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A Comprehensive Review: Green Synthesis of Nanoparticles from Azadirachta Indica Plant

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Abstract: An environmentally friendly and sustainable process is the green synthesis of neem plant nanoparticles. Because neem plant extracts contain a lot of bioactive components, they are used as capping and reducing agents. In the process, neem components are removed and mixed with metal precursor solutions. Under carefully regulated conditions, metal ions are reduced and nanoparticles are produced. These unique neem-synthesized nanoparticles are utilized in agriculture, medicine, environmental remediation, and catalysis. Because of its cost, environmental friendliness, and scalability, the green synthesis approach reduces the usage of hazardous chemicals. This could lead to advancements in green nanotechnology.

Keywords: Neem plant, environmentally friendly, synthesized nanoparticles

I. INTRODUCTION

The purpose of this project is to develop an E-Book Distribution Platform. It is a system that enables readers to place their book order online. The reason to develop the system is due to the issues of facing by Readers. Beside that it provides user friendly web-pages and effective advertising medium to the new books to the readers at reasonable price.

The advent of digital technologies has revolutionized the way books are marketed, sold, and consumed. This paper presents the design and development of an E-Book Distribution Platform, a comprehensive web and mobile-based platform that facilitates the browsing, purchasing, and reading of books in digital and physical formats. The system incorporates modern features such as real-time inventory management, personalized book recommendations using machine learning algorithms, secure payment gateways, and user-generated reviews. By analyzing user behavior and preferences, the app enhances user experience and engagement. The architecture supports scalability, multi-device access, and seamless integration with third-party APIs such as Google Books and PayPal. Additionally, the application promotes inclusivity by offering multilingual support and accessibility features. This study emphasizes the growing significance of online platforms in democratizing access to literature, empowering self-publishing authors, and transforming the traditional book retail industry.

In order to create future devices that are both environmentally green and human-friendly, nanoparticles will be crucial. Plant-based nanoparticle synthesis is a green chemistry technique that links nanotechnology and plant biotechnology. Metal ions are bio-reduced and nanoparticles are produced using plant extracts. The importance of plant metabolites, including proteins, sugars, terpenoids, polyphenols, alkaloids, and phenolic acids, in reducing metal ions into nanoparticles and enhancing their stability has since been demonstrated. The atoms in The properties of nonmetric materials differ greatly from those of bulk materials. The need for environmentally friendly techniques is particularly high due to the general toxicity of the chemicals employed in conventional chemical methods to manufacture nanoparticles. [1].

It is believed that nanoparticles (NPs) are the fundamental building blocks of nanotechnology. Nanotechnology is an interdisciplinary field that includes material science, biology, chemistry, physics, and health. Currently, a range of physical and chemical methods have been documented for producing metal nanoparticles. Because of all the documented chemical reactions and energy-intensive pathways that make them environmentally hazardous, these options are not appropriate for use in biology, medicine, or the clinical area. Therefore, developing eco-friendly processes is crucial to today's nanomaterial synthesis. Biotechnology, a focused combination of biological and nanotechnological techniques for the biosynthesis of nanoparticles, is a result of nanotechnology. [2].

Due to their unique properties, colloidal silver nanoparticles find widespread application in photonics, electronics, chemical detection, biosensing, and medicines. There is a lot of interest in developing flexible methods to produce silver nanoparticles with precisely specified and regulated characteristics because of the range and importance of these applications. [3].

Using neem (Azadirachta Indica) leaf broth, bimetallic Au Core-Ag shell nanoparticles with precisely defined composition and shape have been successfully produced. It was recently discovered that an extract of parthenium hysterophorous L. leaves might be used to create silver nanoparticles at room temperature. The photoluminescence property and the change in particle size with reaction temperature and reaction duration, however, were not sufficiently studied. [3].

Inorganic nanoparticles include silicon nanoparticles and magnetic nanoparticles. Among the groups of metallic nanoparticles are gold, silver, alloy, zinc, and other metals. Ag is a magnetic substance. Important biological qualities are provided by nano silver for use in consumer goods, food technology, textile and fabric applications, and medicine. In addition, nano silver's special optical and physical characteristics suggest that it will play a significant role in medicine in the future. [4] [5].

