



# Green Synthesis and Characterization of Metal Nanoparticles Using Vinca Rosea: A Comprehensive Review

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## Abstract:

The Green Synthesis Of Metal Nanoparticles (Mnps) Using Plant-Based Materials Has Emerged As A Sustainable And Eco-Friendly Alternative To Traditional Physical And Chemical Methods. Various Medicinal Plants Have Been Utilized During This Process, Including Species From The Vinca Genus, Specifically Vinca Rosea And Vinca Minor. Vinca Plants Are Highlighted In The Literature Due To The Variety Of Phytochemicals Enabling The Facilitation Of Nanoparticle Biosynthesis Including Flavonoids And Alkaloids, Tannins, And Phenolic Compounds Acting As Reducing And Stabilizing Agents During Biosynthesis. The Systematic Review Also Provides A Comprehensive Evaluation Of Existing Literature That Discusses Biosynthesizes And Characterizations Of Metal Nanoparticles From Sources Of Vinca Species. The Review Discusses The Various Biosynthesized Methods Including Standards Such As Ambient And Microwave-Assisted, Along With Other Parameters Affecting The Morphologies Of Nanoparticles Including Temperature, Ph, And Concentration Of The Extract. Synthesis Characterization Techniques Highlighted By This Review Includes UV-Visible Spectroscopy, X-Ray Diffraction (XRD), Fourier-Transform Infrared Spectroscopy (FTIR), Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM), And Energy Dispersive X-Ray Analysis (EDX). Vinca Rosea Silver Nanoparticles (Agnps)

Generated Notable Interest, Being The Most Studied Literature. Agnps From Vinca Rosea Undergo Spherical Morphology Development With Average Particle Sizes Were Between 10 And 100 Nm. While The Current Findings Are Promising, The Review Also Identifies Several Research Gaps, Including Limited Standardization Across Studies And Insufficient Understanding Of The Specific Phytochemical Roles. Overall, Vinca-Mediated Metal Nanoparticle Synthesis Presents A Green And Effective Approach With Considerable Promise For Future Biomedical And Industrial Applications.

**Keywords:** Green Synthesis, Vinca Rosea, Metal Nanoparticles, Multifunctional Therapeutics, Sustainable

Nanotechnology.

**Introduction:**

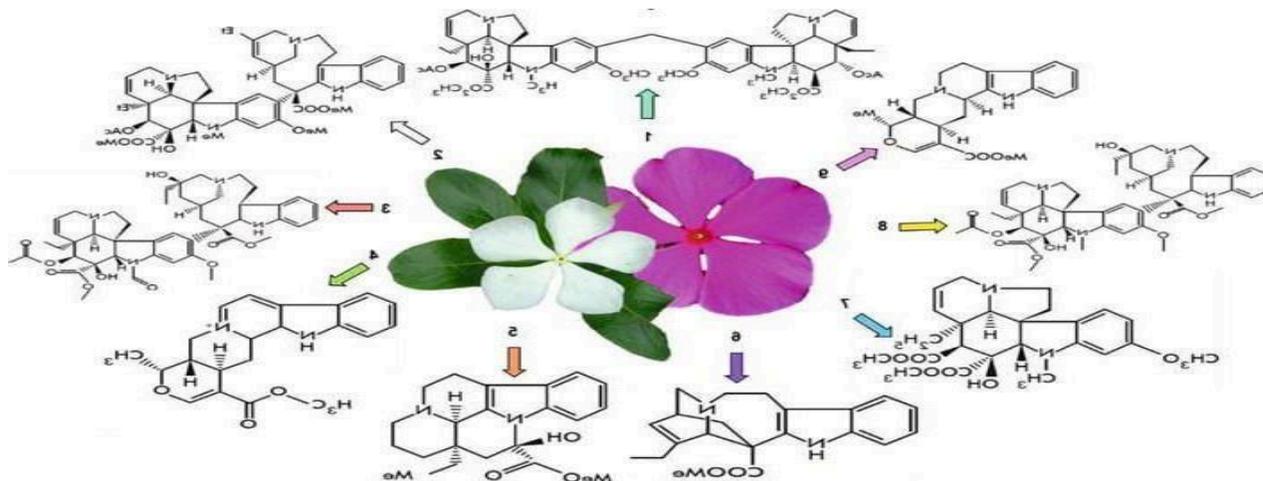
Metal Nanoparticles (Mnps) Have Unique Optical, Catalytic, And Biomedical Properties That Are Very Dependent On Their Size, Shape, And Surface Chemistry. Research Utilizing Plant Extracts To Synthesize Mnps Is Increasingly Seen As A Sustainable Alternative To Traditional Chemical And Physical Methods. [1] Catharanthus Rosea Is A Perennial Herb (Fig.1) Which Lived Longer . It Has Many Medicinal Uses In The Country Like India , Africa , Australia . These Plant Contains More Than 70 Alkaloids Mostly Indole Alkaloid Was There. [2] The Alkaloids Present As In Chemical Constituents In The Plant Have Anticancer Activity. The Main Chemical Constituent Were Vincristine And Vinblastine Which Gives Activity Against Lymphomas Hodgkin Disease , Acute Lymphocytectic Leukemia , Breast Cancer , Soft Tissue Sarcoma , Neuroblastosis . Catharanthus Rosea Also Have Activity Like Antiviral , Antimalarial , Antifungal , Antibacterial , Antiinflammatory , Anti Diurectics , Antifertility .[ 3-7] The Vinca Species, Possessing Abundant Phytochemical Compounds And Therapeutic Actions, Have Been Used In The Green Synthesis Of Several Mnps: Silver, Zinc Oxide, & Bimetallic Nanoparticles.



