**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-**

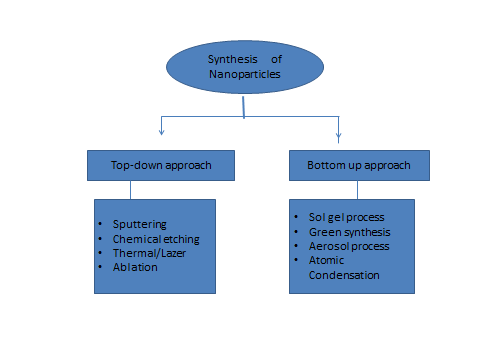
The field of nanotechnology has advanced exponentially in the last decade and many products containing nanoparticles are now used in various applications such as in food science, cosmetics and pharmaceuticals. Nanoparticles (NPs) are defined as particles with one dimension ranging between 1 and 100 nm. 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. Nilavukkarasi Et.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-dia  betic | 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 Chauhan  92019  ) |
| 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) induced  diabetes 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 2011 Anshida 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.

## References-

Pratibha, Komal Rajoriya, Ashwini Singhal, Ramhari Meena, Anita Kumari Biogenic Synthesis and Characterisation of Flueggea leucopyrus Willd Leaf Mediated Copper Nanoparticles for Antibacterial, Antioxidant, and Antidiabetic Activities[Journal of Herbal Medicine](https://www.sciencedirect.com/journal/journal-of-herbal-medicine) [Volume 44](https://www.sciencedirect.com/journal/journal-of-herbal-medicine/vol/44/suppl/C), March 2024, 100859

[Susanta Paul](https://bnrc.springeropen.com/articles/10.1186/s42269-024-01182-6#auth-Susanta-Paul-Aff1), [Ishita Sarkar](https://bnrc.springeropen.com/articles/10.1186/s42269-024-01182-6" \l "auth-Ishita-Sarkar-Aff1), [Nilanjan Sarkar](https://bnrc.springeropen.com/articles/10.1186/s42269-024-01182-6" \l "auth-Nilanjan-Sarkar-Aff1), [Anannya Bose](https://bnrc.springeropen.com/articles/10.1186/s42269-024-01182-6" \l "auth-Anannya-Bose-Aff2), [Mainak Chakraborty](https://bnrc.springeropen.com/articles/10.1186/s42269-024-01182-6" \l "auth-Mainak-Chakraborty-Aff1), [Amrita Chakraborty](https://bnrc.springeropen.com/articles/10.1186/s42269-024-01182-6#auth-Amrita-Chakraborty-Aff1) & [Swarupananda Mukherjee](https://bnrc.springeropen.com/articles/10.1186/s42269-024-01182-6" \l "auth-Swarupananda-Mukherjee-Aff1-Aff3)  “[Bulletin of the National Research Centre](https://bnrc.springeropen.com/) volume 48, Article number: 33 (2024) Silver nanoparticles in diabetes mellitus: therapeutic potential and mechanistic insights” [Bulletin of the National Research Centre](https://bnrc.springeropen.com/) volume 48, Article number: 33 (2024)

Kalaiselvi Krishnamoorthy , Selvaraj Jayaraman , Rajapandiyan Krishnamoorthy , Salim Manoharadas , Mohammad Alshuniaber , Biba Vikas , Vishnu Priya Veeraraghavan “Green synthesis and evaluation of anti-microbial, antioxidant, anti-inflammatory, and anti-diabetic activities of silver nanoparticles from Argyreia nervosa leaf extract: An invitro study “ Journal of King Saud University - Science 35 (2023) 102955

Gauhar Rehman , Muhammad Umar , Nasrullah Shah , Muhammad Hamayun , Abid Ali , Waliullah Khan , Arif Khan , Sajjad Ahmad , Abdulwahed Fahad Alrefaei , Mikhlid H. Almutairi , Yong-Sun Moon and Sajid Al“Green Synthesis and Characterization of Silver Nanoparticles Using Azadirachta indica Seeds Extract: In Vitro and In Vivo Evaluation of Anti-Diabetic Activity” Pharmaceuticals **2023**, 16(12), 1677; <https://doi.org/10.3390/ph16121677>

