Prayogik Rasayan

Synthesis of Nanoparticles Utilizing a Hazardous Weed *Parthenium hysterophorus* - A Short Review

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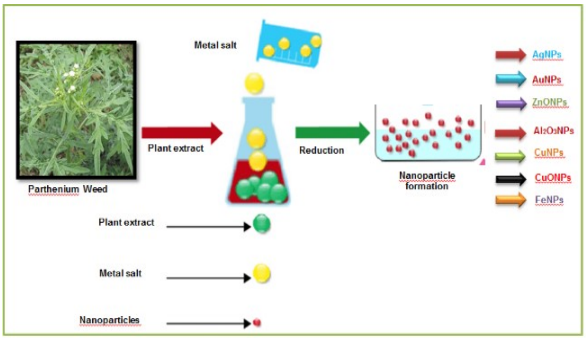
Abstract

Nanoparticles possess enhanced stability and durability compared to macromolecules. Along with various applications they have shown great promise in targeted drug delivery systems. But the various chemical synthesis methods lead to the presence of some toxic chemical species that may have adverse effects in medical applications. On the other hand, synthesis of nanoparticles using plant extracts, also known as green synthesis, offers several advantages over traditional chemical synthesis methods. In this study we choose *Parthenium hysterophorus* which is a noxious weed that poses numerous risks and hostile properties to humans, animals, and the environment. One of the best practices of its management is the synthesis of nanoparticles from *Parthenium* weed, particularly *Parthenium hysterophorus* which has been explored in recent studies. Here's an outline of typical approach for synthesizing various nanoparticles from *Parthenium*.

Keywords: Parthenium, Weed, Extract, Synthesis, Nanoparticles.



Introduction

Nanoparticles and macromolecules are both valuable in various applications, but due to some special characteristics nanoparticles are often preferred over macromolecules in certain contexts. Nanoparticles typically have dimensions ranging from 1 to 100 nanometers, whereas macromolecules are generally larger.[1] The small size of nanoparticles results in a high surface-to-volume ratio,[2] which allows for greater reactivity and enhanced interactions with surrounding materials. This feature is particularly advantageous in catalysis, sensing, and drug delivery, where a larger surface area facilitates more efficient reactions and interactions. They can be engineered to emit, absorb, or scatter light at specific wavelengths, enabling their use as contrast agents in various imaging techniques, including magnetic resonance imaging (MRI), computed tomography (CT), and optical imaging. Nanoparticles are also extensively studied for energy-related applications, such as solar cells, batteries, and fuel cells.[3,4]

There are several chemical procedures reported for the synthesis of nanoparticles but the chemical synthesis of nanoparticles leads to the presence of some toxic chemical species adsorbed on the surface that may have hostile effects in medical applications.[5] On the other hand, the synthesis of nanoparticles using plant extracts, also known as green synthesis, offers several advantages over traditional chemical synthesis methods such as environmentally friendly, cost-effective and in this method there is no need to use high pressure, energy, temperature and toxic chemicals.[6] Nanoparticles synthesized using plant extracts often exhibit excellent biocompatibility, which is crucial for biomedical applications and if that plant will be a hazardous weed then it will be more valuable for our environment. So we choose *Parthenium*, also known as *Parthenium hysterophorus* or "congress grass," which is a highly invasive and noxious weed that poses numerous risks and adverse effects to humans, animals, and the environment.[7,8,9]

Parthenium weed is known for its ability to colonize disturbed habitats and rapidly spread, displacing native plant species and reducing biodiversity.[10,11] It can negatively impact ecosystems by altering soil composition, inhibiting the growth of other plant species, and disrupting natural habitats for native flora and fauna. People working in fields, agricultural settings, or areas heavily infested with *Parthenium* weed may be at risk of occupational health issues. The presence of *Parthenium* weed can have significant economic implications. Its invasiveness can lead to increased costs for farmers and landowners in terms of weed control measures, reduced crop productivity, and potential loss of livestock.[12,13,14] *Parthenium* contains naturally arising organic compounds such as parthenin, *p*-coumeric acid, caffeic acid, ferulic acid, anicic acid, fumaric acid, vanicillic acid, coronopilin, ambrosonalides, 2B-hydroxycoronopilin, 1,3-hydroyparthenin, pseudoguananolides, hystrin, charminarone, aglycone-flavanols, hysterones A to D and acetylated pseudo-

guananolides.[15,16,17,18] Figure 1 represents some of these sesquiterpene lactones which are isolated from *Parthenium*.