**Figure 1 :** Catharanthus Rosea Plant

**Phytochemical Profile Of Vinca Species:**

*Vinca* Plants Are Rich In Alkaloids (E.G., Vincristine, Vinblastine), Flavonoids, Tannins, And Phenolic Compounds, Which Act As Reducing And Stabilizing Agents In Nanoparticle Synthesis. The Composition And Concentration Of These Bioactive Compounds Influence The Reduction Process And Stabilization Of Nanoparticles. [8-10]



**Figure 2.** Alkaloids Produced By *Catharanthus Roseus* (1) Vindolicine (C<sub>51</sub>H<sub>64</sub>N<sub>4</sub>O<sub>12</sub>, 925.08 G/Mol); (2) Anhydrovinblastine (C<sub>46</sub>H<sub>56</sub>N<sub>4</sub>O<sub>8</sub>, 792.97 G/Mol); (3) Vincristine (C<sub>46</sub>H<sub>56</sub>N<sub>4</sub>O<sub>10</sub>, 824.95 G/Mol); (4) Ajmalicine (C<sub>21</sub>H<sub>24</sub>N<sub>2</sub>O<sub>3</sub>, 352.43 G/Mol); (5) Tabersonine (C<sub>21</sub>H<sub>24</sub>N<sub>2</sub>O<sub>2</sub>, 336.44 G/Mol); (6) Catharanthine (C<sub>21</sub>H<sub>24</sub>N<sub>2</sub>O<sub>2</sub>, 336.42); (7) Vindoline (C<sub>25</sub>H<sub>32</sub>N<sub>2</sub>O<sub>6</sub>, 456.53 G/Mol); (8) Vinblastine (C<sub>46</sub>H<sub>58</sub>N<sub>4</sub>O<sub>9</sub>, 810.97 G/Mol); And (9) Ajmalicine (C<sub>21</sub>H<sub>24</sub>N<sub>2</sub>O<sub>3</sub>, 352.43 G/Mol) Image Retrieved From <https://www.intechopen.com/chapters/64496>

### Methodologies For Nanoparticle Synthesis Using Vinca Extracts:

Studies Have Demonstrated That *Vinca* Extracts Can Be Effectively Used To Synthesize Various Metal Nanoparticles Such As Silver (Ag), Gold (Au), Zinc Oxide (Zno), And Bimetallic Nanoparticles. Each Metal Salt Reacts Differently Under The Influence Of Phytochemicals Present In The Extracts: **Silver Nanoparticles (AgNps):** Mukunthan KS Et Al. (2011) Synthesized Silver Nanoparticles Using Aqueous Leaf Extract Of *Vinca Rosea* And 1 Mm Silver Nitrate (AgNO<sub>3</sub>). The Extract Was Obtained By Boiling 10 G Of Dried Leaves In 100 Ml Deionized Water For 10 Minutes. [11] Upon Mixing With AgNO<sub>3</sub> And Heating At 80°C, A Dark Brown Color Indicated Nanoparticle Formation.