[Dina M. Khodeer](https://loop.frontiersin.org/people/2059346) ,[Ali M. Nasr](https://loop.frontiersin.org/people/1920199) ,[Shady A. Swidan](https://loop.frontiersin.org/people/1920937) ,[Sarah Shabayek](https://loop.frontiersin.org/people/1969282) [Roaa M. Khinkar](https://loop.frontiersin.org/people/2075046) [Mohammed M. Aldurdunji](https://loop.frontiersin.org/people/2061968) Maryam A. Ramadan [Jihan M. Badr](https://loop.frontiersin.org/people/1941593) "Characterization, antibacterial, antioxidant, antidiabetic, and anti-inflammatory activities of green synthesized silver nanoparticles using Phragmanthera austroarabica A. G. Mill and J. A. Nyberg extract Front. Microbiol., 05 January 2023Sec. MicrobiotechnologyVolume 13 - 2022

[Manonmani Raju](https://link.springer.com/article/10.1007/s11356-023-26261-5#auth-Manonmani-Raju-Aff1),  [Balaji Parasuraman](https://link.springer.com/article/10.1007/s11356-023-26261-5#auth-Balaji-Parasuraman-Aff2),  [Palanisamy Govindasamy](https://link.springer.com/article/10.1007/s11356-023-26261-5#auth-Palanisamy-Govindasamy-Aff2), [Pazhanivel Thangavelu](https://link.springer.com/article/10.1007/s11356-023-26261-5" \l "auth-Pazhanivel-Thangavelu-Aff2) & [Sasikumar Duraisamy](https://link.springer.com/article/10.1007/s11356-023-26261-5" \l "auth-Sasikumar-Duraisamy-Aff1) Improve anti-diabetic and anticancer activity of green synthesized Cuo nanoparticles derived from Tabernaemontana divaricate leaf extract “Enviromental Science and pollution 13 march 2023

Ali Alkaladi ,Aaser Mohamed Abdelazim and Mohamed Afifi ,Mohamed Afifi “Antidiabetic Activity of Zinc Oxide and Silver Nanoparticles on Streptozotocin-Induced Diabetic Rats “Int. J. Mol. Sci. 2014, 15(2), 2015-2023; [https://doi.org/10.3390/ijms15022015[MDPI](https://doi.org/10.3390/ijms15022015%5bMDPI)]

Wongchai Anupong , Ruangwong On-uma , Kumchai Jutamas , Saleh H. Salmen , Sulaiman Ali Alharbi , Deepika Joshi , G.K. Jhanani  “Antibacterial, antifungal, antidiabetic, and antioxidant activities potential of Coleus aromaticus synthesized titanium dioxide nanoparticles” [Environmental Research](https://www.sciencedirect.com/journal/environmental-research)[Volume 216, Part 3](https://www.sciencedirect.com/journal/environmental-research/vol/216/part/P3), 1 January 2023, 114714

Dharmalingam Kirubakaran , Kuppusamy Selvam , Palanisamy Prakash , MuthugounderSubaramanian Shivakumar , Manickam Rajkumar *In-vitro* antioxidant, antidiabetic, anticholinergic activity of iron/copper nanoparticles synthesized using *Strobilanthes cordifolia* leaf extract”open nano,[Volume 14](https://www.sciencedirect.com/journal/opennano/vol/14/suppl/C), November 2023, 100188[elsveir]

Avinash Sharma , Rupak Nagraik , Somesh Sharma , Gaurav Sharma , Sadanand Pandey, Shavkatjon Azizov , Pankaj Kumar Chauhan , , Deepak Kumar e “Green synthesis of ZnO nanoparticles using Ficus palmata: Antioxidant, antibacterial and antidiabetic studies” “Results in Chemistry 4 (2022) 100509

Muhammad Naveed,Hira Batool,Shafiq ur Rehma ,Aneela Javed,Syeda Izma Makhdoom,Tariq Aziz\*,Amal A. Mohamed,Manal Y. Sameeh,Mashael W. Alruways,Anas S. Dablool “Characterization and Evaluation of the Antioxidant, Antidiabetic, Anti-Inflammatory, and Cytotoxic Activities of Silver Nanoparticles Synthesized Using *Brachychiton populneus* Leaf Extract “*Processes* 2022, *10*(8), 1521; <https://doi.org/10.3390/pr10081521>[MDPI]