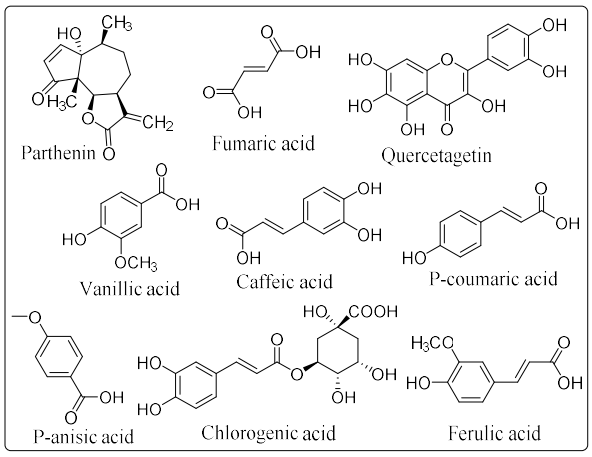


Figure 1: Chemicals isolated from *Parthenium*

Almost all parts of Parthenium weed (including, stem, leaves, pollen, trichomes etc.) is known to produce allelochemicals, which are secondary metabolites that can have both beneficial and harmful effects on other plants, animals, and microorganisms. Due to the various health and environmental risks associated with *Parthenium* weed, it is important to implement effective control and management strategies to prevent its spread and minimize its impact on human health, agriculture, and ecosystems.[19,20,21,22] Among the various management practices one of the most important management practice is the synthesis of various nanoparticles from *Parthenium* plant extracts. This chapter includes the details of various nanoparticles synthesized from *Parthenium* plant extracts.

2. Literature survey of nanoparticles synthesized from *Parthenium* plant extracts:

Along with lots of negative effects *Parthenium* has many beneficial aspects too and synthesis of nanoparticles from *Parthenium* is one of them. Plant extracts, which are rich in various phytochemicals,[23] act as both reducing and capping agents for the formation and stabilization of nanoparticles. These phytochemicals (e.g., flavonoids, polyphenols) have inherent reducing properties that can convert metal ions into nanoparticles, while also acting as stabilizers to prevent nanoparticle aggregation. The phytochemicals in plant extracts can also impart additional functional properties to the nanoparticles. This method reduced the use of toxic chemicals, making it safer for both the environment and researchers.

1. Silver nanoparticles (AgNPs) have gained significant attention in various fields due to their unique properties and potential applications.[24,25] AgNPs can promote wound healing by accelerating tissue regeneration and reducing the risk of infection. It can be used as carriers for drug delivery. Silver nanoparticles are also used in the fabrication of solar cells and photovoltaic devices due to their excellent electrical conductivity and optical properties. Some of the key importance of silver nanoparticles are shown in figure 2:

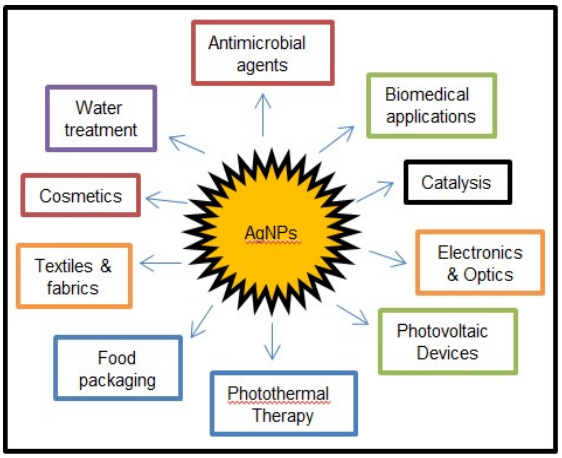


Figure 2: Properties and applications of Silver nanoparticles

There are several chemical methods reported regarding the synthesis of silver nanoparticles but the use of hazardous chemicals and solvents may raise environmental concerns. Along with additional purification steps might be required to remove excess reagents and byproducts in chemical synthesis of nanoparticles. To overcome these problems Vyom Parashar and his team exploring the utility of *Parthenium* in Silver nanoparticle synthesis from *Parthenium* leaf extracts.[26] In this method the plant extract was added to the aqueous solution of Silver Nitrate ($AgNO_3$) and then the sample was incubated in dark for 24 hours. Silver ions present in the aqueous solution of silver complex were reduced and was monitored by UV-Visible spectroscopy. Formation of silver nanoparticles was indicated by the color change which occurs due to excitation of surface plasmon vibrations.[27] Transmission Electron Microscopic (TEM) analysis was done for further characterization of the silver nanoparticles. After Parashar *et al*. many others[28,29,30] had synthesized silver nanoparticles using this leaf extract to explore the various properties of silver nanoparticles.