Lalsangi, D Et Al (2023), Keshari, A Et Al. (2021) Used A Similar Method With Extracts For Synthesis Of Silver Nanoparticles Using *Vinca* Leaves Extract.[12,13]

**Gold Nanoparticles (AuNps):** Patil Et Al. (2017) Synthesized Gold Nanoparticles Using Aqueous Extract Of *Vinca Rosea* Leaves And 1 Mm Chloroauric Acid (HAuCl<sub>4</sub>·3H<sub>2</sub>O) As The Gold Ion Precursor. The Extract Was Prepared By Boiling 10 G Of Fresh Leaves In 100 Ml Of Deionized Water For 15 Minutes. The Solution Was Filtered And Added Dropwise To The Gold Salt Under Constant Stirring. A Color Change From Pale Yellow To Ruby Red Indicated Nanoparticle Formation. Characterization Via UV-Vis Spectroscopy Showed An SPR Band Around 530 Nm, And TEM Analysis Revealed Predominantly Spherical Particles Ranging From 15–40 Nm In Size. The Nanoparticles Also Exhibited Moderate Antioxidant And Antibacterial Activity.[14,15] Pratap R Et Al (2023) Synthesis Of Gold Nanoparticles Using Dual Extract Of *Tulsi-Vinca* For Breast Cancer Tumor Regression In Mice [15]

**Copper Nanoparticles (Cu):** Reddy Et Al. (2020) Synthesized Copper Nanoparticles Using *Vinca* Minor Extract And Copper Sulfate (CuSO<sub>4</sub>). The Reaction Mixture Was Incubated At 60°C And Yielded Reddish-Brown Particles With Antibacterial Properties.[16] Vindhya PS Et Al (2023) Synthesize Copper Nanoparticles Using A Manganese Doped Copper Nanoparticles Using *Vinca* Leaf Extract. The Leaf Extract Contains Various Phytochemical Component. *Vinca*+Manganese+Copper (Vr+Mn+Cu) Shows The Antibacterial And Antioxidant Properties Against Some Pathogens.[17]

**Zinc Oxide Nanoparticles (Zno Nps):** Joshi T Et Al. (2016) Used Ethanolic Extract Of *Vinca Rosea* Leaves To Synthesize Zno Nanoparticles From Zinc Acetate. 10 G Of Leaves Were Soaked In 100 Ml Ethanol, Filtered, And Mixed With 0.1 M Zinc Acetate. The Solution Was Stirred And Then Calcined At 400°C To Yield Crystalline Zno Nps. Chandrasekaran Et Al (2024) Used Similar Synthesis Procedure.[18] Chandrashekhar, Et.Al. Explored Synthesis Of New Metal Nanoparticles From Leaf Extract Derived From Zno And Vanadium Doped . This Synthesis Indicated Morphology Of Nanoparticles. V – Zno Nanoparticles Estimated Against Breast Cancer . The Capped Zno Nanoparticles Wad Showed Cytotoxic Activity Than Capped V – Zno Nanoparticles. [19]

**Silver And Manganese Nanoparticle:** Alexandra Ciorita Et.Al. That, They synthesized Ag-MnO<sub>2</sub> Nanoparticles. Basically, They Made The Nanoparticles In Two Main Steps Making The MnO<sub>2</sub> Nanoparticles (The "Base" Particles) They Took A

Chemical Called  $Kmno_4$  (It's A Purple Powder). They Mixed This Powder With Pure Water And Some Liquid From A Plant. They Put This Mixture In A Sonicator (A Machine That Uses Sound Waves To Mix Things Really Well) For 1 Hour. The Colour Of

The Liquid Changed From Purple To Dark Brown, Which Told Them That Tiny  $MnO_2$  Nanoparticles Were Forming. They Then Cleaned These Nanoparticles By Washing Them With Water And Alcohol Several Times Using A Centrifuge (A Machine That Spins Things Really Fast To Separate Them). Finally, They Dried The Cleaned Nanoparticles In An Oven At 60 Degrees Celsius For 24 Hours. Putting Silver (Ag) Onto The  $MnO_2$  Nanoparticles They Took The  $MnO_2$  Nanoparticles They Made In The First Step. They Mixed These Nanoparticles With A Solution Of  $AgNO_3$  (A Chemical That Contains Silver) And More Of The Plant Extract. They Stirred This Mixture Really Well Using A Magnetic Stirrer (A Machine That Uses A Magnet To Stir) For 6 Hours At Room Temperature. This Process Allowed The Silver To Attach Itself To The Surface Of The  $MnO_2$  Nanoparticles, Creating Ag-  $MnO_2$  Nanoparticles.[20]

