**A Review on Green Synthesis and Characterization of Nanoparticles**

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***Abstract-Nanoparticles are structures that possess unique properties with high surface area-to-volume ratio. Their small size, up to 100 nm, and potential for surface modifications have enabled their use in a wide range of applications.. Additionally, the materials used in the synthesis of NPs are primary determinants of their application. Based on the chosen material, NPs are generally classified into three categories: organic, inorganic, and carbon-based. These categories include a variety of materials, such as proteins, polymers, metal ions, lipids and derivatives, magnetic minerals, and so on. Each material possesses unique attributes that influence the activity and application of the NPs. Consequently, certain NPs are typically used in particular areas because they possess higher efficiency along with tenable toxicity. NPs were characterized using Powder X- ray diffraction (XRD), Ultraviolet–visible spectroscopy (UV–Vis), Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM), Energy Dispersive Spectroscopy (EDS), Fourier Transform Infrared spectroscopy (FTIR) and Dynamic light scattering (DLS) analysis. antidiabetic effect the term of alpha-glucosides inhibitors and alph-amylase inhibitors.***

***Keywords****- Nanoparticles, Metal nanoparticles, Ant diabetic ,Scanning electron microcopy , Emission electron Micrescopy , plant extract, alpha amylase Inhibitor*

**Introduction-**

The field of nanotechnology has advanced exponentially in the last decade and many products containing nanoparticles are now used in various applications such as in food science, cosmetics and pharmaceuticals. Nanoparticles (NPs) are defined as particles with one dimension ranging between 1 and 100 nm. NPs exhibit different properties depending on their size and surface functionalities The small size and large surface area account for the extensive use of NPs in various areas such as cosmetics, electronics and both diagnostic and therapeutic medical applications . The exponential growth and increasing interest in nanotechnology have been enhanced by the ability to image nanomaterial’s using techniques with atomic resolution capabilities such as scanning emission microscopy, scanning transmission electron microscopy and tandem electron microscopy . (Najahi-Missaoui et al., 2020)

The advantages of using nanoparticles as a drug delivery system include the following:

* Particle size and surface characteristics of nanoparticles can be easily manipulated to achieve both passive and active drug targeting after parenteral administration(Hall et al., 2007)
* They control and sustain release of the drug during the transportation and at the site of localization, altering organ distribution of the drug and subsequent clearance of the drug so as to achieve increase in drug therapeutic efficacy and reduction in side effects.
* Controlled release and particle degradation characteristics can be readily modulated by the choice of matrix constituents. Drug loading is relatively high and drugs can be incorporated into the systems without any chemical reaction; this is an important factor for preserving the drug activity.
* Site-specific targeting can be achieved by attaching targeting ligands to surface of particles or use of magnetic guidance.
* The system can be used for various routes of administration including oral, nasal, parenteral, intra-ocular etc.
* In spite of these advantages, nanoparticles do have limitations; i.e., their small size and large surface area can lead to particle-particle aggregation, making physical handling of nanoparticles difficult in liquid and dry forms. In addition, small particles size and large surface area readily result in limited drug loading and burst release. These practical problems have to be overcome before nanoparticles can be used clinically or made commercially available.

The present review details the latest development of nanoparticulate drug delivery systems, surface modification issues, drug loading strategies, release control and potential applications of nanoparticles.( VJ Mohanraj et.al. 2007)

**Method of preparation of Nanoparticles**-



**Synthesis of Nanoparticles**-Products from nature or those derived from natural products, such as extracts of various plants or parts of plants, tea, coffee, banana, simple amino acids, as well as wine, table sugar and glucose, have been used as reductants and as capping agents during synthesis. Polyphenols found in plant material often play a key role in these processes. The techniques involved are simple, environmentally friendly, and generally one-pot processes. Tea extracts with high polyphenol content act as both chelating/reducing and capping agents for nanoparticles. We discuss the key materials used in the field: silver, gold, iron, metal alloys, oxides, and salts. Oxana V et.al.(2013)

**Bottom up approach-**Liquid phase methods are also numerous. It is within the liquid phase that all of self-assembly and synthesis occurs. Liquid phase methods are upscalable and low cost.Electrodeposition and electroless deposition are very simple ways to make nanomaterials (dots, clusters, colloids, rods, wires, thin films). Prabhu, S et.al.(2022)

