presence of oxygen vacancies in ZnONPs, which play a vital role in the dye degradation process. The presence of 5% of ZnONPs as catalysts under exposure of 10 W UV lamp could degrade 10 ppm MO in 5 hours and MB in 3 hours efficiently. ZnONPs exhibit high antioxidant and antibacterial properties, especially with the presence of phenolic compounds. *Artemia* sp.

assay discovered that low toxicity of ZnONPs has the potential to work as water treatment agents. To conclude, for pharmaceutical and industry use, ZnONPs can be further developed.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

SINTESIS DAN PENCIRIAN ATAS BIOGEN ZINK OKSIDA NANOPARTIKEL FOTOKATALIS DAN PENILAIAN ATAS CIRI-CIRI ANTIOKSIDA, ANTIBAKTERIA DAN NANO-KETOKSIKAN.

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Dalam proses pewarnaan dan percetakan dalam pembuatan tekstil, lebih daripada 8000 bahan kimia terbabit. Metil Oren (MO) dan Metilena biru (MB) merupakan pewarna sintetik yang biasa digunakan dalam proses pewarnaan. Kesalahan pengunaan dan pembuangan pewarna sintetik ini akan mendorong kepada impak negatif terhadap alam sekitar. Fotomangkin nanopartikel merupakan teknik yang perintis untuk rawatan air, terutamanya untuk yang mengandungi sebatian organik yang susah dihapuskan. Keunikan ciri-ciri fizikal dan sifat kimia menjadikan zink oksida nanopartikel (ZnONPs) terkenal dalam nanoteknologi. Kajian ini menonjolkan potensi ejen nano yang baru atas anti-oksida dan fotomangkin aktiviti. Ekstrak bunga asam belanda (Rosel) dan daun kelapa sawit memainkan peranan sebagai agen penurunan manakala natrium hidroksida (NaOH) digunakan sebagai ejen pemendakan dalam proses sintesis ZnONPs. Sintesis ZnONPs tanpa tambahan ekstrak tumbuhan digunakan sebagai kawalan kosong dalam penyelidikan. Pencirian dan kajian analisis dijalankan atas ZnONPs. GC-MS menemukan bahawa asid lemak tepu dan tidak tepu merupakan unsur utama dalam kedua-dua jenis ekstrak. EDX menunjukkan ZnONPs merangkumi dua element, Zn dan O, dalam ketulenan yang tinggi. Analisis FTIR menunjukkan kewujudan sebatian fenolik dan ikatan Zn-O dalam produk sintesis hijau. Dari segi morfologi, saiz ZnONPs adalah 10-15 nm. Nanopartikel ini didapati dalam bentuk bulat bertimbunan. Spektra XRD menunjukkan ZnONPs mempunyai 20-30 nm kristalit saiz. ZnONPs didapati dalam struktur wurtzit melalui spektral Raman. UV-Vis menemukan ZnONPs mempunyai jurang jalur yang besar, iaitu 2.9 eV dan 3.2 eV. TGA membuktikkan kestabilan terma yang tinggi daripada ZnONPs. ESR mendedahkan kehadiran kekosongan oksigen dalam ZnONPs, yang memainkan peranan penting dalam proses pelunturan pewarna sintetik. Kehadiran 5% ZnONPs sebagai pemangkin bawah pendedahan kepada 10 W lampu UV dapat meluntukan 10 ppm MO dalam 5 jam dan MB dalam 3 jam secara efektif. Seterusnya, ZnONPs

menunjukkan ciri-ciri anti-oksida dan anti-bakteria yang tinggi, terutamanya dengan kewujudan sebatian fenolik. Asai Artemia sp. menemukan ZnONPs mengandungi toksik yang rendah mempnya potensi untuk kerja sebagai agen rawatan air. Kesimpulannya, untuk kegunaan famasi dan industry, ZnONPs dapat diperluaskan.

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LIST OF ABBREVIATIONS

UPM	Universiti Putra Malaysia
UKM	Universiti Kebangsaan Malaysia
Kyutech	Kyushu Institute of Technology
ZnONPs	Zinc Oxide Nanoparticles
ZnO (O)	Synthesized Zinc Oxide Nanoparticles with Oil Palm Leaf
ZnO (R)	Synthesized Zinc Oxide Nanoparticles with Roselle Flower
ZnO (B)	Synthesized Zinc Oxide Nanoparticles without Extract
DPPH	2,2-diphenyl-1-picryl-hydrazyl-hydrate
MO	Methyl Orange
MB	Methylene Blue
CB	Conduction Band
VB	Valence Band
1D	One-Dimensional Structure
2D	Two-Dimensional Structure
3D	Three-Dimensional Structure
SEM	Scanning Electron Microscope
EDX	Energy Dispersive X-ray
FE-SEM	Field Emission Electron Microscope
TEM	Transmission Electron Microscope
XRD	X-ray Diffraction
DLS	Dynamic Light Scattering
UV-Vis	Ultraviolet- visible Spectroscopy
FTIR	Fourier Transform Infrared Spectroscopy

TGA	Thermogravimetric Analysis
ESR	Electron Spin Resonance
GC-MS	Gas Chromatography-Mass Spectroscopy
KBr	Potassium bromide
Cu K- α	Copper K-Alpha
UV	Ultraviolet

CHAPTER 1

INTRODUCTION

1.1 Background of Study

A large number of researches had been done on the field of nanotechnology. They have diverse applications in medicine, biology, physics, chemistry, and material sciences (Chaudhuri & Malodia, 2017). Nanoparticles define as particles having at least one dimension with the size range of 1 nm to 100 nm (Boholm & Arvidsson, 2016). High surface area and nanoscale size increased their exposure as part of daily life. They were used as drug delivery, cosmetics, food packaging, therapeutics, and to name a few (Gatoo *et al.*, 2014).

Zinc oxide, an inorganic compound, is said to be one of the most exploited metal oxides. It was explored extensively by researchers due to simplicity, rapidity, and unique properties (Pholnak *et al.*, 2011). They are found in white powder form and insoluble in water (Chaudhuri & Malodia, 2017). In the biological field, zinc oxide nanoparticles (ZnONPs) are applied as drug delivery, nanomedicine, biological sensing, and biological labelling. They have antibacterial, antifungal, antidiabetic, and variety potential (Bala *et al.*, 2015).

Fascinating researches had done to synthesize nanoparticles in the most simply and cost-effectively way. It can be synthesized in conventional and non-conventional methods with the theory of top-down and bottom-up. In these decades, green synthesis is desirable compared to chemical and physical synthesis. Green synthesis provides high efficiency, ecologically, and reproducible (Jin & Jin, 2019). In green synthesis, the production of ZnONPs is accomplished with plant extracts or living organisms, such as algae and fungi (Zelechowska, 2014). During the synthesis process, plant extract or biological agents act as reducing agents.

Medicinal plants are frequently used as antimicrobial and antifungal agents. They are introduced to replace the usage of antibiotics that may bring adverse effects to the environment. Oil palm leaf was chosen as one of the green products in this research. They pose high antimicrobial, anticancer, and antifungal potential (Rajoo *et al.*, 2013). Malaysia is the second-largest producer of palm oil in the world. The crop is nominated as “golden crop” in Malaysia (Pohl & Loong, 2016). However, the biowaste of the oil palm tree which include leaves were left aside without further management (Nordin *et al.*, 2016). In this research, oil palm leaf was used to synthesize ZnONPs with a green method. From the findings, a new achievement was successfully approached.

Besides, roselle flower, also known as *Hibiscus sabdariffa* Linn, is a common bright red shrub. It is facile to find worldwide. Roselle flowers contain high phenolics, flavonoids, and anthocyanidins (Villasante *et al.*, 2019). Riching of active compounds made them used in various sectors. It can be a source of natural colouring, antimicrobial, antifungal, antidiabetic and anti-cholesterol agents (Bariyyah *et al.*, 2019). They can inhibit Gram-negative and Gram-positive bacteria (Borrás-Linares *et al.*, 2015).

The aims of this study were synthesizing and characterizing ZnONPs with and without plant extracts. Besides, the potentials of ZnONPs photocatalytic, antibacterial and antioxidants were tested. Their acute toxicity had also been investigated to ensure the safety of use.

1.2 Problem Statement

Bacteria is abundant in nature. Harmless bacteria colonized on human skin. However, overgrowth of these bacteria may risk human health. For instance, *Staphylococcus aureus* will cause skin disease and infections (Hay & Morris‐Jones, 2016). Besides, living organisms like *Escherichia coli*, *Aspergillus*, and *fusarium* will lead to water contamination (Graça *et al.*, 2016; Richardson & Rautemaa-Richardson, 2019). These phenomena bring rapid and large fluctuations to the environment and health effects. In this case, these culprits frequently fight by antibiotics. However, extensively used of antibiotics is risky to human health. It may enhance the selective pressure on infectious bacteria. It will also have adverse effects on natural bacterial diversity (Bighiu *et al.*, 2019).

Methyl orange (MO) dye, $C_{14}H_{14}N_3NaO_3S$, is an orange colour synthetic dye used in various textile industries, leather industries, and paper printing. Nevertheless, MO has adverse effects on the environment and human body (Bhatia & Verma, 2017). Methylene blue (MB), $C_{16}H_{18}ClN_3S$, is a blue colour basic synthetic dye that is extensively utilized in medical treatment. Principally, MB is used to eliminate malaria due to its attractive features (Weitzel *et al.*, 2017). Indeed, the toxicity of MB is low. However, the complex aromatic in dye provides stability against biodegradation in aquatic ecosystem. The sunlight will be obstructed and not manage to penetrate the water. This circumstance will retard the growth of aquatic living (Cengiz & Cavas, 2008). To date, various nanoparticles developed as photocatalyst in photocatalytic activity.

In this case, a shortage of researches looks over the impact and the risk of nanoparticles, especially towards aquatic systems. Most of the materials will release into marine systems. This action will indirectly cause the aquatic system as inevitable receptacles (Rekulapally *et al.*, 2019). One of the efficient and straightforward acute toxicity tests of nanoparticles is using brine shrimp, *Artemia* species. This assay was implemented by estimating the mortality and hatching rate of brine shrimps.

