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Sustainable Biogenic Fabrication of Nanoparticle Synthesis Methods via Medicinal Plants Extract: Approaches and Review

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Abstract

This review focused on the utilization of nanoscale metals such as Ag and Cu, which are considerable throughout a range of industries spanning environmental, medical, and engineering sectors, making the synthesis of these nanomaterials a pertinent subject. Currently, green chemical and biological strategies are predominantly employed for the synthesis of nanoscale metals; however, these strategies come with unintended disadvantages such as environmental contamination, excessive power consumption, and achievable fitness hazards. In addressing these challenges, inexperienced synthesis has emerged as a promising alternative, making use of plant extracts instead of physical and industrial chemical dealers to limit metal ions.

Keywords: Eco-Friendly, nanoparticles, synthesis, medicinal, plants, extracts.

Introduction

Medicinal plant extracts have been utilized for many years in traditional medicine throughout many cultures, serving as a historic sourceof medication. Knowledge about their advisable results has been passed down through generations within human communities. Natural products are a precious supply of drug compounds, with various pioneering medicines derived from ordinary natural treatments now being used in modern-day pharmacotherapy. The extraction technique is an imperative issue of separating bioactive molecules from plant sources, with contemporary strategies, such ultrasound-aided and supercritical fluid extraction methods complementing [1]. Numerous plant extracts have demonstrated significant anti-arthritic and anti-inflammatory effects. Numerous researchers discovered that alcoholic extracts and fractions from *Chenopodium album* L. and *Sisymbrium officinale* (L.) Scop. exhibited anti-inflammatory and antioxidant properties in vitro. These plants, suitable for human consumption, have a rich history in traditional medicine for addressing inflammatory issues. The investigation revealed that every species should suppress the production of the pro-inflammatory mediator nitric oxide in LPS-activated murine macrophages. Nanometallic materials are metals and alloys that form nanocrystalline grains with particle sizes ranging from approximately 5 to 100 nm. Nanoscale metals possess a greater surface area compared to their non-nano or bulk equivalents. Additionally, because of the small measurement effect, floor effect, interface impact, and quantum effect, they possess distinct physical and chemical properties no longer found in non-nano metals. Numerous types of nanoscale metals exist that serve diverse purposes in biology, medicine, and engineering. For instance, Au nanoparticles (Au NPs) possess organic functions for enzyme regulation, antimicrobial properties, and act as a muscle relaxant, while Ag NPs enhance the inhibition ability against both gram-positive and gram-negative bacteria [2]. Fe nanoparticles also impede bacterial proliferation and are effective in the remediation of matrices tainted with organic substances, steel, and non-metal ions, as well as dyes. Pd NPs are also employed in various applications such as dye degradation, antimicrobial activity, and catalysis. Currently, there is an increasing amount of research focused on the synthesis of nanoscale metals utilizing chemical, physical, and green synthesis methods. Physical and chemical methods are slowly being replaced by inexperienced synthesis techniques because of issues related to high energy consumption, the release of harmful and toxic materials, and the need for complex equipment and synthesis conditions. Physical methods encompass aerosols, ultraviolet light, and thermal breakdown, all of which require excessive temperature and electricity [3]. For instance, the aerosol technique necessitates a flame temperature of roughly 2400 K to generate atomized aerosol droplets and form nanoparticulate metals. The creation of PdO NPs through plasma-assisted vapor deposition at temperatures ranging from 250 °C to 800 °C involves significant energy consumption. For chemical methods, Sodium borohydride, a costly and hazardous reagent, along with various dispersant stabilizers and organic solvents, is typically utilized [4]. Conversely, novice synthesis utilizes natural and eco-friendly materials (e.g., reducing agents). Certain eco-friendly materials can also function as end-capping agents and dispersants simultaneously, which not only lowers energy use but also prevents the need for toxic and hazardous chemicals. Currently, novice synthesis frequently employs microorganisms (fungi, bacteria, and algae) or extracts from leaves, plants, roots, peels, fruits, and seeds of different species as a green biogenic synthesis [5]. Green substances consist of polyphenols and proteins that can alter chemical reagents as reducing agents to convert metallic ions into lower valence states. Steel nanoparticles can be synthesized in the presence of novel substances and under suitable conditions such as temperature, concentration, ambient air, and others. In favorable conditions, the application of untrained synthesized steel nanoparticles even exceeds those created through chemical methods. For instance, the particle size of Fe_3O_4 nanoparticles created using an inexperienced synthesis method is 2–80 nm, significantly smaller than the 87–400 nm particles produced via the wet chemical method [6]. Previous studies have shown the benefits of biological synthesis compared to chemical methods and underscored the capabilities and possibilities of biological synthesis [7]. Green biogenic synthesis offers numerous advantages over chemical and physical methods: it is non-toxic, free from pollution, environmentally friendly, costefficient, and more sustainable [8]. Additionally, there are issues with the reaction time for extracting raw materials and the quality of the final products. For instance, the raw materials are not easily obtainable, the synthesis duration is prolonged, and the product's particle size is remarkably uniform [9]. This review outlines methods related to eco-friendly synthesis of nanomaterials and assesses the associated limitations (see Figure 1). This evaluation aims to identify the key issues and challenges associated with the green synthesis of metal nanoparticles, while also outlining potential future research avenues. This summary provides a more thorough assessment and conversation regarding inexperienced synthesis, which holds potential for advancing new research in the future [8].