**Sol-gel method:-** . [**Dmitry Bokov**](https://onlinelibrary.wiley.com/authored-by/Bokov/Dmitry) **et.al. (2021)**In this method, the molecular precursor (usually metal alkoxide) is dissolved in water or alcohol and converted to gel by heating and stirring by hydrolysis/alcoholysis. Since the gel obtained from the hydrolysis/alcoholysis process is wet or damp, it should be dried using appropriate methods depending on the desired properties and application of the gel. For example, if it is an alcoholic solution, the drying process is done by burning alcohol. After the drying stage, the produced gels are powdered and then calcined. The sol-gel method is a cost-effective method and due to the low reaction temperature there is good control over the chemical composition of the products. The sol-gel method can be used in the process of making ceramics as a molding material and can be used as an intermediate between thin films of metal oxides in various application

**Table 1.**Common precursors for the synthesis of metal oxides using sol-gel method and their functional groups

|  |  |
| --- | --- |
| **S.N.** | **Precursor** |
| 1 | Tetraethoxysilane (TEOS) |
| 2 | Tetramethoxysilane (TMOS) |
| 3 | Dibutylphosphate |
| 4 | Titanium tetraisopropoxide |
| 5 | Vanadium O(Amt)3 |

**Green Synthesis-** The advantages of using plant and plant-derived materials for biosynthesis of metal nanoparticles have interested researchers to investigate mechanisms of metal ions uptake and bioreduction by plants, and to understand the possible mechanism of metal nanoparticle formation in plants.