Most of the common physical and chemical methods implemented to synthesize metal oxide are complicated. In chemical synthesis, toxic and expensive chemical might be involved during the synthesis process. The produced ZnONPs by this non-environmentally friendly path may lead to pollution and detrimental to human being health. Moreover, most of the physical synthesis of metal oxide nanoparticles requires higher energy compared to chemical and biological methods. These include higher-energy ball milling and calcination at high temperature. The steps involve are not energy-saving and are relatively more expensive compare to green synthesis. Therefore, numerous researches undergo producing metal oxide nanoparticles, which is environmentally friendly.

1.3 Significant of Research

A significant way to produce ZnONPs with plant extract with a shorter time and simpler way had been introduced. Environmentally benign materials and renewable of reaction materials had been implemented. The process requires low cost to produce small size with high purity nanoparticles within short reaction times. Besides, synthesized ZnONPs may develop for pharmaceutical uses and wastewater treatment.

1.4 Objectives

The objectives of this research are:

1. To synthesize ZnONPs with and without plant extracts by co-precipitation method.
2. To study the morphological, optical and structural properties of synthesized ZnONPs.
3. To elucidate the potential of synthesized ZnONPs in antioxidant, antibacterial and photocatalytic activity.
4. To evaluate the toxicity of synthesized ZnONPs using brine shrimp (*Artemia* sp) lethality and hatching assay.

1.5 Structure of the Thesis

Chapter 1 gives a brief introduction to the research, significance and structure of thesis study. In **Chapter 2**, reviews of properties of zinc oxide nanoparticles (ZnONPs), the way to synthesize the metal oxide and detailed information on the plants used in the research were presented. This chapter discusses the advancing activities of the synthesized ZnONPs to show their potential on antioxidant, photocatalytic, antibacterial and antifungal.

Chapter 3 presents the materials, analytical instruments used and the experimental procedures during the research. **Chapter 4** discusses the outcome from each of the analytical characterizations and exhibits the potential of ZnONPs in antioxidant and photocatalytic activity. In the final chapter, **Chapter 5** encapsulates the findings of the whole thesis.

REFERENCES

Abdelhakim, H., El-Sayed, E., & Rashidi, F. (2020). Biosynthesis of zinc oxide nanoparticles with antimicrobial, anticancer, antioxidant and photocatalytic activities by the endophytic Alternaria tenuissima. *Journal of applied microbiology, 128*(6), 1634-1646.

Abdelkhalek, A., & Al-Askar, A. A. (2020). Green synthesized ZnO nanoparticles mediated by *Mentha Spicata* extract induce plant systemic resistance against Tobacco mosaic virus. *Applied Sciences, 10*(15), 5054.

Abdullah, F., Bakar, N. A., & Bakar, M. A. J. O. (2020). Low temperature biosynthesis of crystalline zinc oxide nanoparticles from *Musa acuminata* peel extract for visible-light degradation of methylene blue. *Optik, 206*, 164279.

Acosta-Humánez, F., Pitalúa, R. C., & Almanza, O. (2013). Electron paramagnetic resonance in Zn1− xCoxO. *Journal of magnetism and magnetic materials, 329*, 39-42.

Acosta-Humánez, M., Montes-Vides, L., & Almanza-Montero, O. (2016). Sol-gel synthesis of zinc oxide nanoparticle at three different temperatures and its characterization via XRD, IR and EPR. *Dyna, 83*(195), 224-228.

Afanasyev, S., Kychkina, T., & Savvinova, L. (2019). *Scanning electron microscope (advantages and disadvantages).* Paper presented at the Colloquium-journal.

Agarwal, H., Kumar, S. V., & Rajeshkumar, S. (2017). A review on green synthesis of zinc oxide nanoparticles–An eco-friendly approach. *Resource-Efficient Technologies, 3*(4), 406-413.

AL-Asady, Z. M., AL-Hamdani, A. H., & Hussein, M. A. (2020). *Study the optical and morphology properties of zinc oxide nanoparticles.* Paper presented at the AIP Conference Proceedings.

Alamdari, S., Sasani Ghamsari, M., Lee, C., Han, W., Park, H.-H., Tafreshi, M. J., Afarideh, H., & Ara, M. H. M. (2020). Preparation and Characterization of Zinc Oxide Nanoparticles Using Leaf Extract of *Sambucus ebulus*. *Applied Sciences, 10*(10), 3620.

Aldalbahi, A., Alterary, S., Ali Abdullrahman Almoghim, R., Awad, M. A., Aldosari, N. S., Fahad Alghannam, S., Nasser Alabdan, A., Alharbi, S., Ali Mohammed Alateeq, B., & Abdulrahman Al Mohsen, A. (2020). Greener Synthesis of Zinc Oxide Nanoparticles: Characterization and Multifaceted Applications. *Molecules, 25*(18), 4198.

Ali, A., Phull, A.-R., & Zia, M. (2018). Elemental zinc to zinc nanoparticles: Is ZnO NPs crucial for life? Synthesis, toxicological, and environmental concerns. *Nanotechnology Reviews, 7*(5), 413-441.

Alrubaie, E. A. A.-A., & Kadhim, R. E. (2019). Synthesis of Zno Nanoparticles from Olive Plant Extract. *Plant Archives, 19*(2), 339-344.

Ambika, S., & Sundrarajan, M. (2015). Antibacterial behaviour of *Vitex negundo* extract assisted ZnO nanoparticles against pathogenic bacteria. *Journal of photochemistry and photobiology B: biology, 146*, 52-57.

Amirkhanlou, S., Ketabchi, M., & Parvin, N. (2012). Nanocrystalline/nanoparticle ZnO synthesized by high energy ball milling process. *Materials letters, 86*, 122-124.

Antoniadis, A., Takavakoglou, V., Zalidis, G., Darakas, E., & Poulios, I. J. C. t. (2010). Municipal wastewater treatment by sequential combination of photocatalytic oxidation with constructed wetlands. *Catalysis Today, 151*(1-2), 114-118.

Arpita, M., & Banerjee, D. K. (2017). Review on amaging benefits of roseelle (*Hibiscus Sabdarifaa* L) and their uses. *Word journal of pharmacy and pharmaceutical sciences, 6*(7), 217-227.

Arya, V. (2010). Living Systems: eco-friendly nanofactories. *Digest Journal of Nanomaterials and Biostructures, 5*(1), 9-21.

Ashrafi, A., & Jagadish, C. (2007). Review of zincblende ZnO: Stability of metastable ZnO phases. *Journal of Applied Physics, 102*(7), 4.

Awwad, A. M., Amer, M. W., Salem, N. M., & Abdeen, A. O. (2020). Green synthesis of zinc oxide nanoparticles (ZnO-NPs) using *Ailanthus altissima* fruit extracts and antibacterial activity. *Chemistry International, 6*(3), 151-159.

Azad, K., & Gajanan, P. (2017). Photodegradation of methyl orange in aqueous solution by the visible light active Co: La: TiO2 nanocomposite. *Chemical Sciences Journal, 8*(164).

Azam, A., & Babkair, S. S. (2014). Low-temperature growth of well-aligned zinc oxide nanorod arrays on silicon substrate and their photocatalytic application. *International journal of nanomedicine, 9*, 2109.

Babushkin, V., Spiridonov, A., & Kozhukhar, A. (2016). Application of NIR and FTIR in food analysis. *Journal of Physical Science and Application, 6*(2), 47-50.

Bai, C., & Tang, M. (2020). Toxicological study of metal and metal oxide nanoparticles in zebrafish. *Journal of Applied Toxicology, 40*(1), 37-63.

Bala, N., Saha, S., Chakraborty, M., Maiti, M., Das, S., Basu, R., & Nandy, P. (2015). Green synthesis of zinc oxide nanoparticles using *Hibiscus subdariffa* leaf extract: effect of temperature on synthesis, anti-bacterial activity and anti-diabetic activity. *RSC Advances, 5*(7), 4993-5003.

Balouiri, M., Sadiki, M., & Ibnsouda, S. K. (2016). Methods for in vitro evaluating antimicrobial activity: A review. *Journal of Pharmaceutical Analysis, 6*(2), 71-79.

Bariyyah, S. K., Prajitno, A., & Yuniarti, A. (2019). Phytochemical screening and antimicrobial activity of roselle (*Hibiscus sabdariffa* L.) Flower Extract Against *Aeromonas hydrophila*. *The Journal of Experimental Life Science, 9*(2), 65-69.

Battez, A. H., González, R., Viesca, J., Fernández, J., Fernández, J. D., Machado, A., Chou, R., & Riba, J. (2008). CuO, ZrO2 and ZnO nanoparticles as antiwear additive in oil lubricants. *Wear, 265*(3-4), 422-428.

Bello, M. A., Ruiz-León, Y., Sandoval-Sierra, J. V., Rezinciuc, S., & Diéguez-Uribeondo, J. J. J. (2017). Scanning electron microscopy (SEM) protocols for problematic plant, oomycete, and fungal samples. *Journal of Visualized Experiments*(120), 55031.

Bharadwaj, N., & Sharma, A. (2016). Detection of *Escherichia coli*, *Staphylococcus aureus* and *salmonella typhi* in drinking water of government institutions and organizations of gwalior city. *International Journal of Engineering Sciences & Research Technology, 5*(7), 769-774.

Bhatia, S., & Verma, N. (2017). Photocatalytic activity of ZnO nanoparticles with optimization of defects. *Materials Research Bulletin, 95*, 468-476.

Bighiu, M. A., Haldén, A. N., Goedkoop, W., & Ottoson, J. (2019). Assessing microbial contamination and antibiotic resistant bacteria using zebra mussels (*Dreissena polymorpha*). *Science of the total Environment, 650*, 2141-2149.

Bitenc, M., & Orel, Z. C. (2009). Synthesis and characterization of crystalline hexagonal bipods of zinc oxide. *Materials Research Bulletin, 44*(2), 381-387.