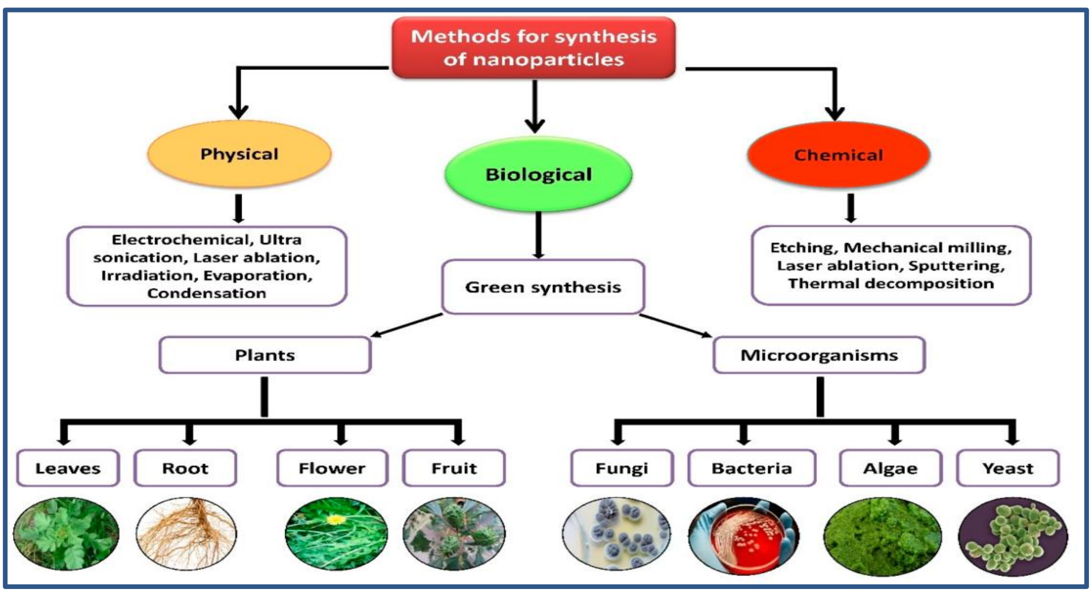

Figure 1. Methods of metallic nanoparticles synthesis [8].