Atomic, molecular, and supramolecular manipulation of matter is the focus of the quickly developing field of nanotechnology. The term "nanotechnology" was initially used by Nobel laureate Richard Feynman. He talked about the possibility of reordering and modifying particular atoms and molecules in his 1959 lecture, "There's Plenty of Room at the Bottom." [6] [7].

1.1 Types of Nanoparticles

Nanoparticles are extremely tiny particles that range in size from one to one hundred nanometers (nm). A wide range of materials, such as metals, electronics, polymers, and ceramics, can be used to create them. Because of their unique physical and chemical characteristics that distinguish them from their bulk counterparts, nanoparticles are attractive prospects for a wide range of applications in fields like health, electronics, energy, and environmental science. [8].

1.2 APPLICATIONS OF NANOPARTICLES

1.2.1 Applications of Nanoparticles in Medicine

Nanoparticles are appealing tools for illness diagnosis and treatment because of their special qualities, which include their small size, large surface area, and high reactivity. They can be functionalized with a range of substances, such as medications, antibodies, and nucleic acids, to target specific cells or tissues, and they are readily transportable over biological barriers like the blood-brain barrier. Furthermore, nanoparticles with controlled release characteristics can be developed, allowing for continuous drug administration over extended periods of time. Some of the most significant uses of nanoparticles in medicine are listed below. [9, 10].

- Drug Delivery: Antibiotics, vaccines, and anticancer drugs are just a few of the drugs that have been delivered by nanoparticle techniques. Targeting specific cells or tissues can boost their therapeutic effectiveness and protect the drugs from being broken down and eliminated by the immune system. Liposomal nanoparticles, for example, have been used to deliver anticancer drugs to tumor cells, increasing therapeutic efficacy and reducing side effects. [9, 10].
- Imaging: Computed tomography (CT), magnetic resonance imaging (MRI), and fluorescence imaging are just a few of the imaging techniques that can use nanoparticles as contrast agents. They can improve imaging's sensitivity and specificity and enable the detection of tiny lesions that are challenging to detect using conventional imaging techniques. For example, super paramagnetic iron oxide nanoparticles have been used as MRI contrast agents to detect liver tumors. [9].
- Bio sensing: Nanoparticles can be used as biosensors to detect a wide range of biomolecules, such as proteins, nucleic acids, and carbohydrates. Their high sensitivity and specificity enable the identification of

biomolecules at low concentrations. For example, gold nanoparticles have been used as biosensors to detect prostate-specific antigen (PSA), a biomarker for prostate cancer. [9].

- Gene Therapy: Nanoparticles can be used as vectors to deliver therapeutic genes to cells or tissues to cure genetic disorders. They can stop nucleases from damaging the genes and aid in their absorption by the cells. For example, cationic liposomal nanoparticles were used to deliver therapeutic genes to lung cancer cells, resulting in decreased tumor growth and improved survival rates. [9, 10].

1.2.2 Applications of Nanoparticles in Electronics

Electronic devices that use nanoparticles include solar cells, sensors, and memory devices. They can boost electrical device performance by improving their mechanical strength, optical properties, and conductivity. Furthermore, because of their simple, inexpensive, and scalable manufacturing, nanoparticles are attractive for use in commercial settings. There are several uses for nanoparticles in electronics, some of which are mentioned here. [11].

- Memory Devices: In memory technologies such as flash memory and phase-change memory, nanoparticles have been used to improve performance and reduce power consumption. One example is the use of gold nanoparticles to increase the durability and data retention of flash memory systems. [11].
- Sensors: Nanoparticles have been used to create sensors for a range of applications, such as food safety, medical care, and environmental monitoring. Because of its high sensitivity and selectivity, analytes can be detected at low concentrations. For example, silver nanoparticles have been used to develop sensors that can identify heavy metal ions in water. [11].
- Solar cell: Solar cells have been developed using nanoparticles to improve their efficiency and reduce their cost. Apart from promoting the flow of charge within the cells, they can enhance the absorption of sunlight. For example, third-generation solar cells have been made using semiconductor nanoparticles known as quantum dots. [11].
- Flexible electronics: Flexible electronics, which can be stretched or twisted without breaking, have been made using nanoparticles. They might be able to enhance the mechanical properties of the devices and enable their integration with flexible substrates. For example, flexible, transparent electrodes for wearable technology and touch screens have been made using silver nanoparticles. [11].