Velmurugan Sekar , Mysoon M. Al-Ansari , Jayaraman Narenkumar , Latifah Al-Humaid , Paulraj Arunkumar , Amutha Santhanam “ Synthesis of gold nanoparticles (AuNPs) with improved anti-diabetic, antioxidant and anti-microbial activity from Physalis minima “ Journal of King Saud University – Science 34 (2022) 102197

[Rijuta G Saratale](https://pubmed.ncbi.nlm.nih.gov/?term=Saratale+RG&cauthor_id=28612655), [Han Seung Shin](https://pubmed.ncbi.nlm.nih.gov/?term=Shin+HS&cauthor_id=28612655) , [Gopalakrishnan Kumar](https://pubmed.ncbi.nlm.nih.gov/?term=Kumar+G&cauthor_id=28612655) , [Giovanni Benelli](https://pubmed.ncbi.nlm.nih.gov/?term=Benelli+G&cauthor_id=28612655) , [Dong-Su Kim](https://pubmed.ncbi.nlm.nih.gov/?term=Kim+DS&cauthor_id=28612655) , [Ganesh D Saratale](https://pubmed.ncbi.nlm.nih.gov/?term=Saratale+GD&cauthor_id=28612655) 2Exploiting antidiabetic activity of silver nanoparticles synthesized using Punica granatum leaves and anticancer potential against human liver cancer cells (HepG2) Artif Cells Nanomed Biotechnol 2018 Feb;46(1):211-222.[pubmed]

[D. Ashwini](https://rjptonline.org/search.aspx?key=D.%20Ashwini), [Gayathri Mahalingam](https://rjptonline.org/search.aspx?key=Gayathri%20Mahalingam)Green Synthesized Metal Nanoparticles, Characterization and its Antidiabetic activities - A ReviewReaserch journal of pharmacy and technology [Volume - 13,      Issue - 1,     Year - 2020](https://rjptonline.org/Issues.aspx?VID=13&IID=1)

Suresh Yarrappagaari , Rajasekar Gutha , Lohitha Narayanaswamy , Lavanya Thopireddy ,Lakshminarsimhulu Benne , Syed Siraj Mohiyuddin , V. Vijayakumar , RajeswaraReddy Saddala ”Eco-friendly synthesis of silver nanoparticles from the whole plant ofCleome viscosa and evaluation of their characterization, antibacterial,antioxidant and antidiabetic properties” Saudi Journal of Biological Sciences 27 (2020) 3601–3614

Gitishree Dasa, Jayanta Kumar Patraa, Han-Seung Shinb ,”Biosynthesis, and potential effect of fern mediated biocompatible silver nanoparticles by cytotoxicity, antidiabetic, antioxidant and antibacterial, studies” Materials Science & Engineering C 114 (2020) 111011

Santosh Mallikarjun Bhavi ; Shubha K Mirji ; Bothe Thokchom ; Sapam Riches Singh ; Raju B Maliger ; Shivanand S Bhat ; Pooja Joshi ; BP Harini ; Ramesh Babu Yarajarla1; Salim Al Jadidi “Potential Antidiabetic Properties of Syzygium Cumini (L.) Skeels Leaf Extract-Mediated Silver Nanoparticles” Austin Journal of Analytical & Pharmaceutical Chemistry Volume 11, Issue 1 (2024)