Synthesis scenario

In the process of industrial nanoparticle synthesis, advanced instruments lead to high electricity usage, extended response durations, and the requirement for additional physical tools and chemical reagents. Nevertheless, to address this issue, the approach moved towards green synthesis techniques. For example, silver nanoparticles (AgNPs) can be produced through green synthesis employing extracts from the roots and leaves of *Ferula persica*. The process entails the reduction of silver ions (Ag^{+}) to create nanoparticles, with the plant extracts serving as reducing and stabilizing agents. A study by Nasiri et al. (2018) specifically employed extracts from the root and leaf of Ferula persica to greenly synthesize silver nanoparticles at 600°C for three hours [9]. While employing guava fruit extract to produce Cu nanoparticles in an 800°C water bath, this method of synthesizing copper nanoparticles with guava fruit extract at 800°C exemplifies a green chemistry approach. The technique utilizes the natural substances found in guava fruit extract to decrease copper ions, leading to the formation of nanoparticles that can subsequently be characterized and possibly applied in different uses, [10]. In contrast, to the chemical synthesis approach, employing semiconductor materials like CuO to produce CuO NPs as a precursor can be achieved with ultrasonic stirring at 80 °C for 2 hours [11].

Consequently, the temperature necessary for nanoscale metals at ambient temperature, such as the mixture of mint leaf extract and $Fe(NO_3)_3$, needs to be placed on a rotary shaker and operated for 72 hours in dark conditions at 200 rpm and 30 °C. In contrast, the algae mixed with $FeCl_3$ must be kept at 24 °C, under dark conditions, and stirred in a rotary shaker for 48 hours [12]. The mixture of black tea and $FeSO_4$ requires 24 hours to produce Fe NPs, followed by drying in an oven for 24 hours at 250 °C. The synthesis of CuO NPs using espresso powder extract necessitates microwave radiation, taking three hours to boil and 4 to 5 hours to dry in a warm air oven. The sol gel method for producing nanoscale metallic oxides requires continuous heating at 60 °C for one hour, stirring for 30 minutes, and centrifugation. The prolonged extraction method is also no longer appropriate. For example, mango skin is intended to be boiled for 12 hours for extraction [13].

Extracts from cherry, mulberry, and oak leaves should be pre-dried in an oven for 48 hours at 50 °C [14]. To obtain algae extract, *Sargassum acinarium* (Linnaeus) Setchell 1933 and *Padina pavonica* (Linnaeus) need to be washed with distilled water before being freeze-dried at −20 °C for three days. Certainly, O_2 is capable of oxidizing metallic nanoparticles; however, it should be noted that the excessive surface to volume ratio and the alteration of natural shape are factors to consider. For instance, the centrifugal separation of Pd NPs using *Euphorbia granulate* leaf extract must be performed in an argon atmosphere [15]. In a different study, the NZVI synthesis was previously conducted with N2 [16]. This condition enhances the ease and worth of the green Chemogenic and Biogenic methods for nanoparticle synthesis. Another critical constraint of inexperienced biosynthesis that necessitates the use of alternatives is the insufficient understanding of the biosynthesis mechanism, making it difficult to achieve accurate chemical reactions to elucidate the synthesis process. For instance, the extract from pomegranate (*Punica granatum* L.) peels [17], can serve as an end-capping agent in the formation of Cu/Cu2O/CuO/ZnO nanostructures. Moreover, an extract from the root of *Zingiber officinale* (ginger) can act as a reducing and capping agent for the synthesis of Ag NPs [18]. While, *Sageretia thea* (Osbeck.) serves as a chelating agent in the formation of Fe_2O_3 NPs [19].

Properties of Solvent of Extractions

(i) H_2O. It is the most polar solvent and is utilized for extracting a variety of polar compounds. Benefits. It dissolves various substances; it is inexpensive, non-toxic, non-flammable, and very polar. Drawbacks. It encourages the growth of bacteria and mold; it can lead to hydrolysis, and a significant amount of heat is necessary to concentrate the extract.

(ii) Alcohol. It is likewise polar in nature, soluble in water, and able to extract polar secondary metabolites. Benefits. It maintains its own preservation at a concentration exceeding 20%. It is non-toxic at low levels, and only a small amount of heat is needed to concentrate the extract. Drawbacks. It does not break down fats, gums, and wax; it is explosive and unstable.

(iii) Chloroform. It acts as a nonpolar solvent and is effective for extracting compounds like terpenoids, flavonoids, fats, and oils. Benefits. It is transparent, has a sugary scent, and dissolves in alcohols. It is also effectively absorbed and processed within the body. Drawbacks. It possesses sedative and cancer-causing qualities.