1.2.3 Applications of Nanoparticles in Energy

Energy storage, energy conversion, and fuel cells are some of the energy-related uses for nanoparticles. They can improve the performance of energy devices by making them more efficient, robust, and safe. Furthermore, nanoparticles are attractive for use in large-scale energy applications due to the abundance of affordable resources available for their manufacture. Some of the most significant uses of nanoparticles in the energy industry are listed below. [12].

- Catalysis: Nanoparticles have been used as catalysts in fuel cells, carbon dioxide reduction, hydrogen synthesis, and other energy-related processes. They can increase the pace and selectivity of the reactions while lowering the amount of catalyst needed. For example, platinum nanoparticles have been used to accelerate oxygen reduction processes in fuel cells. [12].
- Energy Storage: Nanoparticles have been used in the development of energy storage technologies such as batteries and super capacitors to improve their efficiency and reduce their cost. They can improve the electrode's surface area and facilitate the flow of charge throughout the apparatus. For example, lithium-ion batteries with higher energy density have been made using silicon nanoparticles. [12].
- Solar Energy: Nanoparticles have been used to create solar energy technologies including photovoltaic cells and solar fuels in order to boost their efficiency and reduce their cost. They can enhance solar absorption and facilitate charge transmission throughout the gadgets. For example, titanium dioxide nanoparticles have been used in the creation of dye-sensitized solar cells. [12].

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1.2.4 Applications of Nanoparticles in Environmental Science

- Nanoparticles have been employed in environmental research for a number of applications, such as water treatment, air purification, and soil remediation. They can improve the quality of our natural resources and remove pollutants from the air. Furthermore, nanoparticles are attractive for usage in environmentally acceptable applications since they may be produced utilizing sustainable and eco-friendly methods. The following are some of the most notable uses of nanoparticles in environmental research. [13].

  • Water treatment: Nanoparticles have been used to remove heavy metals, organic contaminants, and pathogens from water. By adsorbing, oxidizing, or photocatalyzing the contaminants out, they can improve the water's quality. For example, iron nanoparticles have been used to remove arsenic from contaminated groundwater. [13].
- Air Purification: Particulate matter, nitrogen oxides, and volatile organic compounds are just a few of the pollutants that nanoparticles have been used to remove from the air. They can eliminate the pollutants and improve the quality of the air using adsorption, photocatalysis, or electrostatic attraction. For example, titanium dioxide nanoparticles have been used to remove nitrogen oxides from vehicle exhaust. [13].
- Soil Remediation: Heavy metals, organic pollutants, and pathogens are just a few of the contaminants that have been removed from soil using nanoparticles. They can eliminate contaminants by adsorption, oxidation, or microbial breakdown in addition to improving the quality of the soil. For example, carbon nanoparticles have been used to immobilize heavy metals in contaminated soils. [13].
- Environmental Monitoring: Air, water, and soil quality are among the environmental variables that nanoparticles have been used to monitor. They can facilitate remote and real-time parameter monitoring and offer high geographical and temporal resolution. The development of colorimetric sensors to identify mercury ions in water is one use for gold nanoparticles. [13].

1.3 SYNTHETHIC METHODS OF NANOPARTICLES

Nanoparticles can be made using a variety of methods, each with advantages and disadvantages. These are some commonly employed synthesis processes:

