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Green Synthesis and Characterization of Nanoparticles: Exploring Biological and Catalytic Activities

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ABSTRACT: The new era of chemistry is shifting towards the path of innovative techniques which mainly concentrate on environmental aspects. Nanoparticles have gained significant attention in various fields, including pharmaceutical and biological sciences, due to their unique properties and potential applications. The synthesis of nanoparticles allows for precise control over their size, shape, and surface properties, leading to enhanced drug delivery systems, diagnostic tools, and therapeutic interventions. Several methods are use for preparation of nanoparticles, but in some methods involved hazardous chemicals, costly chemicals, more energy consumption, not easily handled etc.

hence, we will be used greenery method to the preparation of nanoparticles due to they are easily available, safe, and nontoxic. They have a broad type of metabolites that can aid in the reduction of metal ions. The use of plant extracts for nanoparticles synthesis is more advantageous than the other biological process as there is no troublesome of preserving and maintaining the cell culture and is a simple, one-step synthesis process with no chances of mutation as in microorganisms. The low cost of cultivation, short production time, safety and the capacity to up production volumes make plants an attractive platform for nanoparticle synthesis. The plants mediated synthesis of nanoparticles is free from harmful chemicals as well as providing natural capping agents for the stabilization of metal nanoparticles.

I. INTRODUCTION

The various metallic nanoparticles like gold, silver, platinum, zinc, copper, titanium dioxide, magnetic iron-ore, nickel etc. were synthesized from natural resources and are studied exclusively. The different parts of a plant such as a stem, root, fruit, seed, callus, peel, leaves and flower are used to syntheses of metallic nanoparticles in various shapes and sizes by biological approaches. Biosynthesis reaction may be altered by a wide range of metal concentration and quantity of plant extract in the reaction medium, it may transform the shapes and size of the nanoparticles. Biomolecules like proteins, amino acids, enzymes, polysaccharides, alkaloids, tannins, phenolic, saponins, terpenoids and vitamins

This proposed Ph.D. research aims to investigate the synthesis of nanoparticles and explore their biological and catalytic activities for the development of innovative therapeutic approaches. Nano catalyst is recently growing field applicable to almost all type of catalytic organic transformations. These versatile semi heterogeneous nanocatalysts with high surface area are the best alternatives to conventional catalysts, the highest catalytic activity, selectivity and stability can be achieved by their shape, size, composition and nature of nanocatalyst.Thus nanocatalyst is a substance that speed up or slow down chemical reaction without being consumed by them. Several forms of nanocatalyst such as magnetic nanocatalyst, nano mixed metal oxide, core shell nanocatalyst and nano supported catalysts have been employed in catalytic application. Metal nanocatalysts are promising material for the heterogeneous catalyst. In this context, the preparation of new highly active, sustainable and more selective nanocatalyst is of prime importance, especially in the field of organic synthesis.

II. BRIEF HISTORY OF GREEN SYNTHESIS

Green synthesis, Characterization and Bi- evaluation of Metal/metal Oxide nanoparticles. Proposed of the study: Being the relatively newer method than conventional methods of nanoparticle synthesis, the proposed problem leads to ecofriendly, non-hazardous and following the green chemistry principles for synthesis of novel nanoparticles.

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Reduction of particle size to nanometer scale provides unique properties which can be used in practice for development of novel materials. Nanocatalyst is an essential tool of green chemistry as it enables the development of less polluting chemical process and opens up synthetic path way to desired products using sustainable resources. The isolation and recovery of nanocatalyst become difficult so it is important to use appropriate support to design selective reusable and sustainable nanocatalyst. Metal nano particles deposited on the surface of various supporting materials to form supported metal catalyst have been widely studied in academic and industrial field. Magnetic nanocatlyst have been extensively studied as the catalyst support essentially facilitating magnetic separation and recyclability.

III. HYPOTHESIS OF THE STUDY

Preparation of metal nanoparticles using chemical method leads to hazardous reaction condition, expensive technique, required longer time, difficult to separation of nanoparticles, required high energy and pressure but in green synthesis of nanoparticles leads to non- hazardous reaction condition, ecofriendly, single steps reaction, no longer time required, no side product formed, green solvent is used like water. The advantages of green synthesis of nanoparticle using plants are that the plants are easily available and safe to handle and possess a large variety of active agents that can promote the reduction of metal ions. The proposed problem will lead to novel NP's synthesis, its characterization and Bio evaluation of plants parts. The applications for nanoparticles are growing rapidly and including in electronic as sensor, drug delivery, catalyst, domestic waste water treatment.