(iv) Ether. It is a nonpolar solvent and is effective for extracting compounds like alkaloids, terpenoids, coumarins, and fatty acids. Benefits. It mixes with water, has a low boiling point, and is flavorless by nature. It is similarly a highly stable compound and does not interact with acids, bases, or metals. Drawbacks. It is extremely unstable and combustible by nature.

(v) Ionic liquid (eco-friendly solvent). This is an exceptional extracting solvent that is very polar and incredibly heat resistant. It can stay in a liquid form even at 3,000 °C and is usable in high-temperature applications. It exhibits high miscibility with water and other solvents, making it highly effective for extracting polar compounds. Benefits and thus it is appropriate for extraction supported by microwaves. It is not flammable and is effective for liquid–liquid extraction and very polar. Drawback. It is not suitable for making tinctures [20].

Characterization Techniques

Various techniques were employed to identify compounds from extracts of medicinal plants. It involved identifying functional groups, presence of double bonds and rings, arrangement of hydrogen and carbon, along with complete structural clarification. The methods employed consist of mass spectroscopy (MS), ultraviolet spectroscopy (UV), nuclear magnetic resonance spectroscopy (NMR), and infrared spectroscopy (IR).

(i) MS. This technique is effective for identifying compounds by considering their chemical structure and molecular weight. The objective is to identify and sequence the unknown substance within a mixture. The compounds typically recognized consist of peptides and oligonucleotides. The procedure starts by striking an organic molecule with an electron, transforming it into highly energetic charged ions. The signal was initially identified using 70 eV of electron ionization energy; additionally, the sample spectra are detected and documented as percentage peaks. Compounds are recognized according to their molecular weight and relative molecular mass. This can be accomplished by graphing the mass of the fragmented ions in relation to the charges of each individual ion. Significantly, MS offers extensive data on organic compounds. Consequently, one of the typical methods in processing medicinal plants is the integration of MS/HPLC [21].

(ii) Ultraviolet. This approach is appropriate for both qualitative and quantitative assessments of compounds found in the plant extract. Different secondary metabolites like phenols, anthocyanins, tannins, and polymer dyes can be identified at specific frequencies.

This technique can be used to determine the total phenolic content and various other secondary metabolites. Distinct frequencies were utilized to detect flavonoids (320nm), phenolic compounds (280nm), anthocyanins (520nm), and phenolic acids (360nm) [22]. NMR. This technique pays more attention to the physical properties of the bioactive molecule such as number and array of the carbon atom, presence of isotopes of carbon, hydrogen atom, and protons [23].

(iii) Infrared. This approach aims to evaluate the functional groups found in a compound. Understanding the functional group assists in determining the physical and chemical characteristics of a specific compound. Additionally, this process identifies single, double, and multiple bonds. The method consists of sending an organic compound through infrared radiation, which is absorbed at specific frequencies. Liquid samples are identified with sodium chloride plates, while solid samples are analyzed by milling potassium bromide and compressing it into a thin pellet. The outcome is documented as a spectrum indicating percentage transmittance. Finally, the spectra are examined; the peaks identified at specific wave numbers are contrasted with other research.[24]. (See figure 2).