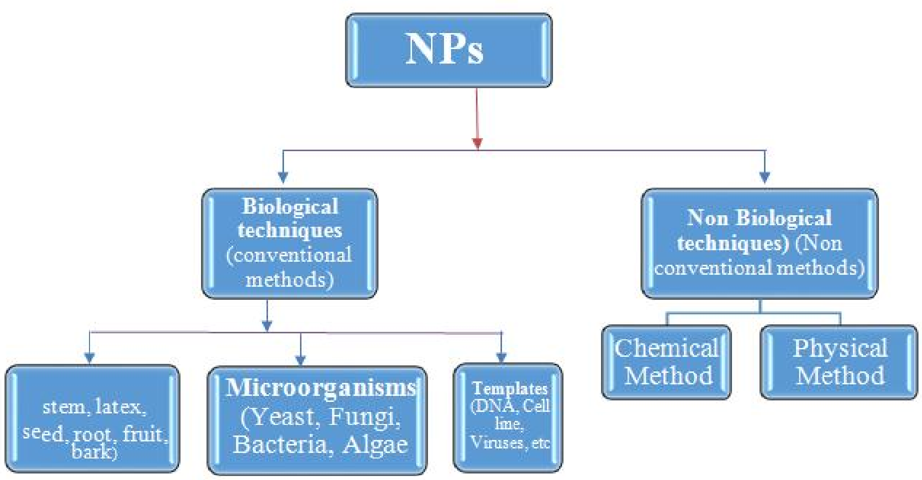

Figure 1: Synthesis Methods of Nanoparticles

1.3.1 Biological techniques

Biological approaches of nanoparticle manufacturing use plants, microbes, and their extracts to stabilize nanoparticles and reduce metal ions. It is commonly called "biosynthesis" or "biofabrication" of nanoparticles. This method of creating nanoparticles is affordable, scalable, and environmentally benign..

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- Microbial synthesis: This method uses bacteria, fungi, and yeast to stabilize nanoparticles and reduce metal ions. The produced nanoparticles are stabilized by the external proteins of the microbiological cells, which act as a reducing environment. Pseudomonas aeruginosa, Bacillus subtilis, and Escherichia coli are a few examples of microorganisms that have been utilized to produce metal nanoparticles. [7].
- Plant extract-based synthesis: This method produces nanoparticles by using plant extracts as a stabilizing and reducing agent. Plant extracts contain a variety of chemicals, including flavonoids, terpenoids, and alkaloids, which can stabilize nanoparticles and reduce metal ions. Nanoparticles have been made from a variety of plant materials, such as aloe vera, Azadirachta indica, and green tea extract.
- Enzyme-mediated synthesis: Enzymes such as lysozyme, lactate dehydrogenase, and alkaline phosphatase have been used in the synthesis of nanoparticles. Enzymes provide a specific setting for nanoparticle production, and the final particles are usually consistent in size and shape. [7].
- Cell-free extract-based synthesis: This method uses cell-free extracts from microorganisms or plants to create nanoparticles. The cell-free extracts contain the necessary reducing agents and enzymes for the production of nanoparticles. This method is simple and efficient for producing nanoparticles.

1.3.2 Non-Biological techniques

Non-biological methods of synthesizing nanoparticles use physical and chemical processes. These are often high-energy procedures that use mechanical, electrical, or thermal energy to create nanoparticles..

- Chemical reduction is the most used non-biological method for creating nanoparticles. This method reduces metal ions utilizing substances like citrate, sodium borohydride, and hydrazine. Various types of nanoparticles, such as copper, silver, and gold, can be produced using the chemical reduction process.[14].
- Sol-gel technique: The sol-gel process produces nanoparticles by converting a precursor solution into a gel and then drying it. The dried gel is then heated to create nanoparticles. This method can be used to produce metal oxide nanoparticles from materials such as iron oxide, zinc oxide, and titanium dioxide. [15].
- Electrochemical method: The electrochemical approach creates nanoparticles by applying an electrical current to a solution containing metal ions. The electrochemical process can produce a variety of nanoparticles, such as copper, silver, and gold. [16].

- Technique of laser ablation: In order to create nanoparticles, a metal target is ablated using a laser beam in the laser ablation technique. The laser ablation process can be used to create a variety of nanoparticles, including titanium dioxide, gold, and silver. [17].

1.3.3 Green synthesis

One method for producing nanoparticles is called "green synthesis," which uses natural resources such as fungi, microorganisms, and plants. This method is environmentally safe and produces nanoparticles with unique properties. Green synthesis has become popular because it can use fewer energy and dangerous chemicals. Attractive substitute for conventional methods of creating nanoparticles [18]. One example of green synthesis is the use of plant chemicals. Among the bioactive compounds present in plants that can serve as reducing and stabilizing agents in the formation of nanoparticles are polyphenols, flavonoids, and alkaloids. Several plant materials have been used to manufacture copper, gold, and silver nanoparticles. [18]. In a 2018 study that looked at the environmentally friendly production of silver nanoparticles, Kumar used an extract from the leaves of Eclipta prostrata. The study found that the silver nanoparticles made from plant extracts were highly stable and shown potent antibacterial action against both gram-positive and gram-negative bacteria. [18].