[Paula E. R. Bitencourt](https://pubmed.ncbi.nlm.nih.gov/?term=Bitencourt%20PE%5BAuthor%5D), [Lariane O. Cargnelutti](https://pubmed.ncbi.nlm.nih.gov/?term=Cargnelutti%20LO%5BAuthor%5D), [Carolina S. Stein](https://pubmed.ncbi.nlm.nih.gov/?term=Stein%20CS%5BAuthor%5D), [Raquel Lautenchleger](https://pubmed.ncbi.nlm.nih.gov/?term=Lautenchleger%20R%5BAuthor%5D), [Luana M. Ferreira](https://pubmed.ncbi.nlm.nih.gov/?term=Ferreira%20LM%5BAuthor%5D), [Manuela Sangoi](https://pubmed.ncbi.nlm.nih.gov/?term=Sangoi%20M%5BAuthor%5D), [Laura Denardi](https://pubmed.ncbi.nlm.nih.gov/?term=Denardi%20L%5BAuthor%5D),[Raphaela M. Borges](https://pubmed.ncbi.nlm.nih.gov/?term=Borges%20RM%5BAuthor%5D),a [Aline Boligon](https://pubmed.ncbi.nlm.nih.gov/?term=Boligon%20A%5BAuthor%5D),b [Rafael N. Moresco](https://pubmed.ncbi.nlm.nih.gov/?term=Moresco%20RN%5BAuthor%5D),a [Letícia Cruz](https://pubmed.ncbi.nlm.nih.gov/?term=Cruz%20L%5BAuthor%5D),b [Régis A. Zanette](https://pubmed.ncbi.nlm.nih.gov/?term=Zanette%20RA%5BAuthor%5D),d [Sydney H. Alves](https://pubmed.ncbi.nlm.nih.gov/?term=Alves%20SH%5BAuthor%5D),c and [Maria Beatriz Moretto](https://pubmed.ncbi.nlm.nih.gov/?term=Moretto%20MB%5BAuthor%5D) Nanoparticle formulation increases Syzygium cumini antioxidant activity in Candida albicans-infected diabetic rats” [Pharm Biol.](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6130601/) 2017; 55(1): 1082–1088.

Shimaa Alahmer , Mostafa El-Noss , Alyaa Farid “Preparation of chitosan nanoparticles loaded with Balanites aegyptiaca extract for treatment of streptozotocin-induced diabetes in rats” [International Journal of Biological Macromolecules](https://www.sciencedirect.com/journal/international-journal-of-biological-macromolecules), March 2024, 130061

Niranjan Bala , S. Saha, M. Chakraborty, M. Maiti , S. Das , R. Basu , P. Nandy Green synthesis of zinc oxide nanoparticles using Hibiscus subdariffa leaf extract: Effect of temperature on synthesis, anti-bacterial activity and anti-diabetic activity in  RSC Advances · January 2015 DOI: 10.1039/C4RA12784F

Pratibha Chauhan, Sunil Mahajan, G.B.K.S. Prasa Preparation and characterization of CS-ZnO-NC nanoparticles for imparting anti-diabetic activities in experimental diabetic [Journal of Drug Delivery Science and Technology](https://www.sciencedirect.com/journal/journal-of-drug-delivery-science-and-technology)[Volume 52](https://www.sciencedirect.com/journal/journal-of-drug-delivery-science-and-technology/vol/52/suppl/C), August 2019, Pages 738-747

Ajinkya B. Chavan , Swapnil Goyal band AnsarM. Patel “Formulation of Silver Nanoparticles using Gymnema sylvestreLeaf Extract and In-vitroAnti-diabetic Activity” Journal of Pharmaceutical Research International34(7A): 39-49, 2022;Article no.JPRI.81504ISSN: 2456-9119

Kalakotla Shanker , G. Krishna Mohan , Vinyas Mayasa , Lakshmi Pravallika  “Antihyperglycemic and anti-hyperlipidemic effect of biologically synthesized silver nanoparticles and G. sylvestre extract on streptozotocin induced diabetic rats-an in vivo approach”[**Materials Letters**](https://www.sciencedirect.com/journal/materials-letters)[Volume 195](https://www.sciencedirect.com/journal/materials-letters/vol/195/suppl/C), 15 May 2017, Pages 240-244

Sravani Gotteparthi , Manvitha Kotaru , Dr. S. Ashok Krishnan , K. Sridevi Evaluation of Anti-Diabetic Activity of Zinc Oxide Nanoparticles of Gymnema sylvestre Extract on Wistar Rats Journal of Drug Delivery & Therapeutics. 2023; 13(11):31-38