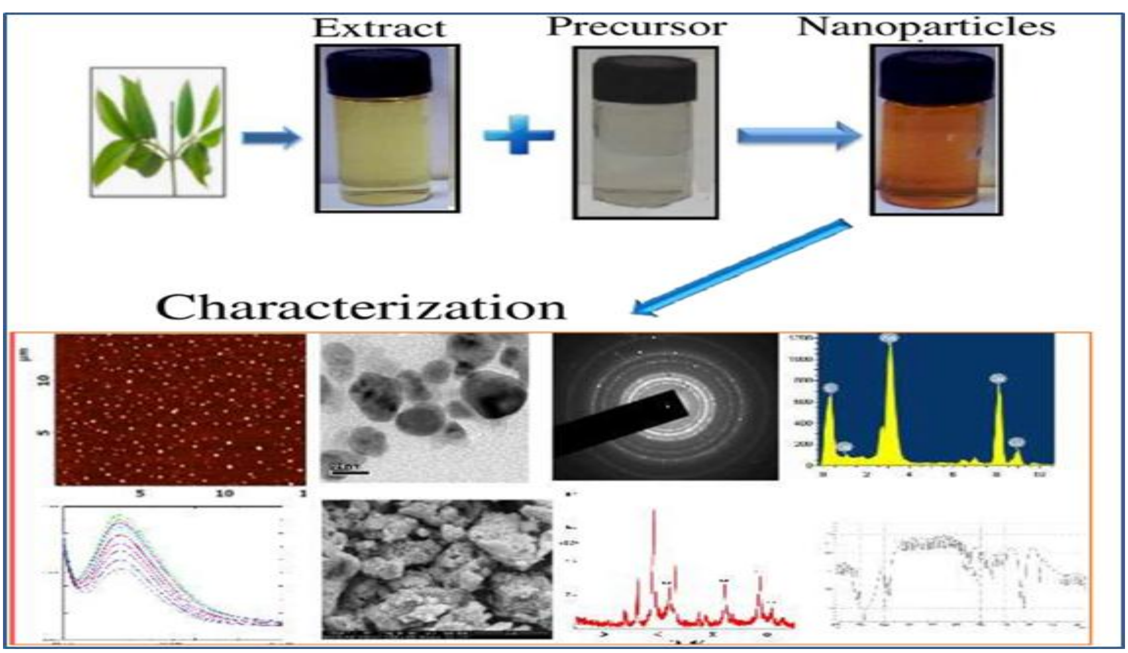

Figure 2. Characterization methods of nanoparticles [25].

Application

Nanoparticles synthesized from metal and plant extracts possess a large surface area, strong adsorption capabilities, and high reducibility, making them effective for pollutant removal. Nonetheless, numerous studies currently indicate that not all metallic nanoparticles produced via green synthesis can eliminate environmental contaminants. The elimination efficiencies of COD and BOD for NZVI produced from *Spinacia oleracea* (spinach) were not high: 73.82% and 60.31%, respectively, after 15 days [26]. The NZVIs created using mandarin, lemon, lime, and orange were employed to degrade chromium, achieving degradation efficiencies between 12% and 37%. NZVI produced from eucalyptus leaf extract is expected to remove 30.4% of total P in wastewater [27]. These low removal quotes for NZVIs highlight problems related to ineffective utilization or wastage of iron. Nanoscale metals synthesized in green methods demonstrate low efficiency in eliminating combined toxic metals [28]. Eucalyptus leaf extracts were employed to synthesize Fe NPs, which were then used to remove combined Cu and Cr(VI) with efficiencies of 33.0% and 58.9%, respectively. Nevertheless, when Cu and Cr(VI) were dealt with individually, their removal effectiveness was recorded at 45.2% and 74.2% [29]. Evidently, the effectiveness of elimination diminishes for blended steel ions [30], which used for practical work [31]. Sewage contains a mixture of heavy metals and other pollutants, rarely consisting of just one heavy metal [32,33]. Consequently, there is a need to enhance the efficiency of green synthesized nanoscale materials for such practical applications used in various pharmaceutical industries [34,35] (see figure 3).