**Copper And Manganese:** Studied By Mohamad M. Ahmad That ,A 5 Mm Solution Of  $CuSO_4$  And A 5 Mm Solution Of  $MnCl_2$  Were Prepared By Dissolving Them In Double-Distilled Water At A 1:1 Ratio, Achieving A Concentration Of 80 Mg/ml, And Stirred Until A Pale Blue Colloid Was Formed At Room Temperature. Subsequently, An Aqueous Solution Of The V. Rosea Plant Leaf Extract Was Added To The Colloidal Suspension, And Stirring Was Maintained For 5 Minutes. Heat Was Then Applied At 90 °C, Resulting In A Transformation Of The Solution To A Dark Green Color, Which Became Clear After An Additional 5 Minutes. Unreacted Plant Components And Metal Precursors Were Removed By Centrifugation At 3000 Rpm For 10 Minutes And Were Subsequently Washed With Water And Ethanol. The Resulting Vr-Mn + Cu Nanoparticle Solution Was Air-Dried At 28 °C And Stored At 4 °C For Future Use. [21]

#### **Characterization Techniques:**

The Synthesized Nanoparticles Are Characterized Using A Variety Of Analytical Techniques That Provide Detailed Information On Their Physical, Chemical, And Structural Properties[11-21]:

**UV-Visible Spectroscopy:** Utilized To Monitor The Formation And Stability Of Nanoparticles By Detecting Surface Plasmon Resonance (SPR) Peaks, Which Are Indicative Of Particle Size And Shape.

X- **Ray Diffraction (XRD):** Employed To Determine The Crystalline Nature And Phase Purity Of Nanoparticles. The Presence Of Sharp Diffraction Peaks Corresponds To The Face-Centered Cubic (Fcc) Structure Typically Observed In Metallic Nanoparticles.

**Fourier-Transform Infrared Spectroscopy (FTIR):** Used To Identify Functional Groups Involved In The Reduction And Capping Of Nanoparticles. Peaks Corresponding To Hydroxyl, Carbonyl, And Amine Groups Suggest Phytochemical Interactions During Synthesis.

**Scanning Electron Microscopy (SEM) And Transmission Electron Microscopy (TEM):** Provide High-Resolution Images To Assess The Morphology, Particle Size Distribution, And Aggregation State. TEM, In Particular, Offers Insights Into The Internal Structure And Crystallinity At The Nanoscale

**Energy Dispersive X-Ray Analysis (EDX):** Coupled With SEM Or TEM, EDX Confirms The Elemental Composition Of Nanoparticles, Validating The Successful Incorporation Of Target Metals. **Dynamic Light Scattering (DLS) And Zeta Potential Analysis:** Though Less Frequently Reported, These Techniques Measure Hydrodynamic Diameter And Surface Charge, Respectively, Offering Insights Into Nanoparticle Stability And Dispersion Behavior In Colloidal Systems.

#### **Biological Activities:**

**Anti-Retroviral Agent:** Investigated By Joshi Et.Al. That The Catharanthus Roseus (Periwinkle) Have The Best Antiviral Activity In Their Leaf Extract, Of Silver Nanoparticles Of Catharanthus Roseus Is An Active. Silver Nanoparticles Of

Catharanthus Roseus Exhibits The Antifungal Activity Against The Pathogens Like Aspergillus Species. It Inhibits The Replication By Deposition Nanoparticles In DNA Genes Which Stopes The Growth Of HIV Virus.[22]

**Hypoglycemic Activity:** Investigated By Senithikumar Chandrashekar Et.Al. That The New Metal Nanoparticles From Catharanthus Roseus Leaf Extract Derives From Zno And Vanadium Doped Vanadium Zinc Oxide Nanoparticles Estimates Against The Breast Cancer .Capped Zinc Oxide Nanoparticles Shows Cytotoxic Activity Than The Vanadium Zinc Oxide Nanoparticles They Shows Strongest Antibacterial Activity Against The Escheria Coli, Aspergillus Niger Species. The Inhibition Of Alpha Amylase Shows The Antidiabetic Activity [23].