2. Zinc oxide nanoparticles (ZnO nanoparticles) hold significant importance across various fields[31] like, it provides effective protection against both UVA and UVB rays and also have been explored for their potential in drug delivery systems, as they can encapsulate and deliver drugs to specific targets in the body. Some of the key areas where ZnO nanoparticles are important shown in figure 3:

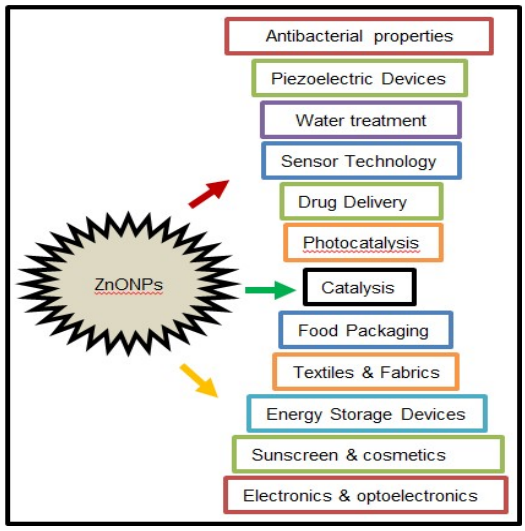


Figure 3: Properties and applications of Zinc oxide nanoparticles

Green synthesis of zinc oxide nanoparticles using *Parthenium* plant extract was reported by Arinjoy Datta and his group.[32] To facilitate the formation of zinc oxide nanoparticles, the *Parthenium* leaf extract was added to the zinc nitrate solution in a 9:1 ratio and the mixture was incubated for 24 hrs. Color change of the solution confirms the formation of zinc oxide nanoparticles and initially the bio-reduction was measured by UV-Visible spectroscopy. Further FTIR spectroscopy was recorded and Scanning Electron Microscopy (SEM) and TEM analysis was done to detect the shape and size of the formed nanoparticles. It's important to note that while zinc oxide nanoparticles have many practical applications, there is ongoing research into their safety and potential environmental impacts, particularly in products like sunscreen and cosmetics.

3. Aluminium oxide nanoparticles (Al_2O_3 nanoparticles), also known as alumina nanoparticles, are widely used in abrasive materials, various chemical reactions, optical coatings, water purification and wastewater treatment and many more.[33] It is Some key areas where aluminium oxide nanoparticles are important include (figure 4):

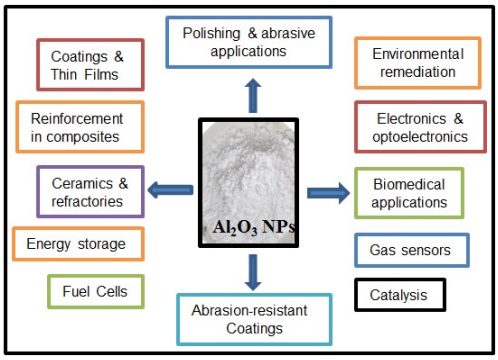


Figure 4: Properties and applications of Aluminium oxide nanoparticles

Using simple solution combustion method Yogendra *et al*. synthesize Aluminium oxide nanoparticles from *Parthenium hysterophorus L*.[34] For the synthesis of NPs, whole plant extract was taken and aluminium nitrate was added to the solution. Then keep it for 24 hrs incubation and color changes to deep yellow colored suspension which indicates the formation of Aluminium oxide nanoparticles. Characterization of the synthesized nanoparticles was done by UV Absorption spectroscopy, SEM, X-Ray Diffractometer analysis and Energy Dispersive Xray analysis (EDX). Proper handling, dispersion, and disposal of these nanoparticles are important to mitigate potential health and environmental risks. Regulators and researchers continue to assess their safety in various applications.