Boholm, M., & Arvidsson, R. (2016). A definition framework for the terms nanomaterial and nanoparticle. *NanoEthics, 10*(1), 25-40.

Bonef, B., Lopez-Haro, M., Amichi, L., Beeler, M., Grenier, A., Robin, E., Jouneau, P.-H., Mollard, N., Mouton, I., & Haas, B. (2016). Composition analysis of III-nitrides at the nanometer scale: Comparison of energy dispersive X-ray spectroscopy and atom probe tomography. *Nanoscale Research Letters, 11*(461), 1-6.

Borrás-Linares, I., Fernández-Arroyo, S., Arráez-Roman, D., Palmeros-Suárez, P., Del Val-Díaz, R., Andrade-Gonzáles, I., Fernández-Gutiérrez, A., Gómez-Leyva, J., & Segura-Carretero, A. (2015). Characterization of phenolic compounds, anthocyanidin, antioxidant and antimicrobial activity of 25 varieties of Mexican Roselle (*Hibiscus sabdariffa*). *Industrial Crops and Products, 69*, 385-394.

Brus, L. (1986). Electronic wave functions in semiconductor clusters: experiment and theory. *The Journal of Physical Chemistry, 90*(12), 2555-2560.

Cambrussi, A. N. C. O., Morais, A. Í. S., Neris, A. d. M., Osajima, J. A., Silva Filho, E. C. d., & Ribeiro, A. B. (2019). Photodegradation study of TiO2 and ZnO in suspension using miniaturized tests. *Matéria (Rio de Janeiro), 24*(4).

Caraciuc, D. P., Telcian, A., Burlibașa, L., Lungu, M. V., Gheorghe, I., Marutescu, L., & Chifiriuc, M. C. Toxicity of zinc oxide and silver nanoparticles – an overview. *Letters in Applied NanoBioScience, 6*(1), 488-493.

Cengiz, S., & Cavas, L. (2008). Removal of methylene blue by invasive marine seaweed: *Caulerpa racemosa* var. cylindracea. *Bioresource technology, 99*(7), 2357-2363.

Chakrabarti, T., Khanda, A., Jana, A., & Sarkar, S. K. (2017). *Modeling of ZnO based HIT solar cells with comparative analysis.* Paper presented at the 2017 IEEE International Conference on Power, Control, Signals and Instrumentation Engineering (ICPCSI).

Chanayath, N., Lhieochaiphant, S., & Phutrakul, S. (2002). Pigment extraction techniques from the leaves of *Indigofera tinctoria* Linn. and *Baphicacanthus cusia* Brem. and chemical structure analysis of their major components. *J Chiang Mai University Journal 1*(2), 149-160.

Chaudhary, A., Kumar, N., Kumar, R., & Salar, R. K. (2019). Antimicrobial activity of zinc oxide nanoparticles synthesized from Aloe vera peel extract. *SN Applied Sciences, 1*(1), 136.

Chaudhuri, S. K., & Malodia, L. (2017). Biosynthesis of zinc oxide nanoparticles using leaf extract of *Calotropis gigantea*: characterization and its evaluation on tree seedling growth in nursery stage. *Applied Nanoscience, 7*(8), 501-512.

Chauhan, A., & Chauhan, P. J. J. A. B. T. (2014). Powder XRD technique and its applications in science and technology. *5*(5), 1-5.

Chiu, W., Khiew, P., Cloke, M., Isa, D., Tan, T., Radiman, S., Abd-Shukor, R., Hamid, M. A., Huang, N., & Lim, H. (2010). Photocatalytic study of two-dimensional ZnO nanopellets in the decomposition of methylene blue. *Chemical Engineering Journal, 158*(2), 345-352.

Chong, M. N., Jin, B., Chow, C. W., & Saint, C. (2010). Recent developments in photocatalytic water treatment technology: a review. *Water Research, 44*(10), 2997-3027.

D'Antoni, B., Iracà, F., & Romero, M. (2017). Current treatment technologies and practical approaches on textile wastewater dyes removal. *J Panta Rei Srl-Water Solutions*, 1-10.

Dąbrowski, A. (2001). Adsorption—from theory to practice. *Advances in colloid and interface science, 93*(1-3), 135-224.

Dai, Z. R., Pan, Z. W., & Wang, Z. (2003). Novel nanostructures of functional oxides synthesized by thermal evaporation. *Advanced Functional Materials, 13*(1), 9-24.

Danaei, M., Dehghankhold, M., Ataei, S., Hasanzadeh Davarani, F., Javanmard, R., Dokhani, A., Khorasani, S., & Mozafari, M. (2018). Impact of particle size and polydispersity index on the clinical applications of lipidic nanocarrier systems. *Pharmaceutics, 10*(2), 57.

Dhanjal, N., Cox, I., & Taylor-Robinson. (2003). *In vivo* electron spin resonance spectroscopy: what use is it to gastroenterologists? *52*(9), 1236-1237.

Divya, M., Sowmia, C., Joona, K., & Dhanya, K. (2013). Synthesis of zinc oxide nanoparticle from Hibiscus rosa-sinensis leaf extract and investigation of its antimicrobial activity. *Res. J. Pharm. Biol. Chem, 4*(2), 1137-1142.

Dodd, A., McKinley, A., Saunders, M., & Tsuzuki, T. (2006). Effect of particle size on the photocatalytic activity of nanoparticulate zinc oxide. *Journal of Nanoparticle Research, 8*(1), 43.

dos Santos Monteiro, E., de Souza Soares, F. M., Nunes, L. F., Santana, A. I. C., de Biasi, R. S., & Elias, C. N. (2020). Comparison of the wettability and corrosion resistance of two biomedical Ti alloys free of toxic elements with those of the commercial ASTM F136 (Ti–6Al–4V) alloy. *Journal of Materials Research Technology, 9*(6), 16329-16338.

Duan, X., Yuan, M., Ou, K., Duan, W., Yi, L., & Zhang, X. (2020). Synthesis process dependent white LPL in Zn2GeO4 ceramic and the long afterglow mechanism. *Materials Today Communications, 24*, 100915.

Dulta, K., Ağçeli, G. K., Chauhan, P., Jasrotia, R., & Chauhan, P. (2021). A novel approach of synthesis zinc oxide nanoparticles by *bergenia ciliata* rhizome extract: antibacterial and anticancer potential. *Journal of Inorganic Organometallic Polymers, 31*(1), 180-190.

Eberhardt, K., Stiebing, C., Matthäus, C., Schmitt, M., & Popp, J. (2015). Advantages and limitations of Raman spectroscopy for molecular diagnostics: an update. *Expert review of molecular diagnostic, 15*(6), 773-787.

Eker, G., & Hatipoglu, M. (2019). Effect of UV wavelength, temperature and photocatalyst on the removal of PAHs from industrial soil with photodegradation applications. *Environmental technology, 40*(28), 3793-3803.

El-Belely, E. F., Farag, M., Said, H. A., Amin, A. S., Azab, E., Gobouri, A. A., & Fouda, A. (2021). Green Synthesis of Zinc Oxide Nanoparticles (ZnO-NPs) Using *Arthrospira platensis* (Class: Cyanophyceae) and Evaluation of their Biomedical Activities. *%J Nanomaterials, 11*(1), 95.

El-Kader, F. A., Hakeem, N., Elashmawi, I., & Ismail, A. (2013). Structural, optical and thermal characterization of ZnO nanoparticles doped in PEO/PVA blend films. *Aust. J. Basic Appl. Sci, 7*(10), 608-619.

El-Magsodi, M. O., Bossier, P., Sorgeloos, P., & Van Stappen, G. (2016). Effect of light colour, timing, and duration of light exposure on the hatchability of *Artemia* spp.(Branchiopoda: Anostraca) eggs. *Journal of Crustacean Biology, 36*(4), 515-524.

Elaine, L., & Chong, K. (2015). Antimicrobial activity of *Elaeis guineensis* leaf extract against *Ganoderma boninense* of oil palm basal stem rot. *Pakistan Journal of Botany, 47*(4), 1593-1597.

Eljiedi, A. A. A., & Kamari, A. (2017). *Removal of Methyl Orange and Methylene Blue Dyes from Aqueous Solution using Lala Clam (Orbicularia Orbiculata) Shell.* Paper presented at the AIP Conference Proceedings.

Emil, E., Alkan, G., Gurmen, S., Rudolf, R., Jenko, D., & Friedrich, B. (2018). Tuning the morphology of ZnO nanostructures with the ultrasonic spray pyrolysis process. *Metals, 8*(8), 569.

Espitia, P. J. P., Soares, N. d. F. F., dos Reis Coimbra, J. S., de Andrade, N. J., Cruz, R. S., & Medeiros, E. A. A. (2012). Zinc oxide nanoparticles: synthesis, antimicrobial activity and food packaging applications. *Food bioprocess technology, 5*(5), 1447-1464.

Espitia, P. J. P., Soares, N. d. F. F., Teófilo, R. F., dos Reis Coimbra, J. S., Vitor, D. M., Batista, R. A., Ferreira, S. O., de Andrade, N. J., & Medeiros, E. A. A. (2013). Physical–mechanical and antimicrobial properties of nanocomposite films with pediocin and ZnO nanoparticles. *Carbohydrate Polymers, 94*(1), 199-208.

Ezealisiji, K. M., Siwe-Noundou, X., Maduelosi, B., Nwachukwu, N., & Krause, R. W. M. (2019). Green synthesis of zinc oxide nanoparticles using *Solanum torvum* (L) leaf extract and evaluation of the toxicological profile of the ZnO nanoparticles–hydrogel composite in Wistar albino rats. *International Nano Letters, 9*(2), 99-107.

Ezenwa, I. (2012). Synthesis and optical characterization of zinc oxide thin film. *Research Journal of Chemical Sciences ISSN, 2231*, 606X.

Fakhari, S., Jamzad, M., & Kabiri Fard, H. (2019). Green synthesis of zinc oxide nanoparticles: a comparison. *Green chemistry letters reviews, 12*(1), 19-24.