[Avinash Sharma](https://analyticalsciencejournals.onlinelibrary.wiley.com/authored-by/Sharma/Avinash), [Rupak Nagraik](https://analyticalsciencejournals.onlinelibrary.wiley.com/authored-by/Nagraik/Rupak), [Baskar Venkidasamy](https://analyticalsciencejournals.onlinelibrary.wiley.com/authored-by/Venkidasamy/Baskar), [Azhar Khan](https://analyticalsciencejournals.onlinelibrary.wiley.com/authored-by/Khan/Azhar), [Kanika Dulta](https://analyticalsciencejournals.onlinelibrary.wiley.com/authored-by/Dulta/Kanika), [Pankaj Kumar Chauhan](https://analyticalsciencejournals.onlinelibrary.wiley.com/authored-by/Kumar+Chauhan/Pankaj), [Deepak Kumar](https://analyticalsciencejournals.onlinelibrary.wiley.com/authored-by/Kumar/Deepak) “ In vitro antidiabetic, antioxidant, antimicrobial, and cytotoxic activity of Murraya koenigii leaf extract intercedes ZnO nanoparticles” Luminescence 2023 Jul;38(7):1139-1148.[pubmed]

Dominic Savio Arumai Selvan , Raju Senthil Kumar , Sundarajan Murugesan , Sugumar Shobana , AzizKalilur Rahiman Antidiabetic activity of phytosynthesized Ag/CuO nanocomposites using Murraya koenigii and Zingiber officinale extracts[Journal of Drug Delivery Science and Technology](https://www.sciencedirect.com/journal/journal-of-drug-delivery-science-and-technology) [Volume 67](https://www.sciencedirect.com/journal/journal-of-drug-delivery-science-and-technology/vol/67/suppl/C), January 2022, 102838

Kumar Anuj , Rana Akhilesh , Singh Amit , Singh Alok , Bioactivity of methanolic extract of Brassica juncea in animal model of diabetes mellitus, Chinese Herbal Medicines (2019), doi: https://doi.org/10.1016/j.chmed.2019.04.007

Ahmed I. Foudah , Mohammad Ayman Salkini , Mohammed H. Alqarni , Aftab Alam Preparation and evaluation of antidiabetic activity of mangiferin-loaded solid lipid nanoparticles[Saudi Journal of Biological Sciences](https://www.sciencedirect.com/journal/saudi-journal-of-biological-sciences)Volume 31, Issue 4, April 2024, 103946

Kaarunya Sampathkumar,†Siriporn Riyajan,§Chiew Kei Tan,†Philip Demokritou,∥Nuannoi Chudapongse,§and Say Chye Joachim Loo Small-Intestine-Specific Delivery of Antidiabetic Extracts fromWithania coagulansUsing Polysaccharide-Based Enteric-CoatedNanoparticles *ACS Omega* 2019, 4, 7, 12049–12057

Badiaa Essghaier , Hédia Hannachi , Rihem Nouir , Filomena Mottola and Lucia Rocco Green Synthesis and Characterization of Novel Silver Nanoparticles Using Achillea maritima subsp. maritima Aqueous Extract: Antioxidant and Antidiabetic Potential and Effect on Virulence Mechanisms of

Bacterial and Fungal Pathogens . Nanomaterials 2023, 13, 1964. https://doi.org/ 10.3390/nano13131964

MRUNAL K. SHIRSAT, VAIBHAV C. SHILIMKAR “Design and Development of nanoparticle based antidiabetic formulation ofAegle marmelos Plant” International Journal of Pharmaceutical Research | Oct - Dec 2020 | Vol 12 | Issue 4

Shahnaz Majeed , Nursyafiqah Binti Zainal Abidin , Ravindran Muthukumarasamy ,Mohammed Danish , Afzan Mahmad , Mohamad Nasir Mohamad Ibrahim ,Abdulaziz M. Alanazi , Mohammed Tahir Ansari , Sreenivas Patro Sisinthy aWound healing and antidiabetic properties of green synthesized silvernanoparticles in 3T3-L1 mouse embryo fibroblast cells through2-NBDG expressionInorganic Chemistry Communications 159 (2024) 111692

Athisa Roselyn Maheo, Scholastica Mary Vithiya B, Augustine Arul Prasad T,. L. Mangesh,

Tamizhdurai Perumal, Wahidah H. Al-Qahtani, and Mani GovindasamyCite This: Cytotoxic, Antidiabetic, and Antioxidant Study of BiogenicallyImprovised Elsholtzia blanda and Chitosan-Assisted Zinc OxideNanoparticles https://doi.org/10.1021/acsomega.2c07530ACS Omega 2023, 8, 10954−10967