4. Gold nanoparticles (Au nanoparticles) have garnered significant importance in various scientific and technological applications due to their unique properties and versatile nature.[35] In cancer treatment it is used in photothermal therapy, where they absorb near-infrared light and generate heat to selectively destroy cancer cells. They can enhance the efficiency of light-emitting diodes (LEDs) and other optoelectronic devices. Gold nanoparticles are also used in the restoration and conservation of historical and cultural artifacts, such as paintings and sculptures. Some key areas where gold nanoparticles are important is shown in figure 5:

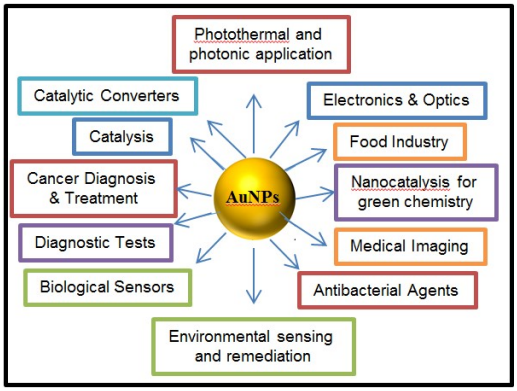


Figure 5: Properties and applications of Gold nanoparticles

Using *Parthenium hysterophorus* plant extract as a reducing agent Ramamurthy *et al*. established the biosynthesize Gold nanoparticles.[36] In this method, along with *Parthenium hysterophorus* plant extract (using leaves and flowers only) gold chloride trihydrate was used as the precursor for the preparation of gold nanoparticles. To adjust the pH at 12 of the solution, sodium hydroxide was added drop wise with stirring. A red colored precipitate indicates the formation of gold nanoparticles. Through UV-Visible spectroscopy, FTIR, powder X-ray diffraction and SEM analysis the characterization of gold nanoparticles was done. Gold nanoparticles possess a unique and tunable surface plasmon resonance (SER)[37] and due to this red colored precipitate appeared. The unique properties of gold nanoparticles make them versatile in a wide range of applications, and ongoing

research continues to explore new uses for these nanoparticles in various fields.

5. Copper nanoparticles (Cu nanoparticles) hold significant importance across various fields[38] and can be used in many products, including coatings, textiles, catalysis and medical devices, to inhibit the growth of bacteria, viruses and fungi. In marine and underwater environments, copper nanoparticles can be used in antifouling coatings to prevent the attachment of barnacles, algae, and other marine organisms to the surfaces of boats and underwater structures. Figure 6 represents some of the key areas where copper nanoparticles are important:

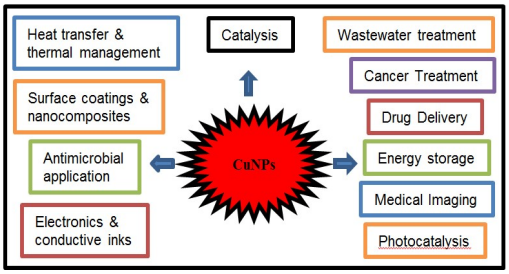


Figure 6: Properties and applications of Copper nanoparticles

Mary *et al*. reported the eco-friendly and green synthesis of copper nanoparticles using *P. hysterophorus* leaf extract.[39] Dry and fresh leaf extract was prepared from Parthenium weed and aqueous copper sulfate solution was added. Then it was incubated for 24 hours and a colour change denotes the formation of copper nanoparticles. XRD, SEM and UV-Visible spectroscopic analysis were done to characterize the nanoparticles. The unique properties of copper nanoparticles make them promising materials for a wide range of industries and technologies.

6. Copper oxide nanoparticles (CuO nanoparticles) are of significant importance due to their uses in various fields which have been shown in figure 7.[40] These nanoparticles can be used for the removal of pollutants from water and air and are incorporated into paints and coatings for their antimicrobial properties. They can also be used in lithium-ion batteries and supercapacitors, contributing to improved energy storage and longer battery life.