Ferreira-Neto, E. P., Worsley, M. A., & Rodrigues-Filho, U. P. (2019). Towards thermally stable aerogel photocatalysts: TiCl4-based sol-gel routes for the design of nanostructured silica-titania aerogel with high photocatalytic activity and outstanding thermal stability. *Journal of Environmental Chemical Engineering, 7*(5), 103425.

Fraise, A., Wilkinson, M., Bradley, C., Oppenheim, B., & Moiemen, N. (2013). The antibacterial activity and stability of acetic acid. *Journal of Hospital Infection, 84*(4), 329-331.

Fukushima, H., Kozu, T., Shima, H., Funakubo, H., Uchida, H., Katoda, T., & Nishida, K. (2015). *Evaluation of oxygen vacancy in ZnO using Raman spectroscopy.* Paper presented at the 2015 Joint IEEE International Symposium on the Applications of Ferroelectric (ISAF), International Symposium on Integrated Functionalities (ISIF), and Piezoelectric Force Microscopy Workshop (PFM).

Gambardella, C., Mesarič, T., Milivojević, T., Sepčić, K., Gallus, L., Carbone, S., Ferrando, S., & Faimali, M. (2014). Effects of selected metal oxide nanoparticles on *Artemia salina* larvae: evaluation of mortality and behavioural and biochemical responses. *Environmental monitoring and assessment, 186*(7), 4249-4259.

Garibo, D., Borbón-Nuñez, H. A., de León, J. N. D., Mendoza, E. G., Estrada, I., Toledano-Magaña, Y., Tiznado, H., Ovalle-Marroquin, M., Soto-Ramos, A. G., & Blanco, A. (2020). Green synthesis of silver nanoparticles using *Lysiloma acapulcensis* exhibit high-antimicrobial activity. *Scientific reports, 10*(1), 1-11.

Gatoo, M. A., Naseem, S., Arfat, M. Y., Mahmood Dar, A., Qasim, K., & Zubair, S. (2014). Physicochemical properties of nanomaterials: implication in associated toxic manifestations. *BioMed research international, 2014*.

Geetha, M., Nagabhushana, H., Shivananjaiah, H. J. J. o. S. A. M., & Devices. (2016). Green mediated synthesis and characterization of ZnO nanoparticles using Euphorbia Jatropa latex as reducing agent. *1*(3), 301-310.

Getie, S., Belay, A., Chandra Reddy, A., & Belay, Z. (2017). Synthesis and characterizations of zinc oxide nanoparticles for antibacterial applications. *Nanomed. Nanotechnol. S, 8*, 004.

Ghoreishi, S., & Haghighi, R. (2003). Chemical catalytic reaction and biological oxidation for treatment of non-biodegradable textile effluent. *Chemical Engineering Journal, 95*(1-3), 163-169.

Graça, M. G., van der Heijden, I. M., Perdigão, L., Taira, C., Costa, S. F., & Levin, A. S. (2016). Evaluation of two methods for direct detection of *Fusarium* spp. in water. *Journal of microbiological methods, 123*, 39-43.

Greenwood, N., & Earnshaw, A. (1997). *Chemistry of the Elements 2nd Edition*: Butterworth-Heinemann.

Gupta, P., & Ramrakhiani, M. (2009). Influence of the particle size on the optical properties of CdSe nanoparticles. *The Open Nanoscience Journal, 3*(1).

Haafiz, M. M., Hassan, A., Khalil, H. A., & Hossain, M. S. (2015). Comparing the effects of microcrystalline cellulose and cellulose nanowhiskers extracted from oil palm empty fruit bunch on mechanical and thermal properties of polylactic acid composites. In *Fillers and Reinforcements for Advanced Nanocomposites* (pp. 27-40): Elsevier.

Hai-Bo, F., Xin-Liang, Z., Si-Cheng, W., Zhi-Gang, L., & He-Bao, Y. (2012). Zn/O ratio and oxygen chemical state of nanocrystalline ZnO films grown at different temperatures. *Chinese Physics B, 21*(3), 038101.

Hammadi, A. H., Habeeb, S. A., Al-Jibouri, L. F., & Hussien, F. H. (2020). Synthesis, Characterization and Biological Activity of Zinc Oxide Nanoparticles (ZnO NPs). *Systematic Reviews in Pharmacy, 11*(5), 431-439.

Hasnidawani, J., Azlina, H., Norita, H., Bonnia, N., Ratim, S., & Ali, E. (2016). Synthesis of ZnO nanostructures using sol-gel method. *Procedia Chemistry, 19*, 211-216.

Hassan, S. S., El Azab, W. I., Ali, H. R., & Mansour, M. S. (2015). Green synthesis and characterization of ZnO nanoparticles for photocatalytic degradation of anthracene. *Advances in Natural Sciences: Nanoscience and Nanotechnology, 6*(4), 045012.

Hay, R. J., & Morris-Jones, R. (2016). Bacterial infections. *Rook's Textbook of Dermatology, Ninth Edition*, 1-100.

Heideman, G., Noordermeer, J. W., Datta, R. N., & van Baarle, B. (2006). *Various ways to reduce zinc oxide levels in S-SBR rubber compounds.* Paper presented at the Macromolecular symposia.

Helen, S. M., & Rani, M. H. E. (2015). Characterization and antimicrobial study of nickel nanoparticles synthesized from *dioscorea* (Elephant Yam) by green route. *Research Journal of Chemical Sciences, 4*(11), 216-219.

Holder, C. F., & Schaak, R. E. (2019). Tutorial on powder X-ray diffraction for characterizing nanoscale materials. In: ACS Publications.

Iqbal, J., Abbasi, B. A., Mahmood, T., Kanwal, S., Ahmad, R., & Ashraf, M. (2019). Plant-extract mediated green approach for the synthesis of ZnONPs: Characterization and evaluation of cytotoxic, antimicrobial and antioxidant potentials. *Journal of Molecular Structure, 1189*, 315-327.

Iskandar, F. (2009). Nanoparticle processing for optical applications–A review. *Advanced Powder Technology, 20*(4), 283-292.

Ja'afar, N. L., Teng, C. P., Rosmi, N. S. A. M., Rambli, S. N. A., Shafie, N. H., Arapoc, D. J., & Bahari, H. (2019). Total antioxidant activity and enzymatic inhibition against alpha-amylase, alpha-glucosidase and pancreatic lipase of irradiated *archidendron bubalinum*. *Mal J Med Health, Sci 15*(SP1), 120-128.

Jang, J., Hur, H. G., Sadowsky, M. J., Byappanahalli, M., Yan, T., & Ishii, S. (2017). Environmental *Escherichia coli:* ecology and public health implications—a review. *Journal of applied microbiology, 123*(3), 570-581.

Javed, Y., Ali, K., Akhtar, K., Hussain, M. I., Ahmad, G., & Arif, T. (2018). TEM for atomic-scale study: Fundamental, instrumentation, and applications in nanotechnology. In *Handbook of materials characterization* (pp. 147-216): Springer.

Jayappa, M. D., Ramaiah, C. K., Kumar, M. A. P., Suresh, D., Prabhu, A., Devasya, R. P., & Sheikh, S. (2020). Green synthesis of zinc oxide nanoparticles from the leaf, stem and *in vitro* grown callus of *Mussaenda frondosa* L.: characterization and their applications. *Applied Nanoscience*, 1-18.

Jayaseelan, C., Rahuman, A. A., Kirthi, A. V., Marimuthu, S., Santhoshkumar, T., Bagavan, A., Gaurav, K., Karthik, L., & Rao, K. B. (2012). Novel microbial route to synthesize ZnO nanoparticles using *Aeromonas hydrophila* and their activity against pathogenic bacteria and fungi. *Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy, 90*, 78-84.

Jha, A. K., & Prasad, K. (2016). Synthesis of ZnO nanoparticles from goat slaughter waste for environmental protection. *International Journal of Current Engineering and Technology, 6*(1), 147-151.

Ji, W., Zhu, D., Chen, Y., Hu, J., & Li, F. (2017). *In-vitro* cytotoxicity of biosynthesized Zinc oxide nanoparticles towards cardiac cell lines of Catla catla.

Jiang, J., Pi, J., & Cai, J. (2018). The advancing of zinc oxide nanoparticles for biomedical applications. *Bioinorganic chemistry and applications, 2018*.

Jin, S.-E., & Jin, H.-E. (2019). Synthesis, characterization, and three-dimensional structure generation of zinc oxide-based nanomedicine for biomedical applications *Pharmaceutics, 11*(11), 575.

Kalita, N. K., & Ganguli, J. N. (2017). *Hibiscus sabdariffa* L. leaf extract mediated green synthesis of silver nanoparticles and its use in catalytic reduction of 4-nitrophenol. *Inorganic and Nano-Metal Chemistry, 47*(5), 788-793.

Kalluri, J. R., Arbneshi, T., Afrin Khan, S., Neely, A., Candice, P., Varisli, B., Washington, M., McAfee, S., Robinson, B., & Banerjee, S. (2009). Use of gold nanoparticles in a simple colorimetric and ultrasensitive dynamic light scattering assay: selective detection of arsenic in groundwater. *Angewandte Chemie, 121*(51), 9848-9851.

Karaköse, E., Çolak, H., & Duman, F. (2017). Green synthesis and antimicrobial activity of ZnO nanostructures *Punica granatum* shell extract. *Green Processing Synthesis, 6*(3), 317-323.

Kato, N. I. (2004). Reducing focused ion beam damage to transmission electron microscopy samples. *Journal of electron microscopy, 53*(5), 451-458.

Katwal, G., Rao, B. M., & Varghese, O. (2017). Visible light photoelectrochemical performance of zinc oxide nanotube-nanorod hybrid structure. *Bulletin of the American Physical Society, 62*.

Kaur, S., & Choudhury, D. G. (2017). *Synthesis and characterization of ZnO and clay supported ZnO nanoparticles and their catalytic and antibacterial applications.*

Kazeminezhad, I., & Sadollahkhani, A. (2016). Influence of pH on the photocatalytic activity of ZnO nanoparticles. *Journal of Materials Science: Materials in Electronics, 27*(5), 4206-4215.