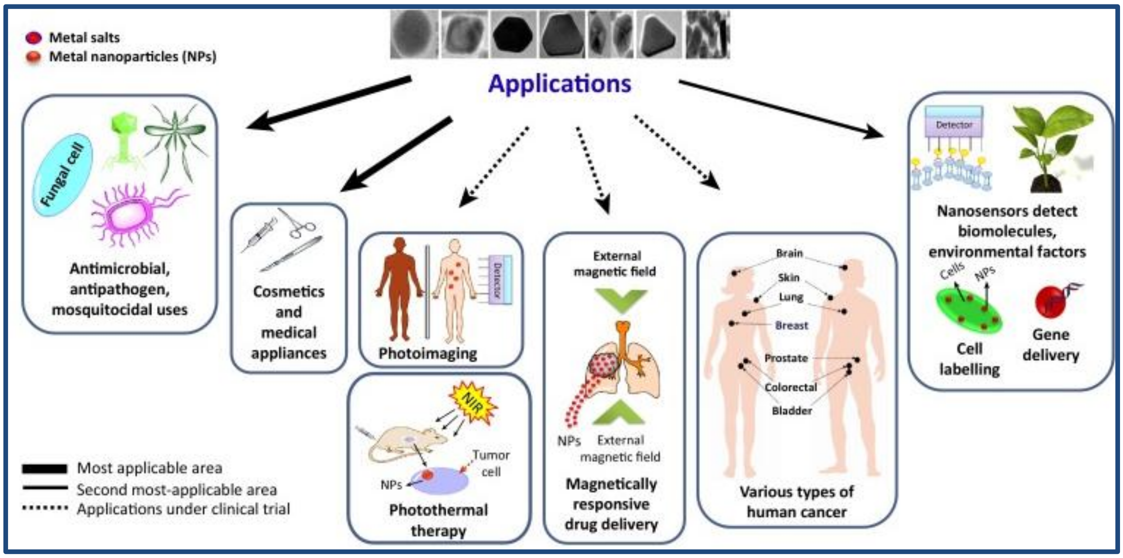

Figure 3. Application of nanoscale materials synthesis [35].

Conclusion:

This review summarized fabrication techniques related to the green synthesis of nanomaterials and assessed the associated limitations. The efficacy of several of these derivatives was demonstrated by numerous clinical trial studies and backed by data regarding their in vitro antimicrobial activity. A wide range of different commercial products currently on the market and their thoroughly documented clinical effectiveness indicate that medicinal plants may be promising sources for discovering new antimicrobial agents in the future. The current review proposes innovative methods and strategies for successful proof-of-concept studies and the creation of novel plant-derived products effective against new challenges associated with human microbial diseases (such as antimicrobial resistance and cancer treatment) utilizing nanoparticles synthesized from these derivatives. Moreover, contemporary understanding of the roles of green chemistry and biogenic synthesis methods was investigated for nanoscale materials utilizing medicinal plant leaf extracts in vitro across various cell types. Specifically, the CuO NPs produced using leaf extracts from medicinal plants damaged the mitochondrial membrane in Hela cells. In another research, the sulforhodamine (SRB) assay validated the effects of iron oxide nanoparticles produced by the aqueous extract of *Psoralea corylifolia* seeds on cancer cells. The investigation revealed the dose-dependent suppression of iron oxide nanoparticles on the majority of human breast cancer cells. Renal tumor cells can also be suppressed at low concentrations. These studies have been conducted in vitro; the effects of untested nanomaterials in vivo remain unknown. Additionally, their findings on various cells in vivo remain to be investigated.

Conflict of interest: The authors declare that they have no conflicts of interest.

References

1- Islam, M., Malakar, S., Rao, M. V., Kumar, N., & Sahu, J. K. Recent advancement in ultrasound-assisted novel technologies for the extraction of bioactive compounds from herbal plants: a review. *Food Science and Biotechnology*, 2023; *32*(13), 1763-1782.

2- Abubakar, A. R., & Haque, M. Preparation of medicinal plants: Basic extraction and fractionation procedures for experimental purposes. *Journal of Pharmacy and Bioallied Sciences*, 2020; *12*(1), 1-10.

3- Dhakite, P. A., & Gadpayale, J. V. Preliminary Phytochemical Screening of Different Solvent Mediated Medicinal Plant Sida sivarajani (Malvaceae) Extracts Evaluated. *Journal of Stress Physiology & Biochemistry*, 2024; *20*(1), 24-28.

4- Awuchi, C. G. Medicinal plants: the medical, food, and nutritional biochemistry and uses. *International Journal of Advanced Academic Research*, 2019; *5*(11), 220-241.

5- Lefebvre, T., Destandau, E., & Lesellier, E. Selective extraction of bioactive compounds from plants using recent extraction techniques: A review. *Journal of Chromatography A*, 2021; *1635*, 461770.

6- Rungsung W, Ratha KK, Dutta S, Dixit AK, Hazra J. Secondary metabolites of plants in drugs discovery. World J Pharm Res 2015;4:604-13.