Also, the use of nanocatalysts for organic synthesis is most significance because it includes some important advantages such as short reaction time, high yield, simple methodology, easy workup procedure and green reaction conditions. It is believed that these well-constructed nanocatalyst with various energy sources such as microwave technology, ball milling, ultra sonication will help the accomplishment of being and sustainable chemical processes. The aim of present research is to synthesize various nanocatalysts by using greenery methods/techniques and its biological evaluation as well as transformation of various organic synthesis.

Therefore, the research efforts have been directed towards synthesis of nanocatalyst and its role in biological activities and organic synthesis, which will satisfy many criteria of green chemistry of organic compound.

IV. RESEARCH METHODOLOGY AND OUTLINE OF RESEARCH WORK:

Research methodology and outline of research work:
NPs can be synthesized by physical and chemical methods including mechanical milling process commonly used in the metalworking industry. Basically, there two types of methods to synthesis of nanoparticles.

A) Top-down approach:
- Mechanochemical method: It is a cost-effective pathway to make nano-powders using ball-shaped mills in low-temperature chemical reactors where the grinding balls increase the kinetic reaction of the reactant powders and provide the required temperature for the reactions by their movements.
- Sputtering: The sputtering, technique of thin film deposition, is suitable for high melting point materials.
- Etching: is one of the common techniques for removing and transferring materials in the generation of NMs and NPs and can be performed by electric or chemical arc discharge methods.

B) Bottom Approach:
- Greener synthesis of MNPs/MONPs: Due to industrialization problems related to the physical processes and the use of toxic and expensive chemicals in the synthesis of nanoparticles, alternative greener syntheses methods have garnered major attention In these greener options, living organisms such as plants, bacteria, fungi, algae and lichens, or constituents from these organisms, are used to synthesize nanoparticles from the metal ions among these, plants are preferred over physical and chemical methods due to their availability, low cost, and eco-friendly nature. Interestingly, these nanoparticles can be sustainably synthesized by using industrial wastes and agricultural residues and often they have better biological and catalytic activity than nanoparticles synthesized by conventional methods using harsh chemicals.

Chemical reduction methods: Reduction of metal salts is the most common strategy to synthesize MNPs/MONPs, which can also be mass-produced at room temperature in one- pot reaction conditions.

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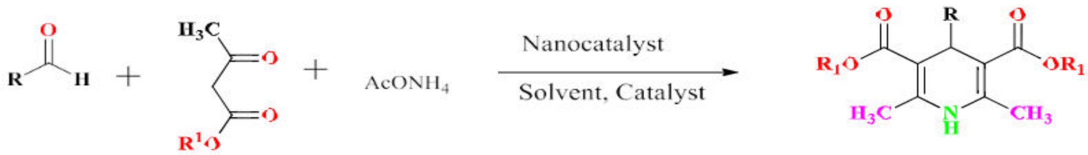
V. APPLICATIONS

The applications of nanotechnology, commonly incorporate industrial, medicinal, and energy uses. These include more durable construction materials, therapeutic drug delivery, and higher density hydrogen fuel cells that are environmentally friendly.

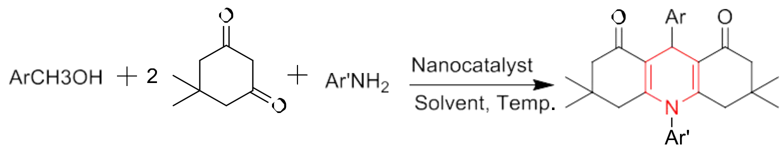
1. Wet chemistry: Wet chemistry methods are the most common bottom-up protocols deployed for synthesizing a wide range of nanomaterials.
Biological Evaluations: The synthesized nanoparticles will be assessed for their biological evaluations as well as catalytic performance in transformation of organic reactions.
Some examples of organic reactions transformation by Nano catalyst.
Reaction of o-phenylenediamines and ketone in aqueous medium by efficient recyclable heterogeneous nanocatalyst.

Nano catalyst used to the synthesis of 1,4-DHPs with heigh yield.