Kerzig, C., & Wenger, O. S. (2019). Reactivity control of a photocatalytic system by changing the light intensity. *Chemical Sciences Journal, 10*(48), 11023-11029.

Khalil, A. T., Ovais, M., Ullah, I., Ali, M., Shinwari, Z. K., Khamlich, S., & Maaza, M. (2017). *Sageretia thea* (Osbeck.) mediated synthesis of zinc oxide nanoparticles and its biological applications. *Nanomedicine, 12*(15), 1767-1789.

Khanal, D. P., Aryal, S., & Aryal, S. (2020). Characterization, and Anti-microbial Properties of Zinc Oxide Nanoparticles Synthesized Using Citrus sinensis (L.) Osbeck Peel Extract. *bioRxiv*.

Khoshnood, R., Jaafarzadeh, N., Jamili, S., Farshchi, P., & Taghavi, L. (2017). Acute toxicity of TiO2, CuO and ZnO nanoparticles in brine shrimp, *Artemia franciscana*. *Iranian Journal of Fisheries Sciences, 16*(4), 1287-1296.

Klaus-Joerger, T., Joerger, R., Olsson, E., & Granqvist, C.-G. (2001). Bacteria as workers in the living factory: metal-accumulating bacteria and their potential for materials science. *TRENDS in Biotechnology, 19*(1), 15-20.

Kohno, M. (2010). Applications of electron spin resonance spectrometry for reactive oxygen species and reactive nitrogen species research. *Journal of clinical biochemistry*.

Kokabi, M., Yousefzadi, M., Nejad Ebrahimi, S., & Zarei, M. (2017). Green synthesis of zinc oxide nanoparticles using seaweed aqueous extract and evaluation of antibacterial and ecotoxicological activity. *Journal of the Persian Gulf, 8*(27), 61-72.

Kołodziejczak-Radzimska, A., & Jesionowski, T. (2014). Zinc oxide—from synthesis to application: a review. *Materials, 7*(4), 2833-2881.

Kosanić, M., Ranković, B., Rančić, A., Stanojković, T., & analysis, d. (2016). Evaluation of metal concentration and antioxidant, antimicrobial, and anticancer potentials of two edible mushrooms *Lactarius deliciosus* and *Macrolepiota procera*. *Journal of Food Processing and Technology, 24*(3), 477-484.

Kosmulski, M. (2018). The pH dependent surface charging and points of zero charge. VII. Update. *Advances in colloid and interface science, 251*, 115-138.

Krone, N., Hughes, B. A., Lavery, G. G., Stewart, P. M., Arlt, W., & Shackleton, C. H. (2010). Gas chromatography/mass spectrometry (GC/MS) remains a pre-eminent discovery tool in clinical steroid investigations even in the era of fast liquid chromatography tandem mass spectrometry (LC/MS/MS). *The Journal of steroid biochemistry and molecular biology, 121*(3-5), 496-504.

Kumar, A., & Pandey, G. (2017). A review on the factors affecting the photocatalytic degradation of hazardous materials. *Mater. Sci. Eng. Int. J, 1*(3), 1-10.

Kumar, B., Smita, K., Cumbal, L., & Debut, A. (2014a). Green approach for fabrication and applications of zinc oxide nanoparticles. *Bioinorganic chemistry and applications, 2014*.

Kumar, B., Smita, K., Cumbal, L., & Debut, A. (2014b). Synthesis of silver nanoparticles using Sacha inchi (*Plukenetia volubilis* L.) leaf extracts. *Saudi journal of biological sciences, 21*(6), 605-609.

Kumar, B., Smita, K., Cumbal, L., Debut, A., & Angulo, Y. (2017). Biofabrication of copper oxide nanoparticles using Andean blackberry (Rubus glaucus Benth.) fruit and leaf. *Journal of Saudi Chemical Society, 21*, S475-S480.

Kumar, V., Singh, N., Kapoor, A., Ntwaeaborwa, O. M., & Swart, H. C. (2013). Fabrication and characterization of n-type aluminum-boron co-doped ZnO on p-type silicon (n-AZB/p-Si) heterojunction diodes. *Materials Research Bulletin, 48*(11), 4596-4600.

Kursawe, M., Anselmann, R., Hilarius, V., & Pfaff, G. (2005). Nano-particles by wet chemical processing in commercial applications. *Journal of sol-gel science and technology, 33*(1), 71-74.

Küünal, S., Rauwel, P., & Rauwel, E. (2018). Plant extract mediated synthesis of nanoparticles. In *Emerging Applications of Nanoparticles and Architecture Nanostructures* (pp. 411-446): Elsevier.

Kweyama, Z. (2018). *Green synthesis of Europium (III) Oxide nanoparticles using Hibiscus sabdariffa flower extract.* University of Zululand,

Lai, Y., Meng, M., & Yu, Y. (2010). One-step synthesis, characterizations and mechanistic study of nanosheets-constructed fluffy ZnO and Ag/ZnO spheres used for Rhodamine B photodegradation. *Applied Catalysis B: Environmental, 100*(3-4), 491-501.

Lebedev, A., Anariba, F., Tan, J. C., Li, X., & Wu, P. (2018). A review of physiochemical and photocatalytic properties of metal oxides against *Escherichia coli*. *Journal of Photochemistry and Photobiology A: Chemistry, 360*, 306-315.

Lee, K. M., Lai, C. W., Ngai, K. S., & Juan, J. C. (2016a). Recent developments of zinc oxide based photocatalyst in water treatment technology: a review. *Water research, 88*, 428-448.

Lee, K. M., Lai, C. W., Ngai, K. S., & Juan, J. C. (2016b). Recent developments of zinc oxide based photocatalyst in water treatment technology: a review. *Water Research, 88*, 428-448.

Lim, J., Yeap, S. P., Che, H. X., & Low, S. C. (2013). Characterization of magnetic nanoparticle by dynamic light scattering. *Nanoscale Research Letters, 8*(1), 1-14.

Lind, H., Broberg, A., Jacobsson, K., Jonsson, H., & Schnürer, J. (2011). Glycerol enhances the antifungal activity of dairy propionibacteria. *International journal of microbiology, 2010*.

Linkov, P., Artemyev, M., Efimov, A. E., & Nabiev, I. (2013). Comparative advantages and limitations of the basic metrology methods applied to the characterization of nanomaterials. *Nanoscale Research Letters, 5*(19), 8781-8798.

Liu, F., Lu, L., Xiao, P., He, H., Qiao, L., & Zhang, Y. (2012). Effect of oxygen vacancies on photocatalytic efficiency of TiO2 nanotubes aggregation. *J Bull. Korean Chem. Soc, 33*(7), 2255-2259.

Liu, H., Wang, Y., Wu, J., Zhang, G., & Yan, Y. (2015). Oxygen vacancy assisted multiferroic property of Cu doped ZnO films. *Physical Chemistry Chemical Physics, 17*(14), 9098-9105.

Liu, S., Zhang, Y., Gao, S., Fei, T., Zhang, Y., Zheng, X., & Zhang, T. (2020). An organometallic chemistry-assisted strategy for modification of zinc oxide nanoparticles by tin oxide nanoparticles: Formation of nn heterojunction and boosting NO2 sensing properties. *Journal of colloid interface science, 567*, 328-338.

Lu, Y., Yin, L., Gray, D. L., Thomas, L. C., & Schmidt, S. J. (2017). Impact of sucrose crystal composition and chemistry on its thermal behavior. *Journal of Food Engineering, 214*, 193-208.

Makvandi, P., Wang, C. y., Zare, E. N., Borzacchiello, A., Niu, L. n., & Tay, F. R. (2020). Metal-based nanomaterials in biomedical applications: Antimicrobial activity and cytotoxicity aspects. *Advanced Functional Materials, 30*(22), 1910021.

Mallikarjunaswamy, C., Ranganatha, V. L., Ramu, R., & Nagaraju, G. (2020). Facile microwave-assisted green synthesis of ZnO nanoparticles: application to photodegradation, antibacterial and antioxidant. *Journal of Materials Science: Materials in Electronics, 31*(2), 1004-1021.

Mantzaris, N. V. (2005). Liquid-phase synthesis of nanoparticles: particle size distribution dynamics and control. *Chemical engineering science, 60*(17), 4749-4770.

Marinho, J., Romeiro, F., Lemos, S., Motta, F., Riccardi, C., Li, M., Longo, E., & Lima, R. (2012). Urea-based synthesis of zinc oxide nanostructures at low temperature. *Journal of Nanomaterials, 2012*.

Maureen, C.-O. O., Nnaemeka, O. J., Basil, A. N., & Emeka, O. E. (2019). Photocatalytic degradation of a basic dye using zinc oxide nanocatalyst. *Int. Lett. Chem. Phys. Astron, 81*, 18-26.

Mayer, J., Giannuzzi, L. A., Kamino, T., & Michael, J. (2007). TEM sample preparation and FIB-induced damage. *MRS bulletin, 32*(5), 400-407.

Mickymaray, S., Al Aboody, M. S., Rath, P. K., Annamalai, P., & Nooruddin, T. (2016). Screening and antibacterial efficacy of selected Indian medicinal plants. *Asian Pacific Journal of Tropical Biomedicine, 6*(3), 185-191.

Modi, S., & Fulekar, M. (2020). Green synthesis of zinc oxide nanoparticles using garlic skin extract and its characterization. *Journal of Nanostructures, 10*(1), 20-27.

Mohamad, N. A. N., Arham, N. A., Jai, J., & Hadi, A. (2014). *Plant extract as reducing agent in synthesis of metallic nanoparticles: a review.* Paper presented at the Advanced Materials Research.

Mohamed, M. A., Jaafar, J., Ismail, A., Othman, M., & Rahman, M. (2017). Fourier transform infrared (FTIR) spectroscopy. In *Membrane Characterization* (pp. 3-29): Elsevier.