Green synthesis is not just more ecologically benign than traditional methods of creating nanoparticles. Green chemistry is economical because it makes use of readily available and inexpensive natural resources. Green synthesis is accessible to researchers in impoverished countries due to its simplicity and lack of costly equipment. [19].

"Green synthesis" is the process of creating various materials, including organic molecules, nanoparticles, and other materials, using environmentally responsible and sustainable methods. This process is also known as viable synthesis or

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environmentally friendly synthesis. Green synthesis aims to lessen the harmful impacts of chemical synthesis on the environment, human health, and resources by using renewable resources, non-toxic solvents, and reducing the energy and waste generated during the synthesis process. [20]. Microbial synthesis, synthesis based on plant extracts, and chemical reduction employing non-toxic reducing chemicals are some examples of green synthesis methods. In comparison to conventional chemical synthesis, green synthesis has several advantages, including minimal toxicity, cheap cost, scalability, and high yield. [20].

The biosynthesis of nanomaterials is a relatively new and mostly unexplored topic of study that has emerged from natural methods for the creation of nano- and micro-scaled inorganic materials. Green chemistry concepts and bio-organism-based synthesis can coexist. [21].

1.4 AZADIRACTA INDICA

Azadirachta indica, the scientific name for neem, is a versatile medicinal shrub that has long been utilized in traditional medicine. Indigenous to India, neem trees are widely cultivated. Throughout the tropics for its many advantages, such as its ability to repel insects and its antiviral, anti-inflammatory, antifungal, and anti-cancer qualities. Neem has recently been employed for the ecological synthesis of nanoparticles, which has garnered a lot of attention because to its sustainable and environmentally favorable qualities. [22].

Neem leaves, bark, seeds, and oil have been used to create nanoparticles with a variety of applications and properties. This article will look at the many parts of the Neem plant that have been utilized to make nanoparticles and their properties. [22].

1.4.1 Neem Leaves

Bioactive substances with strong anti-inflammatory, anti-bacterial, anti-fungal, anti-cancer, and antiviral effects, such as Azadirachta, Nimbidin, and Nimbidin, are abundant in neem leaves. Neem leaves were utilized in a green synthesis process to produce copper oxide, zinc oxide, gold, and silver nanoparticles. [23].

1.4.2 Neem Bark

Neem wood contains bioactive compounds such triterpenoids, flavonoids, and tannins that have potent anti-inflammatory, antibacterial, and anti-cancer properties. Neem wood has been used to manufacture environmentally friendly silver, gold, and zinc oxide nanoparticles.

1.4.3 Neem Seeds

Bioactive substances with strong anti-inflammatory, anti-bacterial, anti-fungal, and antiviral effects, such as Azadirachta, Nimbidin, and Nimbidin, are abundant in neem seeds. Environmentally friendly silver, gold, and iron oxide nanoparticles have been made from neem seeds. [24].

1.4.4 Neem Oil

Neem oil has been used to create environmentally friendly silver, gold, and iron oxide nanoparticles. In one of their experiments, Singh (2014) investigated the environmentally friendly synthesis of silver nanoparticles using neem oil. The study found that Neem oil-derived silver nanoparticles were incredibly stable and showed strong antibacterial action against a range of bacterial species. Anitha also conducted an experiment in 2020 on the environmentally friendly production of gold nanoparticles using neem oil. As stated Neem oil-derived gold nanoparticles shown potent anti-inflammatory and anti-cancer properties prior to the investigation [25].

1.4.5 Applications of Azadirachta indica

Nanoparticles derived from Azadirachta indica extract have a wide range of applications because of their unique physical and chemical properties. These nanoparticles may be made using the natural compounds of Azadirachta indica in an environmentally responsible way, which makes them very economical and sustainable. This article will examine the various applications of these nanoparticles and include recent studies that have examined their potential.

1.4.5.1 Biomedical Applications of Azadirachta indica

Azadirachta indica extract was used to create nanoparticles, which may eventually find use in biomedicine. Their large surface area and tiny size make them ideal for use as medication delivery systems. Numerous studies indicate that these nanoparticles have been used to deliver anticancer, pain, and antibacterial medications. According to a recent study, doxorubicin, an anticancer drug, was effectively delivered to cancer cells by silver nanoparticles derived from Azadirachta indica extract, which significantly reduced the growth of tumors. [25, 26].