7- Tesfahuneygn, G., & Gebreegziabher, G. Medicinal plants used in traditional medicine by Ethiopians: a review article. *J Respir*

Med Lung Dis, 2019; *4*(1), 1-3.

8- Vijayaraghavan, K., & Ashokkumar, T. Plant-mediated biosynthesis of metallic nanoparticles: A review of literature, factors affecting synthesis, characterization techniques and applications. *Journal of environmental chemical engineering* 2017;.5(5), 4866-4883.

9- Nasiri, J., Rahimi, M., Hamezadeh, Z., Motamedi, E., & Naghavi, M. R. Fulfillment of green chemistry for synthesis of silver nanoparticles using root and leaf extracts of *Ferula persica*: Solid-state route vs. solution-phase method. *Journal of Cleaner Production*, 2018; 192: 514-530.

10- Caroling, G. M. N. P., Priyadharshini, M. N., Vinodhini, E., Ranjitham, A. M., & Shanthi, P. Biosynthesis of copper nanoparticles using aqueous guava extract-characterisation and study of antibacterial effects. *Int J Pharm Biol Sci*, 2015; *5*(2), 25-43.

11- Cai, Y., Yang, F., Wu, L., Shu, Y., Qu, G., Fakhri, A., & Gupta, V. K. Hydrothermal-ultrasonic synthesis of CuO nanorods and CuWO4 nanoparticles for catalytic reduction, photocatalysis activity, and antibacterial properties. *Materials Chemistry and Physics*, 2021; *258*, 123919.

12- Majekodunmi SO. Review of extraction of medicinal plants for pharmaceutical research. MRJMMS 2015;3:521-7.

13- Tiwari P, Kumar B, Kaur M, Kaur G, Kaur H. Phytochemical screening and extraction: A review. Int Pharm Sci 2011;1:98-106.

14- Kokoska, L., Kloucek, P., Leuner, O., & Novy, P. Plant-derived products as antibacterial and antifungal agents in human health care. *Current medicinal chemistry*, 2019; *26*(29), 5501-5541.

15- Mukhopadhyay N., Sampath V., Pai S., Babu U.V., Lobo R. Antiarthritic medicinal plants: A Review. Res. J. Pharm. Technol. 2019;12:375. doi: 10.5958/0974-360X.2019.00068.4.

16- Vishal V., Ganesh S., Mukesh G., Ranjan B. A review on some plants having anti-inflammatory activity. J. Phytopharmacol. 2014;3:214–221.

17- Recio M., Andujar I., Rios J. Anti-inflammatory agents from plants: Progress and potential. Curr. Med.

Chem. 2012;19:2088–2103. doi: 10.2174/092986712800229069.

18- Amodeo V., Marrelli M., Pontieri V., Cassano R., Trombino S., Conforti F., Statti G. *Chenopodium album* L. and *Sisymbrium officinale* (L.) Scop.: Phytochemical content and in vitro antioxidant and anti-inflammatory potential. Plants. 2019;8:505. doi: 10.3390/plants8110505.

19- Shang A., Gan R.-Y., Xu X.-Y., Mao Q.-Q., Zhang P.-Z., Li H.-B. Effects and mechanisms of edible and medicinal plants on obesity: An updated review. Crit. Rev. Food Sci. Nutr. 2021;61:2061–2077. doi: 10.1080/10408398.2020.1769548.

20- Marrelli M., Statti G.A., Conforti F. A review of biologically active natural products from Mediterranean wild edible plants: Benefits in the treatment of obesity and its related disorders. Molecules. 2020;25:649. doi: 10.3390/molecules25030649.

21- Parys, W., Dołowy, M., & Pyka-Pająk, A.. Significance of chromatographic techniques in pharmaceutical analysis. *Processes*, 2022;*10*(1), 172.

22- Loum, J., Byamukama, R., & Wanyama, P. A. G. UV–Vis Spectrometry for Quantitative Study of Tannin and Flavonoid Rich Dyes from Plant Sources. *Chemistry Africa*, 2020; *3*(2), 449-455.