Mohamed, S. (2014). Oil palm leaf: a new functional food ingredient for health and disease prevention. *Journal of Food Processing and Technology, 5*(2).

Mohammadian, M., Es'haghi, Z., & Hooshmand, S. (2018). Green and chemical synthesis of zinc oxide nanoparticles and size evaluation by UV–vis spectroscopy. *Journal Nanomed Research, 7*(1), 00175.

Moravec, P., Kupčík, J., Vodička, P., & Schwarz, J. (2019). Generation of ZnO nanoparticles for long-term exposure experiments. *Aerosol Science and Technology, 53*(2), 172-183.

Mourdikoudis, S., Pallares, R. M., & Thanh, N. T. (2018). Characterization techniques for nanoparticles: comparison and complementarity upon studying nanoparticle properties. *Nanoscale 10*(27), 12871-12934.

Mujeeb, F., Bajpai, P., & Pathak, N. (2014). Phytochemical evaluation, antimicrobial activity, and determination of bioactive components from leaves of *Aegle marmelos*. *BioMed research international, 2014*.

Munshi, G. H., Ibrahim, A. M., & Al-Harbi, L. M. (2018). Inspired preparation of zinc oxide nanocatalyst and the photocatalytic activity in the treatment of methyl orange dye and paraquat herbicide. *International Journal of Photoenergy, 2018*.

Mydeen, S. S., Kumar, R. R., Kottaisamy, M., & Vasantha, V. (2020). Biosynthesis of ZnO nanoparticles through extract from Prosopis juliflora plant leaf: Antibacterial activities and a new approach by rust-induced photocatalysis. *Journal of Saudi Chemical Society, 24*(5), 393-406.

Nagajyothi, P., Cha, S. J., Yang, I. J., Sreekanth, T., Kim, K. J., & Shin, H. M. (2015). Antioxidant and anti-inflammatory activities of zinc oxide nanoparticles synthesized using *Polygala tenuifolia* root extract. *Journal of Photochemistry and Photobiology A: Chemistry, 146*, 10-17.

Nageswara Rao, B., Srinadhu, E. S., Madhusudhanrao, V., & Satyanarayana, N. (2018). Structural and optical studies of ZnO nanostructures synthesized by rapid microwave assisted hydrothermal and solvothermal methods. *Transactions of the Indian Ceramic Society, 77*(3), 169-174.

Nakkala, J. R., Mata, R., & Sadras, S. R. (2016). The antioxidant and catalytic activities of green synthesized gold nanoparticles from *Piper longum* fruit extract. *Process Safety and Environmental Protection, 100*, 288-294.

Narendhran, S., & Sivaraj, R. (2016). Biogenic ZnO nanoparticles synthesized using *L. aculeata* leaf extract and their antifungal activity against plant fungal pathogens. *Bulletin of Materials Science, 39*(1), 1-5.

Nasimi, P., & Haidari, M. (2013). Medical use of nanoparticles: Drug delivery and diagnosis diseases. *International Journal of Green Nanotechnology, 1*, 1943089213506978.

Nava, O., Luque, P., Gómez-Gutiérrez, C., Vilchis-Nestor, A., Castro-Beltrán, A., Mota-González, M., & Olivas, A. (2017). Influence of Camellia sinensis extract on Zinc Oxide nanoparticle green synthesis. *Journal of Molecular Structure, 1134*, 121-125.

Naveed Ul Haq, A., Nadhman, A., Ullah, I., Mustafa, G., Yasinzai, M., & Khan, I. (2017). Synthesis approaches of zinc oxide nanoparticles: the dilemma of ecotoxicity. *Journal of Nanomaterials, 2017*.

Nayak, A., Sahoo, J. K., Sahoo, S. K., & Sahu, D. (2020). Removal of congo red dye from aqueous solution using zinc oxide nanoparticles synthesised from *Ocimum sanctum* (Tulsi leaf): a green approach. *International Journal of Environmental Analytical Chemistry*, 1-22.

Nguyen, C. H., Fu, C.-C., & Juang, R.-S. (2018). Degradation of methylene blue and methyl orange by palladium-doped TiO2 photocatalysis for water reuse: efficiency and degradation pathways. *Journal of cleaner production, 202*, 413-427.

Noor, N. (2019). *Microplasmas in ZnO Nano-forests under high voltage stress.* University of Connecticut,

Nordin, N. A., Sulaiman, O., Hashim, R., Kassim, M., & Haafiz, M. (2016). Characterization of different parts of oil palm fronds (*Elaeis guineensis*) and its properties. *International Journal on Advanced Science, Engineering and Information Technology, 6*(1), 74-76.

Norris, K. H. (1998). Interactions among instrument bandpass, instrument noise, sample-absorber bandwidth and calibration error. *NIR news, 9*(4), 3-5.

Nowak, E., Szybowicz, M., Stachowiak, A., Koczorowski, W., Schulz, D., Paprocki, K., Fabisiak, K., & Los, S. (2020). A comprehensive study of structural and optical properties of ZnO bulk crystals and polycrystalline films grown by sol-gel method. *Applied Physics A, 126*(7), 1-12.

Ofori-Boateng, C., & Lee, K. T. (2013). Sustainable utilization of oil palm wastes for bioactive phytochemicals for the benefit of the oil palm and nutraceutical industries. *Phytochemistry reviews, 12*(1), 173-190.

Ogunyemi, S. O., Abdallah, Y., Zhang, M., Fouad, H., Hong, X., Ibrahim, E., Masum, M. M. I., Hossain, A., Mo, J., & Li, B. (2019). Green synthesis of zinc oxide nanoparticles using different plant extracts and their antibacterial activity against Xanthomonas oryzae pv. oryzae. *Artificial cells, nanomedicine, and biotechnology, 47*(1), 341-352.

Ong, C. B., Mohammad, A. W., Rohani, R., Ba-Abbad, M. M., & Hairom, N. H. H. (2016). Solar photocatalytic degradation of hazardous Congo red using low-temperature synthesis of zinc oxide nanoparticles. *Process Safety and Environmental Protection, 104*, 549-557.

Osuntokun, J., Onwudiwe, D. C., & Ebenso, E. E. (2019). Green synthesis of ZnO nanoparticles using aqueous *Brassica oleracea* L. var. italica and the photocatalytic activity. *Green Chemistry Letters and Reviews, 12*(4), 444-457.

Pan, Z. W., & Wang, Z. L. (2001). Nanobelts of semiconducting oxides. *Science, 291*(5510), 1947-1949.

Pantidos, N., & Horsfall, L. E. (2014). Biological synthesis of metallic nanoparticles by bacteria, fungi and plants. *Journal of Nanomedicine & Nanotechnology, 5*(5), 1.

Park, K. Y., & Jeong, H. J. (1999). Effect of Temperature on Particle Size for Vapor-Phase Synthesis Of Ultrafine Iron Particles. *Korean Journal of Chemical Engineering, 16*(1), 64-68.

Parthasarathy, P., Narayanan, S. K., & Energy, S. (2014). Determination of kinetic parameters of biomass samples using thermogravimetric analysis. *Environmental Progress, 33*(1), 256-266.

Patil, B. N., & Taranath, T. C. (2016). *Limonia acidissima* L. leaf mediated synthesis of zinc oxide nanoparticles: a potent tool against *Mycobacterium tuberculosis*. *International journal of mycobacteriology, 5*(2), 197-204.

Peng, X., Palma, S., Fisher, N. S., & Wong, S. S. (2011). Effect of morphology of ZnO nanostructures on their toxicity to marine algae. *Aquatic Toxicology, 102*(3-4), 186-196.

Pholnak, C., Sirisathitkul, C., & Harding, D. J. (2011). Characterizations of octahedral zinc oxide synthesized by sonochemical method. *Journal of Physics and Chemistry of Solids, 72*(6), 817-823.

Pillai, A. M., Sivasankarapillai, V. S., Rahdar, A., Joseph, J., Sadeghfar, F., Rajesh, K., & Kyzas, G. Z. (2020). Green synthesis and characterization of zinc oxide nanoparticles with antibacterial and antifungal activity. *Journal of Molecular Structure, 1211*, 128107.

Pohl, C., & Loong, C. (2016). *In-situ data collection for oil palm tree height determination using synthetic aperture radar.* Paper presented at the IOP Conference Series: Earth and Environmental Science.

Purbayanto, M. A. K., Rusydi, A., & Darma, Y. (2020). The effect of crystallinity on the surface modification and optical properties of ZnO thin films. *Physical Chemistry Chemical Physics*.

Quradha, M. M., Khan, R., Rehman, M.-u.-., & Abohajeb, A. (2019). Chemical composition and in vitro anticancer, antimicrobial and antioxidant activities of essential oil and methanol extract from Rumex nervosus. *Natural product research, 33*(17), 2554-2559.

Raj, A., & Lawerence, R. (2018). Green synthesis and charcterization of zno nanoparticles from leafs extracts of rosa indica and its antibacterial activity. *nutrition, 11*(3), 1339-1348.

Raj, L., & Jayalakshmy, E. J. O. J. C. (2015). Biosynthesis and characterization of zinc oxide nanoparticles using root extract of Zingiber officinale. *31*(1), 51-56.

Raja, V., Selvan, G., Anbarasu, R., & Baskar, S. (2019). *Green synthesis of zinc oxide nanoparticles using Hyptis leaf extract and Activated carbon based Zinc oxide composite of Supercapacitor Applications*.

Rajabi, S., Ramazani, A., Hamidi, M., & Naji, T. (2015). *Artemia* salina as a model organism in toxicity assessment of nanoparticles. *DARU Journal of Pharmaceutical Sciences, 23*(1), 20.

Rajoo, A., Sasidharan, S., Jothy, S. L., Ramanathan, S., & Mansor, S. M. (2013). Ultrastructural Study of *Elaeis guineensis* (Oil Palm) Leaf and Antimicrobial Activity of its Methanol Extract against *Staphylococcus Aureus*. *Tropical Journal of Pharmaceutical Research, 12*(3), 419-423.