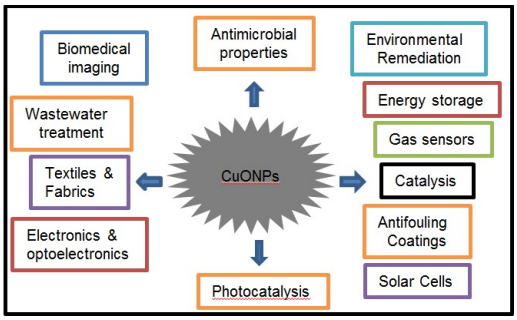


Figure 7: Properties and applications of Copper oxide nanoparticles

Mansi Singh under the supervision of Dr. Jai Gopal Sharma submitted her project report on the green synthesis of CuONPs using *parthenium hysterophorus*.[41] Parthenium plant extract was added into the copper sulphate solution until the colour changed from aqua blue to green. After the development of green colour it was stirred for 2 hours then these solutions were incubated overnight at room temperature having beaker covered with aluminium foil. Formed nanoparticles were imperiled to various characterizations to confirm the formation of copper oxide nanoparticles such as UV-Vis spectroscopy, FTIR, XRD, EDX, SEM and DLS (Dynamic Light Scattering).

7. Iron nanoparticles (Fe nanoparticles) hold significant importance because of their uses in various fields.[42] It can be used to remove pollutants, heavy metals and contaminants from water through processes like adsorption, coagulation, and catalytic degradation. Magnetic iron nanoparticles can be guided to specific tumor sites using an external magnetic field for hyperthermia treatment or drug delivery. Some of the key areas where iron nanoparticles are important include (Figure 8):

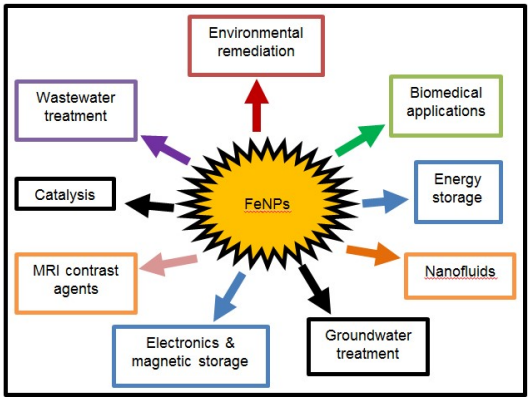


Figure 8: Properties and applications of Iron nanoparticles

Koduru *et al*. had proposed the green synthesis of iron nanoparticles using *P. hysterophorus* leaf extract.[43] In their method aqueous solution of ferrous sulphate was mixed drop-wise with *Parthenium* leaf extract in the ratio of 3:1 and pH of solution was maintained nearly 11.0 by continual addition of 1 M NaOH solution. Formation of intense black colour solution from dark green solution indicates that iron nanoparticles have been synthesized and FTIR, SEM, EDS analysis were done to characterize the iron nanoparticles. Iron nanoparticles are used as model materials for studying nanoscale properties and behaviors.

These nanoparticles are often stabilized using various functional groups, and the choice of stabilizing agent depends on the desired properties and applications of the nanoparticles. Commonly used functional groups for stabilizing these nanoparticles include: thiol groups (-SH), amine groups ($-NH_2$), carboxylate groups (-COO-), hydroxyl groups (-OH), phosphine groups ($-PR_3$), phosphonate groups (PO_3H_2), silanol groups (-Si-OH), polymeric stabilizers and

surfactants. These functional groups are often part of organic molecules that act as capping agents or stabilizers on the surface of the silver nanoparticles.

Parthenium weed (*Parthenium hysterophorus*) hold health risks to individuals, especially those who come into direct contact with it. It's important to note that the specific health risks can vary based on individual sensitivity, the form of exposure, and the duration of contact. Researchers should take appropriate precautions to minimize the risk of exposure and associated health effects. They should maintain Personal Protective Equipment (PPE), good laboratory practices and hand hygiene.

3. Conclusion

Parthenium weed has gained attention in nanoparticle synthesis due to their potential as bioresources. The exact number of nanoparticles synthesized from parthenium weed can vary depending on the specific research studies conducted in this area. It's important to note that the synthesis of nanoparticles from *Parthenium* weed is a relatively recent and developing field, and the number of published studies exploring this topic may be limited.

To date, there have been a few research studies reporting the synthesis of nanoparticles using *Parthenium* extracts or components. These studies have primarily focused on synthesizing metal nanoparticles, such as silver nanoparticles or gold nanoparticles, using *Parthenium* as a reducing and stabilizing agent. However, the number of nanoparticles synthesized in each study can vary depending on the experimental conditions and objectives.

It's worth mentioning that the synthesis of nanoparticles from *Parthenium* is an active area of research, and more studies may emerge in the future exploring different types of nanoparticles and their applications. As research progresses, the number and diversity of nanoparticles synthesized from *Parthenium* weed are likely to increase.

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