1.4.5.2 Environmental Applications of Azadirachta indica

Additionally, nanoparticles derived from Azadirachta indica extract have been found to have potential applications in environmental remediation. They can be used as catalysts in air and water purification systems, among other environmental systems. Numerous studies have shown that these nanoparticles can be utilized to remove organic pollutants, heavy metals, and pigments from the air and water. According to a recent study, silver nanoparticles derived from Azadirachta indica extract may be able to eliminate water chromium. [27, 28].

1.4.5.3 Food and Nutrition Applications of Azadirachta indica

Additionally, it has been found that the food and nutrition industry may benefit from the use of nanoparticles made from Azadirachta indica extract. They can be used as food additives and preservatives because of their strong antibacterial and antioxidant properties. The application of these nanoparticles in food preservation and nutritional value has been the subject of numerous investigations. Improvement. Silver nanoparticles derived from Azadirachta indica extract were found to be effective in inhibiting the growth of foodborne bacteria in milk in a recent study [29].

1.4.5.4 Energy Applications of Azadirachta indica

Nanoparticles made from Azadirachta indica extract have also been found to have potential use in the renewable energy sector. They can be used as catalysts in fuel cells, solar cells, and other energy conversion devices because of their exceptional catalytic activity and stability. Numerous studies have reported using these nanoparticles to produce hydrogen and methanol, two renewable fuels. A recent study found that using gold nanoparticles derived from Azadirachta indica extract, carbon dioxide may be electrochemically converted to formic acid. [30].

II. LITERATURE REVIEW

2.1 The green synthesis of nanoparticles using Azadirachta indica

Native to the Indian subcontinent, neem trees are also known as Azadirachta indica. It has been used in traditional medicine for thousands of years and has been found to have a wide range of pharmacological and biological properties. Neem extract has garnered a lot of attention lately for the environmentally friendly creation of nanoparticles because of its cost, non-toxicity, and eco-friendliness.

In 2023, Aloufi and his colleague published a study evaluating the structural, optical, and antibacterial properties of green (Sn(Fe:Ni)O2) nanoparticles derived from Azadirachta indica leaf extract. The intriguing physicochemical characteristics of metal oxide nanoparticles have led to their widespread recognition. Although there are alternative methods for producing these nanoparticles, the biological method utilizing plant extracts is recommended since it offers a straightforward, economical, efficient, quick, and environmentally friendly synthesis option. Tin (ferrous: nickel) dioxide (Sn (Fe:Ni)O2) nanoparticles were made in this work using a green technique and an Azadirachta indica leaf extract as a reducing agent. Dynamic light scattering (DLS), energy-dispersive X-ray (EDX) spectroscopy analysis, Feld emission scanning electron microscopy (FESEM), Fourier transform infrared (FTIR), and photoluminescence (PL) measurement were among the techniques used to characterize the synthesized nanoparticles. Furthermore, (Sn (Fe: Ni) O2) nanoparticles' antibacterial properties against bacterial strains of We looked into Escherichia coli, Pseudomonas aeruginosa, Bacillus subtilis, Klebsiella pneumonia, Streptococcus pneumoniae, and Staphylococcus aureus. The tetragonal Sn (Fe: Ni) O2 nanoparticles were identified using XRD patterns. The DLS spectra confirmed that the nanoparticles' hydrodynamic diameter was 143 nm. The FESEM image showed the spherical shape of the produced nanoparticles. Map data and chemical composites were examined using the EDAX spectrum. In the FTIR spectra, the

Sn-O stretching band was found at 550 cm-1, and the Sn-O-Sn stretching band was found at 615 cm-1. Photoluminescence spectra were used to identify the surface flaws on the synthesized (Sn (Fe: Ni) O2) nanoparticles. When compared to traditional medicines like amoxicillin, (Sn(Fe:Ni)O2) nanoparticles showed higher antibacterial activity against all tested pathogens, as indicated by the inhibition zone, highlighting the enormous potential of nanoparticles in the healthcare sector. [31].