Raliya, R., Tarafdar, J. C., & Biswas, P. (2016). Enhancing the mobilization of native phosphorus in the mung bean rhizosphere using ZnO nanoparticles synthesized by soil fungi. *Journal of agricultural and food chemistry, 64*(16), 3111-3118.

Rauf, M. A., Owais, M., Rajpoot, R., Ahmad, F., Khan, N., & Zubair, S. J. R. a. (2017). Biomimetically synthesized ZnO nanoparticles attain potent antibacterial activity against less susceptible S. aureus skin infection in experimental animals. *7*(58), 36361-36373.

Ravichandran, V., Sumitha, S., Ning, C. Y., Xian, O. Y., Kiew Yu, U., Paliwal, N., Shah, S. A. A., Tripathy, M., & Reviews. (2020). Durian waste mediated green synthesis of zinc oxide nanoparticles and evaluation of their antibacterial, antioxidant, cytotoxicity and photocatalytic activity. *Green Chemistry Letters, 13*(2), 102-116.

Reed, A. E., & Weinhold, F. (1983). Natural bond orbital analysis of near-Hartree–Fock water dimer. *The Journal of chemical physics, 78*(6), 4066-4073.

Rekulapally, R., Chavali, L. N. M., Idris, M. M., & Singh, S. (2019). Toxicity of TiO2, SiO2, ZnO, CuO, Au and Ag engineered nanoparticles on hatching and early nauplii of *Artemia sp*. *PeerJ, 6*, 6138.

Riaz, G., & Chopra, R. (2018). A review on phytochemistry and therapeutic uses of *Hibiscus sabdariffa* L. *Biomedicine & Pharmacotherapy, 102*, 575-586.

Richardson, M., & Rautemaa-Richardson, R. (2019). Exposure to aspergillus in home and healthcare facilities' water environments: Focus on biofilms. *Microorganisms, 7*(1), 7.

Robinson, T., McMullan, G., Marchant, R., & Nigam, P. (2001). Remediation of dyes in textile effluent: a critical review on current treatment technologies with a proposed alternative. *Bioresource technology, 77*(3), 247-255.

Sagar Raut, D., & Thorat, R. T. (2015). Green Synthesis of Zinc Oxide (ZnO) Nanoparticles Using *OcimumTenuiflorum* Leaves. *International journal of science research 4*(5), 1225-1228.

Salah, N., Habib, S. S., Khan, Z. H., Memic, A., Azam, A., Alarfaj, E., Zahed, N., & Al-Hamedi, S. (2011). High-energy ball milling technique for ZnO nanoparticles as antibacterial material. *International journal of nanomedicine, 6*, 863.

Santhoshkumar, J., Kumar, S. V., & Rajeshkumar, S. (2017). Synthesis of zinc oxide nanoparticles using plant leaf extract against urinary tract infection pathogen. *Resource-Efficient Technologies, 3*(4), 459-465.

Sarkar, S., Banerjee, A., Halder, U., Biswas, R., & Bandopadhyay, R. (2017). Degradation of synthetic azo dyes of textile industry: a sustainable approach using microbial enzymes. *Water Conservation Science Engineering, 2*(4), 121-131.

Sarkheil, M., Johari, S. A., An, H. J., Asghari, S., Park, H. S., Sohn, E. K., & Yu, I. J. (2018). Acute toxicity, uptake, and elimination of zinc oxide nanoparticles (ZnO NPs) using saltwater microcrustacean, *Artemia franciscana*. *Environmental toxicology pharmacology, 57*, 181-188.

Satar, N. S. A., Adnan, R., Lee, H. L., Hall, S. R., Kobayashi, T., Kassim, M. H. M., & Kaus, N. H. M. (2019). Facile green synthesis of ytrium-doped BiFeO3 with highly efficient photocatalytic degradation towards methylene blue. *Ceramics International, 45*(13), 15964-15973.

Sati, A., Sati, S. C., Sati, N., & Sati, O. (2017). Chemical composition and antimicrobial activity of fatty acid methyl ester of *Quercus leucotrichophora* fruits. *Natural product research, 31*(6), 713-717.

Scimeca, M., Bischetti, S., Lamsira, H. K., Bonfiglio, R., & Bonanno, E. (2018). Energy Dispersive X-ray (EDX) microanalysis: A powerful tool in biomedical research and diagnosis. *European journal of histochemistry: EJH, 62*(1).

Seil, J. T., & Webster, T. J. (2012). Antimicrobial applications of nanotechnology: methods and literature. *International journal of nanomedicine, 7*, 2767.

Selim, Y. A., Azb, M. A., Ragab, I., & Abd El-Azim, M. H. (2020). Green synthesis of zinc oxide nanoparticles using aqueous extract of *Deverra tortuosa* and their cytotoxic activities. *Scientific reports, 10*(1), 1-9.

Sengupta, A., & Sarkar, C. K. (2015). *Introduction to nano: basics to nanoscience and nanotechnology*: Springer.

Senthilkumar, N., Nandhakumar, E., Priya, P., Soni, D., Vimalan, M., & Potheher, I. V. (2017). Synthesis of ZnO nanoparticles using leaf extract of *Tectona grandis (L.)* and their anti-bacterial, anti-arthritic, anti-oxidant and in vitro cytotoxicity activities. *New Journal of Chemistry, 41*(18), 10347-10356.

Serpone, N., & Pelizzetti, E. (1989). *Photocatalysis: fundamentals and applications*: Wiley-Interscience.

Shah, M., Fawcett, D., Sharma, S., Tripathy, S. K., & Poinern, G. E. J. (2015). Green synthesis of metallic nanoparticles via biological entities. *Materials, 8*(11), 7278-7308.

Sharma, D., Sabela, M. I., Kanchi, S., Mdluli, P. S., Singh, G., Stenström, T. A., & Bisetty, K. (2016). Biosynthesis of ZnO nanoparticles using Jacaranda mimosifolia flowers extract: synergistic antibacterial activity and molecular simulated facet specific adsorption studies. *Journal of Photochemistry and Photobiology A: Chemistry, 162*, 199-207.

Sharma, S. K., Verma, D. S., Khan, L. U., Kumar, S., & Khan, S. B. (2018). *Handbook of Materials Characterization*: Springer.

Shatkin, J. A. (2017). *Nanotechnology: health and environmental risks*: Crc Press.

Shioya, N., Eda, K., Shimoaka, T., & Hasegawa, T. J. A. P. E. (2020). Hidden thin-film phase of dinaphthothienothiophene revealed by high-resolution X-ray diffraction. *13*(9), 095505.

Siddiqi, K. S., Ur Rahman, A., & Husen, A. (2018). Properties of zinc oxide nanoparticles and their activity against microbes. *Nanoscale Research Letters, 13*(1), 1-13.

Singh, A., & Dutta, P. (2020). Green synthesis, characterization and biological evaluation of chitin glucan based zinc oxide nanoparticles and its curcumin conjugation. *International Journal of Biological Macromolecules, 156*, 514-521.

Singh, S., Singh, G., & Bala, N. (2021). Synthesis and characterization of iron oxide-hydroxyapatite-chitosan composite coating and its biological assessment for biomedical applications. *Progress in Organic Coatings, 150*, 106011.

Sirelkhatim, A., Mahmud, S., Seeni, A., Kaus, N. H. M., Ann, L. C., Bakhori, S. K. M., Hasan, H., & Mohamad, D. (2015). Review on zinc oxide nanoparticles: antibacterial activity and toxicity mechanism. *Nano-Micro Letters, 7*(3), 219-242.

Siripireddy, B., & Mandal, B. K. (2017). Facile green synthesis of zinc oxide nanoparticles by *Eucalyptus globulus* and their photocatalytic and antioxidant activity. *Advanced Powder Technology, 28*(3), 785-797.

Sivarajasekar, N., & Baskar, R. (2015). Agriculture waste biomass valorisation for cationic dyes sequestration: A concise review. *J J. Chem. Pharm. Res, 7*(9), 737-748.

Sohail, M. F., Rehman, M., Hussain, S. Z., Huma, Z.-e., Shahnaz, G., Qureshi, O. S., Khalid, Q., Mirza, S., Hussain, I., & Webster, T. J. (2020). Green synthesis of zinc oxide nanoparticles by Neem extract as multi-facet therapeutic agents. *Journal of Drug Delivery Science Technology, 59*, 101911.

Solá-Gutiérrez, C., Schröder, S., San-Román, M. F., & Ortiz, I. (2020). Critical review on the mechanistic photolytic and photocatalytic degradation of triclosan. *Journal of environmental management, 260*, 110101.

Soto-Robles, C., Luque, P., Gómez-Gutiérrez, C., Nava, O., Vilchis-Nestor, A., Lugo-Medina, E., Ranjithkumar, R., & Castro-Beltrán, A. (2019). Study on the effect of the concentration of *Hibiscus sabdariffa* extract on the green synthesis of ZnO nanoparticles. *Results in Physics, 15*, 102807.

Srivastava, A., & Shivanandappa, T. (2011). Antioxidant and cytoprotective properties of 2-(hydroxymethyl)-3-methoxybenzaldehyde. *Food chemistry, 128*(2), 458-464.

Stan, M., Popa, A., Toloman, D., Silipas, T.-D., & Vodnar, D. C. (2016). Antibacterial and antioxidant activities of ZnO nanoparticles synthesized using extracts of *Allium sativum*, *Rosmarinus officinalis* and *Ocimum basilicum*. *Acta Metallurgica Sinica (English Letters), 29*(3), 228-236.

Sundrarajan, M., Ambika, S., & Bharathi, K. (2015). Plant-extract mediated synthesis of ZnO nanoparticles using Pongamia pinnata and their activity against pathogenic bacteria. *Advanced Powder Technology, 26*(5), 1294-1299.

Supraja, N., Prasad, T., Gandhi, A. D., Anbumani, D., Kavitha, P., & Babujanarthanam, R. (2018). Synthesis, characterization and evaluation of antimicrobial efficacy and brine shrimp lethality assay of *Alstonia scholaris* stem bark extract mediated ZnONPs. *Biochemistry biophysics reports, 14*, 69-77.