Table- Green synthesis using plants

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Plant Part | Scientific Name | Common Name | Antidiabetic and Other Biological Activities | Nanoprticles size | Modal | Referance |
|  Leaf | Flueggea leucopyrus | **Indian snowberry, white honey shrub** | antibacterial, antioxidant, and antidiabetic | CuNPs | L | Pratibha et.al |
| leaves | of Barringtonia racemosa (B. racemosa). B. racemosa’s | Powderpuff Tree | antibiotic and antifungal antidiabetic | (AgNPs | alpha amylase and alpha glucosidase | Shahnaz Majeed et.al.2024 |
| fruits | Magnifera indica | Mango | Antidiabetic | mangiferin-loaded solid lipid nanoparticles (MG-SLNs)  | Alpha (α) – Glucosidase inhibitory assay . Alpha (α) – Amylase inhibitory assay | Ahmed I. Foudah et.a.2024  |
| leaf  |  *Capparis zeylanica* | Ceylon caper | antidiabetic and antimicrobial  | titanium dioxide |  | M. NilavukkarasiEt.al.2024 |
|  |  |  | Antimicrobial, diabetes mellitus | silver nanoparticles’ |  | (2024) |
| leaf | Syzygium cumini | Jamun | promising antidiabetic and wound-healing properties | AgNPs | glucose uptake and α-amylase inhibition assays | Santosh Malikarjun(2024) |
|  | . Balanites aegyptiaca  | Hingot | anti-diabetic | chitosan (CS) NPs | streptozotocin-induced diabetes in rats | Shimaa Aahmer et.al |
| leaf  | M. charantia | **bitter melon** | diabetes mellitus | silver nitrate nanoparticle  |   | Kalaiselvi Krishnamoorthy  |
| Seed | *Azadirachta indica*  | Neem | anti-diabeticanti-diabetic | AI-AgNPs | glucose adsorption assays , glucose uptake by yeast cells assays, and alpha-amylase inhibitory assays. | Gauhar Rehman et.al |
| Bulb | *Allium sativum* | Garlic | Diabetes | AgNPs from 10 to 30 nm | α-amylase and α-glucosidase | D.Jani e.al. |
| leaves | Elsholtzia blanda | Mint | the antidiabetic | zinc oxide nanoparticles | α-amylase and α-glucosidase | Athisa Roselyn Maheo 2023 |
|  |  Achillea maritima;  | **Yarrow** | antioxidant; antibacterial; antifung | AgNP | alpha amylase and alpha glucosidase | Badiaa Essghaier et.a.2023 |
| leaf | Butea monosperma | **Palash** | α- amylase inhibitory and anti-inflammatory | silver nanoparticles | α-amylase inhibition method | Akshay Patil,et.al.2023 |
| Leaf | *Murraya koenigii*  | Curry Leaf Tree | diabetes mellitus, cancer, antioxidant, antimicrobial |  ZnO NPs |  |  [Avinash Sharma](https://analyticalsciencejournals.onlinelibrary.wiley.com/authored-by/Sharma/Avinash)et.a.(2023) |
| leaf  | *Tabernaemontana divaricate* | Crepe jasmine | Antibacterial Antidiabetic | CuO NPs | standard BSA denaturation and α-amylase inhibition technique. | [Manonmani Raju](https://link.springer.com/article/10.1007/s11356-023-26261-5#auth-Manonmani-Raju-Aff1) |
|  |  |  | the antibacterial, antifungal, and antioxidant | TiO2 NPs | the α-amylase and α-Glucosidase  [enzyme activity](https://www.sciencedirect.com/topics/earth-and-planetary-sciences/enzyme-activity) | Wongchai Anupong |
| Leaf | [Gymnema sylvestre](https://www.sciencedirect.com/topics/pharmacology-toxicology-and-pharmaceutical-science/gymnema-sylvestre) | gurmar  | Diabetes mellitus | Zinc Oxide Nanoparticles | Streptozotocin | Sravani Gotteparthiet.al. |
|  | Phragmantheraaustroarabica  |  | antidiabetic activity | AgNP  |  | Dina M. Khodeer |
| leaves | Argyreia nervosa | elephant creeper | antibacterial, anti-inflammatory, antioxidant, and anti-diabetic activities | silver nanoparticles |  | Kalaiselvi Krishnamoorthy(2023)  |
| **Leaf** | **Ficus palmate** | Wild figh | the antibacterial, antifungal, and antioxidant | **zinc oxide nanoparticles** |  | Avinash Sharma et.al(2022) |
|  | Pterocarpus marsupium | Malabar kino | type 2 diabetes | silver nanoparticles | against streptozotocin and nicotinamide induced | J Bagyalakshmi2022 |
| **leaf** | [Murraya koenigii](https://www.sciencedirect.com/topics/pharmacology-toxicology-and-pharmaceutical-science/curry-tree) and Zingiber officinal | Curry Leaf Tree | [antidiabetic](https://www.sciencedirect.com/topics/pharmacology-toxicology-and-pharmaceutical-science/antidiabetic-agent) activit | Ag/CuO nanocomposites | α-amylase, α-glucosidase and glucose-6-phosphatase enzymes, and glucose uptake assay | Ag/CuO nanocomposites et.al(2022) |
| **Leaf** | Gymnema sylvetres | Gurmar | anti-diabetic | silver nanoparticles | inhibiting the enzymes α-amylaseThe  | Ajinnkya B.Chavanet |
|  | *Brachychiton populneus* |  **Kurrajong** | the antioxidant, anti-inflammatory, antidiabetic, and cytotoxic activities | silver nanoparticles |  | **Muhammad Naveed** |
|  |  Physalis minima | Sunberry | anti-oxidant, anti-diabetic, and antibacterial | Gold nanoparticles |  | Velmurugan Sekar et.al. |
|  |  |  | antibacterial, anti-diabetic, and anti-inflammatory | CuO-NPs | STZ-induced diabetic mice, | Shah Faisal et.al.  |
| Leaf | Punica granatum |  [pomegranate](https://en.wikipedia.org/wiki/Pomegranate)  | Antidiabetic | silver nanoparticles 35 to 60 nm | α-amylase and α-glucosidase | Rijuta G Saratalet.al |
| Hole plant | Cleome viscosa | Trickweed | an antibacterial, antioxidant and anti-diabetic age | silver nanoparticles  |  | Suresh Yarrappagaari (2020)et.al |
| leaves and fruits | *Aegle marmelos* | bilwa or bael | *hypoglycemic/antidiabetic* | AgNO3 | Blood Glucose levels in Diabetic rats | MRUNAL K. SHIRSAT1 2020 |
|  root | [Curcumin](https://www.sciencedirect.com/topics/pharmacology-toxicology-and-pharmaceutical-science/curcumin), | Turmaric | anti-diabetic anti-diabetic | CS-ZnO-NC |  | Pratibha Chauhan92019) |
| fruit |  | Ananas comosus | antioxidative, antidiabetic, and cytotoxic | AgNPs |  | Gitishree DasID2019 |
| bulb | *Withania coagulans* | Panir ke phool | Antidiabetic | chitosan nanoparticles |  | Kaarunya Sampathkumar et.al.2019 |
|  | Catathelasma ventricosum |  | antidiabetic activity | Selenium nanoparticles | STZ (streptozocin)-induced diabeticmice | Yuntao Liu (2018) |
| leaf | Calophyllum tomentosum | Bintangur | anti-bacterial, antioxidant, anti-diabetic, anti-inflammatory and anti-tyrosinase activity | AgNPs | a-Amylase inhibition assay Heat induced hemolytic assay of CtAgNPs | M. Govindappa(2018) |
| seed | S. cumini  | Malbar plum |  antidiabetic  |  | Candida albicans-infected diabetic rats. | Paula e.t.a.(2017) |
| leaf | Pouteria sapota | Mamey Sapote | antidiabetic activity | silver nanoparticles | streptozotocin- induced ratsinhibition of alpha-amylase | Prabhu, S.et.al.2017 |
| leav | O. basilicum, Moringa oleifera leaf and flower |  | Antimicrobials, Diabetic, Cancer | Gold nanoparticle Gold nanoparticle | α- amylase inhibition assay | K.Anand et.al.2017 |
| bark and wood | Pterocarpus marsupium | Indian kinotree | anti diabetic | silver nanoparticles | α- amylase inhibition assay | J Bagyalakshmi(1017) |
| leaf | Lonicera japonica | Japanese honeysuckle | anti diabetic | silver nanoparticles | a-Amylase inhibition assay a-Glucosidase inhibition activity | Kannan Balan (2016) |
| eaf | [Gymnema sylvestre](https://www.sciencedirect.com/topics/pharmacology-toxicology-and-pharmaceutical-science/gymnema-sylvestre) | gurmar  | anti-diabetic | silver nanoparticles | streptozotocin induced diabetic rats | Kalakotla Shanker  |
| leaf | Hibiscus subdariffa | Gudhal | anti-diabetic | Zinc oxide (ZnO) nanoparticles | on streptozotocin (STZ) induced diabetic mice | Niranjan balla et.al.(2015) |
|  |  |  | Antidiabetic | Zinc oxide and silver nanoparticlea | Streptozotocin-Induced Diabetic Rats | Ali Alkaladi et.al 2014 |
| seeds | Trigonella foenumgraecum  | fenugreek | antihyperglycemic, antidiabetic |  | streptozotocin (n-STZ) induceddiabetes mellitus in rat, | Chetan p. (2012) |