J Bagyalakshmi, B Sai Krishna Priya and C BavyaEvaluation of Antidiabetic Activity of AqueousExtract of Bark of Pterocarpus MarsupiumSilver Nanoparticles Against Streptozotocin andNicotinamide Induced Type 2 Diabetes in RatsBiomed J Sci & Tech Res | BJSTR. MS.ID.006853ISSN: 2574 -1241April 06, 2022

Dina M. Khodeer , Ali M. Nasr , Shady A. Swidaz,Sarah Shabayek , Roaa M. Khinkar , Mohammed M. Aldurdunji ,Maryam A. Ramadan and Jihan M. Badr Characterization, antibacterial,antioxidant, antidiabetic, andanti-inflammatory activities ofgreen synthesized silver

nanoparticles usingPhragmanthera austroarabicaA. G. Mill and J. A. Nyberg extract 05 January 2023 doi: 10.3389/fmicb.2022.1078061

Gitishree DasID, Jayanta Kumar Patra, Trishna Debnath, Abuzar Ansari, Han-Seung Shin\* Investigation of antioxidant, antibacterial,antidiabetic, and cytotoxicity potential of silver nanoparticles synthesized using the outer peel extract of Ananas comosus (L.) PLOS ONE | https://doi.org/10.1371/journal.pone.0220950 August 12, 2019

M. Govindappa , Hemashekhar , Manoj-Kumar Arthikala , V. Ravishankar Rai , Y.L. Ramachandra Characterization, antibacterial, antioxidant, antidiabetic,anti-inflammatory and antityrosinase activity of green synthesized silver nanoparticles using Calophyllum tomentosum leaves extract Results in Physics 9 (2018) 400–408

Yuntao Liu , Siqi Zeng , Yixi Liua, WenjuanWub, Yingbin Shenc, Lan Zhang a, Cheng Li a, Hong Chena,Aiping Liu a, Li Shena, Bin Hua, Caixia Wanga Synthesis and antidiabetic activity of selenium nanoparticles in thepresence of polysaccharides from Catathelasma ventricosum International Journal of Biological Macromolecules 114 (2018) 632–639

J Bagyalakshmi and H Haritha Green Synthesis and Characterization of SilverNanoparticles Using Pterocarpus marsupium and Assessment of its In vitro Antidiabetic Activity” American Journal of Advanced Drug Delivery ISSN: 2321-547X ,28-09-2017

Kannan Balan, Weixia Qing,a Youyou Wang,a Xiuhua Liu,\*aThayumanavan Palvannan,b Yong Wang,a Fanyi Maa and Yun Zhanga Antidiabetic activity of silver nanoparticles fromgreen synthesis using Lonicera japonica leaf extract Royal Society of Chemistry 2016 6, 40162–40168

Chetan P. Kulkarni1, Subhash L. Bodhankar1\*, Arvindkumar E. Ghule1, V. Mohan2,Prasad A. Thakurdesai2 streptozotocin (n-STZ) induceddiabetes mellitus in rat, Diabetologia Croatica · January 2012

Ganesh Janvale, Shrutkirti Shinde, Dhanvarsha Bhusari, and Sanghmitra KadamIn vitro α- amylase inhibitory and anti-inflammatory activity of Butea monosperma silver nanoparticlesInternational Journal of Advanced Biochemistry ResearchISSN Online: 2617-4707 IJABR 2023; Akshay Patil, 7(2): 19-24

K. Anand, C. Tiloke, Pragalathan Naidoo, A.A. Chuturgoon , Phytonanotherapy for management of diabetes using green synthesis nanoparticles, Journal of Photochemistry & Photobiology, B: Biology (2017), doi: 10.1016/ j.jphotobiol.2017.06.028

Ali Alkaladi Aaser Mohamed Abdelazim and Mohamed Afifi “Antidiabetic Activity of Zinc Oxide and Silver Nanoparticles on Streptozotocin-Induced Diabetic Rats International Journal of Molecular Sciences ISSN 1422-0067 www.mdpi.com/journal/ijm Int. J. Mol. Sci. 2014