2.2 Biosynthesis of nanoparticles using leaf extract of neem

Azadirachta Indica Base Silver Nanoparticle Biosynthesis and Evaluation of Cytotoxic and Antibacterial Effects was the subject of a 2020 study by Asimuddin and his colleague. The development of sustainable and environmentally friendly processes for the production of metallic nanoparticles (NPs) is crucial given the growing environmental threat posed by climate change. Here, we offer a straightforward and environmentally responsible technique for producing silver nanoparticles (AgNPs) utilizing an aqueous solution of silver nitrate (AgNO3) and leaf extract from Azadirachta indica. [32]. The effects of temperature and leaf extract concentration on AgNP production are investigated. The optimal conditions for producing high-quality AgNPs were found to be 60 mg/mL leaf extract, 1 mM AgNO3, 30 minutes of reaction time, and 85 °C. The formation of the nanoparticles was confirmed by the surface Plasmon Resonance (SPR) of the AgNPs using UV-Vis analysis, which showed the largest absorption peak in the UV spectrum at 410 nm. Additional research on the antibacterial properties of biosynthesized AgNPs revealed inhibitory values of 0.5 g/ml for Escherichia coli and 1.0 g/ml for Staphylococcus aureus. A minimum inhibitory dosage of 15.6 g/mL was also required, according to in vitro cytotoxicity experiments using biosynthesized AgNPs against human acute lymphoblastic leukemia cells using the MTT assay. This method makes it possible to create AgNPs on a large scale, which is advantageous for the economy and the environment and may find value in biological applications. Leaf extract from Azadirachta indica was utilized as a reducing agent in the ongoing study to develop a non-toxic, safe, and environmentally acceptable method for producing AgNPs [32]. With this method, AgNPs with a high degree of crystallinity and a spherical shape were created under natural daylight. Numerous physicochemical parameters, such as temperature, length, the amount of leaf extract, and AgNO3, were evidently related to the quality and quantity of the generated AgNPs. A. In light of recent results and examination of previous research, the geographic location of the indica plant also plays a critical role in the properties of the generating AgNPs. However, collaboration between material scientists and natural product chemists is necessary to further investigate this. Though the research can be extended to include resistant strains, promising results might be obtained. The biosynthesized AgNPs have further proved their antibacterial activity against dangerous bacteria, indicating that they have bactericidal characteristics [32]. Furthermore, this study is the first to assess how biosynthesized AgNPs affect ALL patient PBMCs in vitro. The results demonstrate that leukemic cells cannot proliferate when biosynthesized AgNPs are present. This capacity can be further examined against a range of other cell lines to see if it is a viable therapy option. The proposed research is presently underway, and the expansion of the work presented will be published as a separate study at a later date. [32].

2.3 Others Synthetic Methods

Using an efficient and biocompatible home microwave method, Saravanan and his colleague in 2020 produced ZnO nanoparticles from Azadirachta indica leaf extract. utilizing a microwave-assisted solvothermal procedure and leaf extract from Azadirachta indica, ZnO nanoparticles were successfully synthesized utilizing a green synthesis technology. Powder X-ray diffraction was used to confirm the structure of greenly synthesized ZnO NPs as well as the lattice parameters. Energy dispersive X-ray analysis and scanning electron microscopy enable the examination of the greenly synthesized ZnO NPs' shape and elemental makeup. The photoconductivity analysis reveals the positive photoconductive nature of ZnO nanoparticles. [33]. ZnO NPs were effectively synthesized using a simple solvothermal method with leaf extract from Azadirachta indica. The well-established crystallization of the ZnO nanoparticles was shown by the PXRD patterns. Using Scherer's equation, the average particle size was determined. SEM was used to determine the materials' morphology and chemical makeup. As well as EDAX pictures. Photoconductivity measurement establishes the positive photo-conducting properties of ZnO NP. [33].

III. METHODOLOGY

The synthesis of green nanoparticles has garnered a lot of interest recently because of its durability and environmental friendliness. The popular medical plant neem (Azadirachta indica) is a potential source for the production of nanoparticles. Neem plant extracts are used as a stabilizing and reducing agent in this procedure, which provides a detailed guide for the environmentally friendly synthesis of nanoparticles.