Suresh, J., Pradheesh, G., Alexramani, V., Sundrarajan, M., & Hong, S. I. J. A. i. N. S. N. (2018). Green synthesis and characterization of zinc oxide nanoparticle using insulin plant (*Costus pictus* D. Don) and investigation of its antimicrobial as well as anticancer activities. *Advances in Natural Sciences: Nanoscience and Nanotechnology, 9*(1), 015008.

Svetlichnyi, V., & Lapin, I. (2013). Structure and properties of nanoparticles fabricated by laser ablation of Zn metal targets in water and ethanol. *Russian Physics Journal, 56*(5), 581-587.

Taghavi Fardood, S., Moradnia, F., Ghalaichi, A. H., Danesh Pajouh, S., & Heidari, M. (2020). Facile green synthesis and characterization of zinc oxide nanoparticles using tragacanth gel: investigation of their photocatalytic performance for dye degradation under visible light irradiation. *Nanochemistry Research, 5*(1), 69-76.

Tettey, C., & Shin, H. (2019). Evaluation of the antioxidant and cytotoxic activities of zinc oxide nanoparticles synthesized using *Scutellaria baicalensis* root. *Scientific African, 6*, e00157.

Thongam, D. D., Gupta, J., & Sahu, N. K. (2019). Effect of induced defects on the properties of ZnO nanocrystals: surfactant role and spectroscopic analysis. *SN Applied Sciences, 1*(9), 1030.

Thovhogi, N., Diallo, A., Gurib-Fakim, A., & Maaza, M. (2015). Nanoparticles green synthesis by *Hibiscus sabdariffa* flower extract: main physical properties. *Journal of Alloys and Compounds, 647*, 392-396.

Tomaszewska, E., Soliwoda, K., Kadziola, K., Tkacz-Szczesna, B., Celichowski, G., Cichomski, M., Szmaja, W., & Grobelny, J. (2013). Detection limits of DLS and UV-Vis spectroscopy in characterization of polydisperse nanoparticles colloids. *Journal of Nanomaterials, 2013*.

Toor, M. K. (2011). *Enhancing adsorption capacity of bentonite for dye removal: physiochemical modification and characterization.*

Uhm, Y., Han, B., Lee, M., Hong, S., & Rhee, C. (2007). Synthesis and characterization of nanoparticles of ZnO by levitational gas condensation. *Materials Science and Engineering: A, 449*, 813-816.

Ullah, A., Ullah, S., Khan, M. Q., Hashmi, M., Nam, P. D., Kato, Y., Tamada, Y., & Kim, I. S. (2020). Manuka honey incorporated cellulose acetate nanofibrous mats: Fabrication and in vitro evaluation as a potential wound dressing. *International Journal of Biological Macromolecules*.

Umar, H., Kavaz, D., & Rizaner, N. (2019). Biosynthesis of zinc oxide nanoparticles using *Albizia lebbeck* stem bark, and evaluation of its antimicrobial, antioxidant, and cytotoxic activities on human breast cancer cell lines. *International journal of nanomedicine, 14*, 87.

Uribe-López, M., Hidalgo-López, M., López-González, R., Frías-Márquez, D., Núñez-Nogueira, G., Hernández-Castillo, D., & Alvarez-Lemus, M. (2021). Photocatalytic activity of ZnO nanoparticles and the role of the synthesis method on their physical and chemical properties. *Journal of Photochemistry Photobiology A: Chemistry, 404*, 112866.

Varughese, G., Jithin, P., & Usha, K. (2015). Determination of optical band gap energy of wurtzite ZnO: Ce nanocrystallites. *Physical Science International Journal*, 146-154.

Vaseem, M., Umar, A., & Hahn, Y.-B. (2010). ZnO nanoparticles: growth, properties, and applications. *Metal oxide nanostructures their applications, 5*(1).

Venkatasubbu, G. D., Ramakrishnan, V., Sasirekha, V., Ramasamy, S., & Kumar, J. (2014). Influence of particle size on the phonon confinement of TiO2 nanoparticles. *Journal of Experimental Nanoscience, 9*(7), 661-668.

Vijayakumar, S., Arulmozhi, P., Kumar, N., Sakthivel, B., Kumar, S. P., & Praseetha, P. (2019). *Acalypha fruticosa* L. leaf extract mediated synthesis of ZnO nanoparticles: Characterization and antimicrobial activities. *Materials Today: Proceedings*.

Villasante, J., Girbal, M., Metón, I., & Almajano, M. P. (2019). Effects of pecan nut (*Carya illinoiensis*) and roselle flower (*Hibiscus sabdariffa*) as antioxidant and antimicrobial agents for sardines (*Sardina pilchardus*). *Molecules, 24*(1), 85.

Vlasenko, L. (2010). Magnetic resonance studies of intrinsic defects in ZnO: Oxygen vacancy. *Applied Magnetic Resonance, 39*(1-2), 103-111.

Wang, J., Li, S., Yun, F., Zhang, X., & Li, Q. (2020). Achieving indirect-to-direct band gap transition and enhanced photocatalytic performance in blue phosphorene through doping and strain. *International Journal of Quantum Chemistry, 120*(13), e26230.

Wang, L., Hu, C., & Shao, L. (2017). The antimicrobial activity of nanoparticles: present situation and prospects for the future. *International journal of nanomedicine, 12*, 1227.

Wang, X., Sha, Y., & Li, R. (2004). Fragmentation patterns of novel dispirocyclopiperazinium dibromides with strong analgesic activity under electrospray ionization tandem mass spectrometry conditions. *International Journal of Mass Spectrometry, 235*(2), 111-115.

Wang, Z. L. (2004). Zinc oxide nanostructures: growth, properties and applications. *Journal of physics: condensed matter, 16*(25), R829.

Want, E. J., Cravatt, B. F., & Siuzdak, G. (2005). The expanding role of mass spectrometry in metabolite profiling and characterization. *Chembiochem 6*(11), 1941-1951.

Wei, L., Shifu, C., Wei, Z., & Sujuan, Z. (2009). Titanium dioxide mediated photocatalytic degradation of methamidophos in aqueous phase. *Journal of Hazardous materials, 164*(1), 154-160.

Weitzel, T., Rodriguez, M. F., Ciapponi, A., & Calderón, M. (2017). Methylene blue for treating malaria. *The Cochrane Database of Systematic Reviews, 2017*(10).

Welderfael, T., Yadav, O., Taddesse, A. M., & Kaushal, J. (2013). Synthesis, characterization and photocatalytic activities of Ag-N-codoped ZnO nanoparticles for degradation of methyl red. *Bulletin of the Chemical Society of Ethiopia, 27*(2), 221-232.

Wirth, R. (2009). Focused Ion Beam (FIB) combined with SEM and TEM: Advanced analytical tools for studies of chemical composition, microstructure and crystal structure in geomaterials on a nanometre scale. *Chemical Geology, 261*(3-4), 217-229.

Wu, T., & Tang, M. (2018). Review of the effects of manufactured nanoparticles on mammalian target organs. *Journal of Applied Toxicology, 38*(1), 25-40.

Wuhrer, R., & Moran, K. (2016). *Low voltage imaging and X-ray microanalysis in the SEM: challenges and opportunities.* Paper presented at the IOP Conf. Ser. Mater. Sci. Eng.

Xu, Y., Lebrun, R. E., Gallo, P.-J., & Blond, P. (1999). Treatment of textile dye plant effluent by nanofiltration membrane. *J Separation Science Technology, 34*(13), 2501-2519.

Yadav, A., Kon, K., Kratosova, G., Duran, N., Ingle, A. P., & Rai, M. (2015). Fungi as an efficient mycosystem for the synthesis of metal nanoparticles: progress and key aspects of research. *Biotechnology letters, 37*(11), 2099-2120.

Yang, C., Li, Q., Tang, L., Bai, A., Song, H., & Yu, Y. (2016). Monodispersed colloidal zinc oxide nanospheres with various size scales: synthesis, formation mechanism, and enhanced photocatalytic activity. *Journal of materials science, 51*(11), 5445-5459.

Yang, G. (2007). Laser ablation in liquids: Applications in the synthesis of nanocrystals. *Progress in Materials Science, 52*(4), 648-698.

Yang, Y., Zhong, C., Wang, X., He, B., Wei, S., Zeng, F., & Pan, F. (2008). Room temperature multiferroic behavior of Cr-doped ZnO films. *Journal of Applied Physics, 104*(6), 064102.

Yin, N. S., Abdullah, S., & Phin, C. K. (2013). Phytochemical constituents from leaves of *Elaeis guineensis* and their antioxidant and antimicrobial activities. *Int J Pharm Pharm Sci, 5*(Suppl 4), 137-140.

Yusof, N. Z., Abd Gani, S. S., Siddiqui, Y., Mohd Mokhtar, N., & Hasan, Z. A. A. (2016). Potential uses of oil palm (*Elaeis guineensis*) leaf extract in topical application. *J. Oil Palm Res, 28*(4), 520-530.

Zafari-Shayan, S., Moradkhani, S., & Dastan, D. (2016). Analysis of fatty acid composition of two selected Phlomis species. *Journal of HerbMed Pharmacology, 5*.

Zarkani, A. A. (2016). Antimicrobial activity of *Hibiscus sabdariffa* and *Sesbania grandiflora* extracts against some G–ve and G+ ve strains. *Banats J Biotechnol, 7*(13), 17-23.

Zelechowska, K. (2014). Methods of ZnO nanoparticles synthesis. *BioTechnologia. Journal of Biotechnology Computational Biology and Bionanotechnology, 95*(2).

Zikalala, N., Matshetshe, K., Parani, S., & Oluwafemi, O. S. (2018). Biosynthesis protocols for colloidal metal oxide nanoparticles. *Nano-Structures & Nano-Objects, 16*, 288-299.

Zou, C., Liang, F., & Xue, S. (2015). Synthesis and oxygen vacancy-related photocatalytic properties of ZnO nanotubes grown by thermal evaporation. *Research on Chemical Intermediates, 41*(8), 5167-5176.