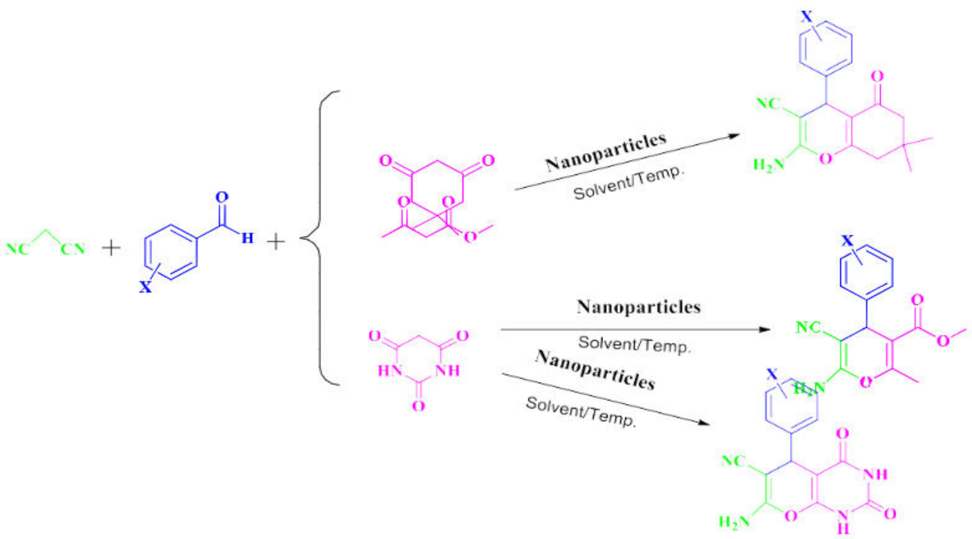
Scheme 1

Nano catalyst to synthesize 1,8-dioxo-decahydroacridine derivatives in a solvent-free condition.



Scheme 2

Nanocatalyzed synthesis of pyran derivatives.



Scheme 3

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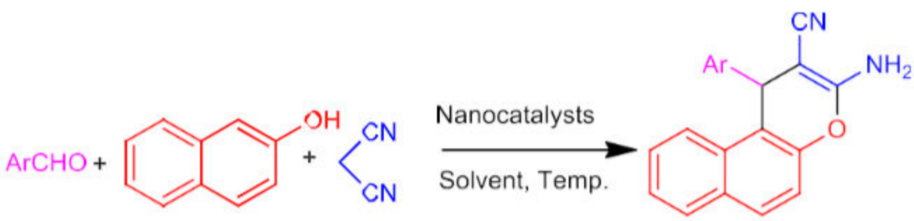
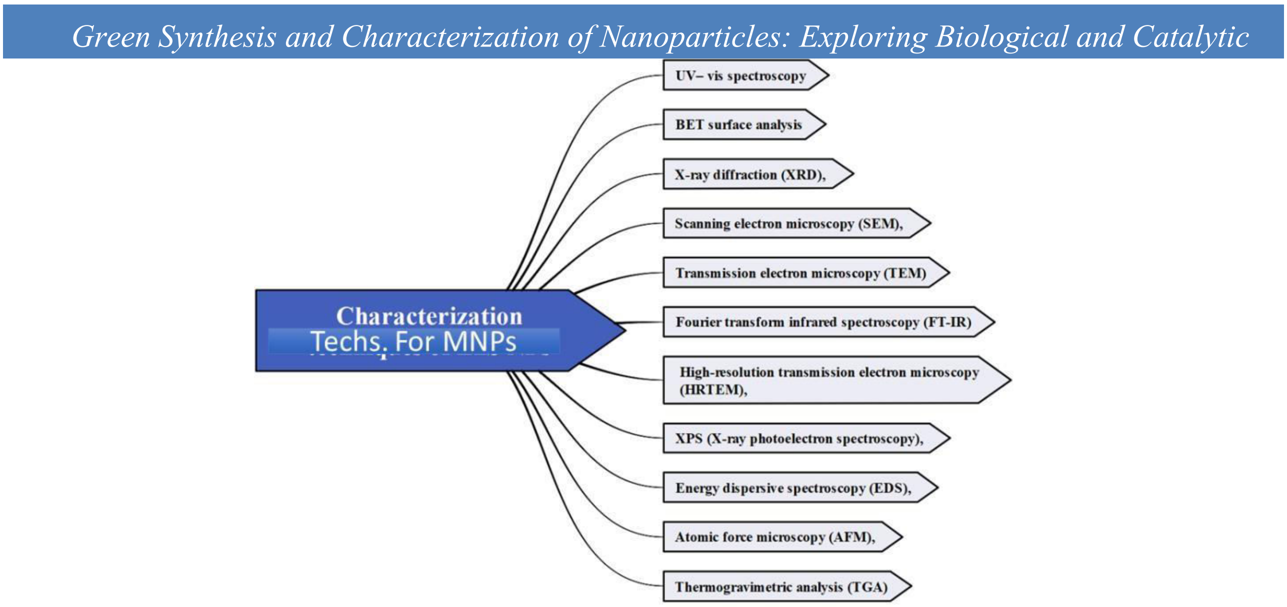
Synthesized nanoparticle thin films that catalyzed the synthesis of 3-amino-1aryl-1H-benzo.