23- Beiranvand, M., & Dehghan, G.. Conferone: a comprehensive review of sources, extraction, characterization, biological and medicinal activities. *Phytochemistry Reviews*, 2025; 1-27.

24- Siddique, I. M. Exploring functional groups and molecular structures: a comprehensive analysis using FTIR spectroscopy. *development*, 2024; *1*(2).

25- Govindappa M. A review on role of plant(s) extracts and its phytochemicals for the management of diabetes. J. Diabetes Metab. 2015;6:1–38.

26- Teoh S.L., Das S. Phytochemicals and their effective role in the treatment of diabetes mellitus: A short review. Phytochem. Rev. 2018;17:1111–1128. doi: 10.1007/s11101-018-9575-z.

27- Marrelli M., Argentieri M.P., Avato P., Conforti F. *Lobularia maritima* (L.) Desv. aerial parts methanolic extract: In vitro screening of biological activity. Plants. 2020;9:89.

28- Faraone I., Rai D.K., Russo D., Chiummiento L., Fernandez E., Choudhary A., Milella L. Antioxidant, Antidiabetic, and Anticholinesterase Activities and Phytochemical Profile of Azorella glabra Wedd. Plants. 2019;8:265.

29- Nabatanzi A., Nkadimeng S.M., Lall N., Kabasa J.D., McGaw L.J. Ethnobotany, phytochemistry and pharmacological activity of *Kigelia africana* (Lam.) Benth. (Bignoniaceae) Plants. 2020;9:753.

30- Guerrero-Solano J.A., Jaramillo-Morales O.A., Velázquez-González C., De la O-Arciniega M., Castañeda-Ovando A., Betanzos-Cabrera G., Bautista M. Pomegranate as a potential alternative of pain management: A Review. Plants. 2020;9:419.

31- Boukhatem M.N., Setzer W.N. Aromatic herbs, medicinal plant-derived essential oils, and phytochemical extracts as poten-tial therapies for coronaviruses: Future perspectives. Plants. 2020;9:800.

32- Madkaikar M., Gupta N., Yadav R.M., Bargir U.A. India's crusade against COVID-19. Nat. Immunol. 2021;22:258–259.

33- Marin B.G., Aghagoli G., Lavine K., Yang L., Siff E.J., Chiang S.S., Salazar-Mather T.P., Dumenco L., Savaria M.C., Aung S.N., et al. Predictors of COVID -19 severity: A literature review. Rev. Med. Virol. 2021;31:1–10.

34- Singh, P., Kim, Y. J., Zhang, D., & Yang, D. C. Biological synthesis of nanoparticles from plants and microorganisms. *Trends in biotechnology* 2016; *34*(7), 588-599.

35- Patil, S., & Chandrasekaran, R. Biogenic nanoparticles: a comprehensive perspective in synthesis, characterization, application and its challenges. *Journal of Genetic Engineering and Biotechnology* 2020; *18*(1), 67.

التصنيع الحيوي المستدام لطرق تخليق الجسيمات النانوية باستخدام مستخلصات النباتات الطبية: طرق ومراجعة

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الخلاصة

ركزت هذه الدراسة على استخدام المعادن النانوية، مثل الفضة والنحاس، والتي تُستخدم بكثرة في مجموعة واسعة من الصناعات، تشمل القطاعات البيئية والطبية والهندسية، مما يجعل تخليق هذه المواد النانوية موضوعًا ذا صلة. حاليًا، تُستخدم الاستراتيجيات الكيميائية والبيولوجية الخضراء بشكل رئيسي في تخليق المعادن النانوية؛ إلا أن هذه الاستراتيجيات تنطوي على عيوب غير مقصودة، مثل التلوث البيئي، والاستهلاك المفرط للطاقة، ومخاطر صحية محتملة. في مواجهة هذه التحديات، برز التخليق الحيوي كبديل واعد، باستخدام المستخلصات النباتية بدلًا من المواد الكيميائية الفيزيائية والصناعية للحد من أيونات المعادن.

الكلمات المفتاحية:صديقة للبيئة، جسيمات نانوية، تركيب، طبية، نباتات، مستخلصات.