**Characterization of nanoparticles**- Nanoparticles are characterized by following method-

* UV spectrophotometry analysis confirmed the presence of metal with the maximum absorbance of 427 nm.
* FTIR analysis supported the existence of alcohols with the OH stretch and alkenes with the C–C stretch.
* The existence of metal NPs with an average hydrodynamic diameter of 36.58 nm was confirmed using dynamic light scattering (DLS).
* Energy dispersive X-ray spectroscopy (EDX) confirmed the presence of metal.
* spherical structure particles with the size distribution ranging from 10 to 17 nm with polydispersity, under transmission electron microscopy (TEM).
* Thermo gravimetric analysis (TGA) findings revealed that AgNPs maintain good thermal stability even at high temperatures.
* scanning electron microscope (SEM) was utilized to perform morphological and structural analysis. To evaluate the form and bonding arrangement of biosynthesized1

**Table-Physicochemical properties with characterization of nanoparticles**

|  |  |  |  |
| --- | --- | --- | --- |
| **S.N.** | **properties of nanoparticles** | **Characterization of nanoparticles** | **Refernces** |
| 1 | Particle shape, size, and distribution | Dynamic light scattering Electron microscopy (scanning/transmission) Atomic force microscopy | B. Akbari et.al.(2011) |
| 2 | Particle roughness and topography | X-ray diffraction (XRD) , Electron diffraction (ED) , X-Ray Photoemission Spectroscopy (XPS) formerly known as ESCA–Electron Spectroscopy for Chemical Analysis | Christie M. Sayes 2009 |
| 3 | Surface area and surface chemistries |  Auger electron spectroscopy (AES), X-ray photoelectron spectroscopy (XPS), time-of-flight secondary-ion mass spectrometry (TOF-SIMS), low-energy ion scattering (LEIS), and scanning-probe microscopy (SPM), including scanning tunneling microscopy (STM) and atomic force microscopy (AFM) | D. R. Baer et.al 2011Anshida Mayeen et.al.2018 |
| 4 |  Stability, dispersion, swelling, agglomeration, and aggregation | Scanning electron microscopy (SEM) Environmental SEM (ESEM), Zeta potential | Ping-Chang Lin 2013 |
| 5 | Purity | UV–VIS spectrophotometer | P. Senthil Kumar2019 |
| 6 | Reactivity and hydrophobicity | Raman Spectroscopy, Fourier Transform Infrared Spectroscopy | Deena Titus et.al.2019 |
| 7 | Chemical | UV–VIS spectrophotometer | Christie M. Sayes |
| 8 | Electrical | UV–VIS spectrophotometer, X-ray diffraction (XRD) and Scanning Electron Microscopy (SEM) | AK Singh 2010 |
| 9 | Optical |  X-ray diffraction pattern (XRD) reveals single phase monoclinic structure. Scanning electron microscopy (SEM) showed the rectangular morphology of as prepared CuO nanoparticles. The transmission electron microscopy (TEM) | Amrut. S. Lanje et.al.2010 |
| 10 | Biological | In vitro cell viability In vivo Microbial colony viability | Ajeet Kumar , A. Jemec et.al.(2017) |

**Summary-** Nanoparticles are synthesize different technique .Nanoparticles are used in treatment of various disease like antimicrobial, antioxidant, anti-inflammatory, anti diabetics and anticancer activity by using plants extract. These ate easily formation and characterization by using various analytical techniques.

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