3.1 Material and Equipment's Required

- Neem leaves or neem extract: The neem (Azadirachta indica) leaf is the primary source of the bioactive compounds used in green synthesis. Throughout the production process, either fresh neem leaves or neem leaf extract can be utilized.
- Solvent: A suitable solvent is needed to extract the bioactive components from neem leaves. Water, ethanol, methanol, or a combination of these solvents are commonly used for this purpose.
- Reducing agent: A reducing agent is required to facilitate the reduction of metal ions and the formation of nanoparticles. It has been demonstrated that several of the bioactive compounds found in neem extract, including as phenolic, flavonoids, and terpenoids, have reducing effects..
- Metal precursor: A metal precursor or a salt containing those metal ions is required if you want to synthesize metal nanoparticles. Common metal precursors include copper sulphate ($CuSO_4$), gold chloride ($AuCl_3$), and silver nitrate ($AgNO_3$).
- Reaction vessel: A suitable reaction vessel is needed to finish the synthesis process. Any container, like a glass flask or beaker, that is suitable for the reaction conditions can be utilized.
- Stirrer or magnetic stirring bar: To guarantee even mixing of the reaction components during the synthesis process, a stirrer or magnetic stir bar is helpful.
- Heating device: Depending on the synthesis procedure, a heating tool, such as a microwave or hot plate, may be required to control the temperature and speed up the reaction.
- Filtration system: After the synthesis, you will need a filtration apparatus, such as filter paper or a membrane filter, to extract the nanoparticles from the reaction mixture.

3.2 Collection and Preparation of Neem Plant Extract:

Gather fresh neem leaves or other parts of the plant. Rinse the collected plant material well in distilled water to get rid of any dirt or pollutants. Dry the plant material in the shade to prevent the degradation of active compounds. Using a mill and pestle, grind the dried neem leaves or plant parts into a fine powder. [34].

3.3 Preparation of Neem Extract:

Ten grams of neem powder should be weighed before being added to a sanitized beaker. Add a suitable solvent (1:10) (w/v) to the beaker, such as ethanol or distilled water. Use a magnetic stirrer to stir the mixture at room temperature for a certain period of time (e.g., 24 hours) in order to extract the bioactive compounds from the neem plant. [34].

3.4 Synthesis of Nanoparticles:

Step 2 involves measuring out 50 mL of neem extract and transferring it to a sterile reaction vessel, such as an Erlenmeyer flask. Add an appropriate precursor solution containing metal salts (like silver nitrate) to the reaction vessel. Use a magnetic stirrer to agitate the mixture for a set period of time, say two hours, at an appropriate temperature, like 60°C. Watch for a change in color in the reaction mixture, which indicates the formation of nanoparticles. It is usual practice to produce brownish nanoparticles using neem plant extract. [34].

3.5 Characterization of Nanoparticles:

Take a small sample of the synthesized nanoparticles and centrifuge the mixture to separate them from the rest of the solution. Wash the collected nanoparticles thoroughly with distilled water several times to remove any leftover impurities or unreacted materials. Characterize the synthesized nanoparticles using a variety of analytical techniques, including scanning electron microscopy, transmission electron microscopy (TEM), Fourier-transform infrared spectroscopy, X-ray diffraction, and UV-Vis spectroscopy. Ascertain the dimensions, form, crystallinity, and other relevant properties of the produced nanoparticles by examining the obtained data [34].

3.6 Evaluation of Nanoparticle Applications:

Analyze the produced nanoparticles' potential applications, including their antimicrobial, catalytic, and drug-transporting properties. Conduct specific experiments or studies to evaluate the nanoparticles' efficacy and performance in the intended application.

3.7 Optimization and Further Studies:

Adjust the experimental parameters (such as the neem extract concentration, reaction temperature, and reaction duration) to optimize the synthesis process and improve the nanoparticles' characteristics. Conduct additional research to better understand the fundamental mechanisms and interactions behind the green manufacturing of nanoparticles based on neem plant extract.

IV. CONCLUSION

In conclusion, a sustainable and eco-friendly method of producing nanoparticles is provided by the green synthesis of neem plant-derived nanoparticles. Biologically active substances included in neem extracts serve as stabilizing and reducing agents, doing away with the necessity for dangerous chemicals. The method yields nanoparticles with desired qualities for a range of applications and is inexpensive and easily scalable. Neem-derived nanoparticles are useful in many different domains because they have the potential to improve antibacterial, anticancer, and agronomic functions. Overall, neem plant-based green synthesis is a potential method for creating nanoparticles with several advantages for ecological sustainability and scientific progress.

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CONFLICT OF INTEREST

The writers don't have any conflicts of interest.

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