[M. Nilavukkarasi](https://link.springer.com/article/10.1007/s12649-023-02355-6#auth-M_-Nilavukkarasi-Aff1),  [S. Vijayakumar](https://link.springer.com/article/10.1007/s12649-023-02355-6#auth-S_-Vijayakumar-Aff1), [Pradnya Jagtap](https://link.springer.com/article/10.1007/s12649-023-02355-6" \l "auth-Pradnya-Jagtap-Aff2),  [Vaishali Undale](https://link.springer.com/article/10.1007/s12649-023-02355-6#auth-Vaishali-Undale-Aff3),  [Nilambari Gurav](https://link.springer.com/article/10.1007/s12649-023-02355-6#auth-Nilambari-Gurav-Aff4), [Shailendra Gurav](https://link.springer.com/article/10.1007/s12649-023-02355-6" \l "auth-Shailendra-Gurav-Aff5),  [R. Mythili](https://link.springer.com/article/10.1007/s12649-023-02355-6#auth-R_-Mythili-Aff6),  [Sandhanasamy Devanesan](https://link.springer.com/article/10.1007/s12649-023-02355-6#auth-Sandhanasamy-Devanesan-Aff7),  [Mohamad S. Alsalhi](https://link.springer.com/article/10.1007/s12649-023-02355-6#auth-Mohamad_S_-Alsalhi-Aff7) & Woong Kim “ TiO2 Nanoparticles Derived from Capparis Zeylanica: An Effective Treatment for Diabetic and Food Borne InfectionsWaste and Biomass ValorizationVolume 15, pages 1895–1900, (2024

Prabhu, S., Vinodhini, S., Elanchezhiyan, C., & Rajeswari, D. (2017). *Evaluation of antidiabetic activity of biologically synthesized silver nanoparticles using Pouteria sapota in streptozotocin-induced diabetic rats. Journal of* Dominic

Savio ArumaiSelvan , RajuSenthil Kumar , Sundarajan Murugesan , Sugumar Shobana , AzizKalilur Rahiman Antidiabetic activity of phytosynthesized Ag/CuO nanocomposites using Murraya koenigii and Zingiber officinale extracts[Journal of Drug Delivery Science and Technology](https://www.sciencedirect.com/journal/journal-of-drug-delivery-science-and-technology) [Volume 67](https://www.sciencedirect.com/journal/journal-of-drug-delivery-science-and-technology/vol/67/suppl/C), January 2022, 102838Diabetes, 10(1), 28–42. doi:10.1111/1753-0407.12554

[Oxana V. Kharissova](https://www.cell.com/trends/biotechnology/abstract/S0167-7799(13)00015-2)1 ∙ [H.V. Rasika Dias](https://www.cell.com/trends/biotechnology/abstract/S0167-7799(13)00015-2)2 ∙ [Boris I. Kharisov](https://www.cell.com/trends/biotechnology/abstract/S0167-7799(13)00015-2)3 ∙ [Betsabee Olvera Pérez](https://www.cell.com/trends/biotechnology/abstract/S0167-7799(13)00015-2)3 ∙ [Victor M. Jiménez Pérez](https://www.cell.com/trends/biotechnology/abstract/S0167-7799(13)00015-2)3**The greener synthesis of nanoparticles 50 trend to biotechnology**

[Volume 31, Issue 4](https://www.cell.com/trends/biotechnology/issue?pii=S0167-7799(13)X0004-6)p240-248April 2013

[Dmitry Bokov](https://onlinelibrary.wiley.com/authored-by/Bokov/Dmitry), [Abduladheem Turki Jalil](https://onlinelibrary.wiley.com/authored-by/Turki+Jalil/Abduladheem), [Supat Chupradit](https://onlinelibrary.wiley.com/authored-by/Chupradit/Supat), [Wanich Suksatan](https://onlinelibrary.wiley.com/authored-by/Suksatan/Wanich), [Mohammad Javed Ansari](https://onlinelibrary.wiley.com/authored-by/Javed+Ansari/Mohammad), [Iman H. Shewael](https://onlinelibrary.wiley.com/authored-by/Shewael/Iman+H.), [Gabdrakhman H. Valiev](https://onlinelibrary.wiley.com/authored-by/Valiev/Gabdrakhman+H.), [Ehsan Kianfar](https://onlinelibrary.wiley.com/authored-by/Kianfar/Ehsan)Nanomaterial by Sol-Gel Method: Synthesis and Application “In advances material and sciences”

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