2. Characterization:

Comprehensive characterization techniques, such as X-ray diffraction (XRD), EDS, transmission electron microscopy (TEM), FESEM, FTIR, UV-Visible study and surface area analysis, will be utilized to evaluate the physicochemical properties of the synthesized nanoparticles.



VI. RESULT & DISCUSSION

Green synthesis has many advantages compared to chemical and physical methods: it is non-toxic pollution-free, environmentally-friendly, economical, and more sustainable .

Green nanotechnology has emerged as a widely recognized and promising field of science for environmental sustainability through various applications in renewable energy, environmental remediation.

The successful completion work will result in development of newer greener synthetic route/methodology of metal/metal oxide nanoparticles to overcome the synthetic difficulties.

The resultant cost-efficient high yield nanoparticles will possess enhanced biological and therapeutic properties.

Synthesized NPs may have catalytic applications in organic synthesis.

VII. FUTURE SCOPE

We present the following speculations and assumptions to overcome the limitations and shortcomings in current studies, and hopefully put green-synthesized nanoscale metals into practical use.

7.1. Ideal raw materials

Evergreen plants such as Filicium decipiens that could avoid seasonal time constraints is potentially a good alternative material. Filicium decipiens is often used as shade trees and soil conditions usually do not limit their growth (Sharmila et al., 2017). The Filicium decipiens used in the synthesis experiment by G. Sharmila was readily available having directly obtained it from the campus.

7.2. Reduce energy consumption

In order to solve the problem of high energy consumption in some synthesis processes, scientists should explore processes that can be carried out without heating. This can be carried out based on existing energy-saving experiments. For example, using leaf extracts from Hippophae rhamnoides, Gardenia, and Henna to synthesize Fe NPs does not need toxic chemical reagents, and high reaction energy and temperature (Naseem and Farrukh, 2015, Nasrollahzadeh et al., 2015). At present, there are already some extraction methods that are performed at low energy, such as reaction temperature lower than 100 °C for the synthesis of Ag NPs using grape seed extract (Ping et al., 2018), or 22 and 25 °C in the synthesis of Au NPs using Genipa americana fruit extract (Kumar et al., 2016a). Likewise, when Nettle and Thyme leaf extracts were used to synthesize Fe NPs, the required temperature was 80 °C (Leili et al., 2018). Compared with methods that require ≥600 °C, methods with relatively low energy consumptions should be considered.

7.3. Product optimization

Future research should focus on the synthesis of uniformly small sized particles that have large surface area. For CuO NPs, Gloriosa superba L. extract is preferable because it yielded particles that had uniform size ranging from 5 to 10 nm. (Naika et al., 2018). For NZVIs, Mint (Mentha spicata L.) leaf extract synthesized relatively small and uniformly dispersed particles that did not aggregate (Prasad et al., 2014) while Cupressus sempervirens leaf extract synthesized particles with diameter of approximately 1.5 nm (Ebrahiminezhad et al., 2018). Some green materials can synthesize Pd NPs with very small particle size. For example, the average particle size synthesized by Sapindus mukorossi leaf extract was 5 nm (Nagajyothi et al., 2016). The use of gum olibanum, Filicium decipiens leaves, and Hippophae rhamnoides Linn leaves or Carboxymethyl Cellulose in the synthesis of Pd NPs with diameter of 1.5–4.0 nm was also noteworthy (Li et al., 2017, Sharmila et al., 2017, Devi et al., 2019, Kora and Rastogi, 2016).

7.4. Storage of the products

The storage of nanoscale metals also needs to be considered. If nanoscale metals can be kept in ambient condition, the cost of storage or preservation will greatly decrease. The storage of nanoscale metals is related to their stability. The more stable the NPs are, the more economically can they be stored.

VIII.CONCLUSION

Green synthesis of Au, Ag, Fe, Cu, and Pd NPs have been discussed. Studies on various plant materials show that the green synthesis of nanoscale metals is feasible. In recent years, a large number of research has been reported regarding green synthesis of nanoscale metal. However, green synthesis has many challenges and shortcomings such as low yield, non-uniform particle sizes, complex extraction procedures, seasonal and regional availability of raw materials, and other difficulties that need to be overcome for practical production and application of green synthesized nanomaterials. Therefore, improving yield of nanoscale metal particles, using low-cost raw materials, and employing simple energy-saving technology are the research directions needed in the future. At present, there have been successful cases of using grass to synthesize Ag NPs. Therefore, it is possible that green synthesis of nanoscale metals has a broad prospect and a great potential for development.

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