**Anti-Catalytic Activity:** Explored By Sethuraman Et.Al That The Silver Nanoparticles On Reduction Of Methylene Blue By C.Roseus Leaf Extract Is Well Known Fact That Agnps And Their Composites Show Greater Catalytic Activity In Area Of Dye Reduction And Removal The Reduction Of Methylene Blue By Arsine In The Presence Of Silver Nanoparticles And The Present Study Aims Was To Reduce Of Methylene Blue By Natural Green Aqueous Extract Of C.Roseus Containing Silver Nanoparticles. Pure Methylene Blue [MB] Dye Has A Value Of 664 Nm. Degradation Of Dye Was Visually Observed By The Change In Color From Deep Blue To Light Blue. Finally, The Degradation Process Was Completed At End Of 5th Hr And Was Identified By Observing Colour To Colourless . The Control Exhibited No Color Change.That Reveals Silver Nanoparticles Can Act As An Electron Transfer Mediator Between The Extract And Methylene Blue [MB] By Acting As A Redox Catalyst, Which Is Often Termed As Electron Relay Effect .[23]

**Anti-Pyretic Activity:** Given By Alexandra Doris Et.Al. That The Silver Nano Particles Of Catharanthus Roseus Which Shows Antipyretic Activity .The Leaf Extracts Of Catharanthus Roseus Act As Reducing Agent And Capping Agent In Synthesis Of Nanoparticles Which Forms Stable Silver Nanoparticles .Fever Was A Bacterial Attack On Human Body Which Silver Nanoparticles Reduces The Viable Count Of Bacterial Cells.[24]

**Anti-Cancer Activity :** Explored By Hadil Hussein Et.Al. That Leaf Extract Of Silver Nanoparticle Of Catharanthus Roseus Shows Multiple Mechanisms Which Involves Apoptosis (Program Death Cell) , Generation Of Reactive Oxygen Species , Inhibition The Growth Of Cancerous Cells . These Silver Nanoparticles Deposit Into The Cancer Cell Which Promotes The Reduction Of Cells And Also Inhibits Spreading Migration Of The Cells .[25]

**Anti- Bacterial Activity:** Proved By Ahmad MM Et.Al That There Is More Use Of Antibiotics Against Antibacterial So Leaf Extract Of Catharanthus Roseus Of Silver Nanoparticles Shows Antibacterial Activity With Capped Zinc Oxide Nanoparticles Improves Cytotoxic Activity . With The Combination Of Vanadium Doped Zinc Oxide Nanoparticles Shows Antibacterial Activity Against Escheria Coli, Aspergillus Niger ,Enterococcus, Candida Albiacans[21]

**Anti-Haemolytic Activity:** Haemolysis Assay Of Silver Nanoparticles Cytotoxic Effect Was Studied By Performing Hemolysis Test (Dobrovolskaia 2008) Which As Follow: 2 Ml Of Blood Was Mixed With 0.2M PBS (Ph 7.0). Centrifuged At 10000rpm For 10 Minutes. The Pellet Containing RBC , Washed Three Times By PBS At 10000rpm For 3 Minutes. The RBC Obtained Was Diluted With PBS At 1:10 Ratio. 10 Ml Of Nanoparticles In Tyrode (1, 5, 10, 25 And 50 Mg/Ml) Tyrode (Negative Control) And Triton X-100 (Positive Control) Added To 290 Ml Washed RBC. Incubate The Suspension At Room Temperature On A Shaking Plate During 12 H. (7)After Incubation Time, The Suspension Is Centrifuged At 10000 G Over 5 Min. Supernatant Is Read In A 96-Well Plate Using A Microplate Scanning Spectrophotometer At 550 Nm.[27]

**Anti-Malarial Activity:** Proved By Selvi Sabhnaykam Et.Al.That The Leaf Extract Of Catharanthus Roseus Of Silver Nanoparticles Which Shows Antimalarial Activity. The Silver Nanoparticles Targeting The Larvae Of Malarial Vector Anopheles Stephensi . The Aques Extract Of Catharanthus Roseus Exposed To Thr Larvae Stage Of Malarial Cycle. Silver Nanoparticles Rapidly Synthesized Formation Of Nanoparticles Within 15 Min Of The Cycle . There Is Disruption Of

Parasites In Larva Stage Proliferations Ocured Which Shows The Reduction In Plasmodium Cells . As Its Acts As An Antimalarial Activity .[28]

**Summary Of Research Findings:**

The Synthesis Of Metal Nanoparticles Using *Vinca* Species Has Been The Focus Of Several Experimental Studies, With Silver Nanoparticles (AgNps) Being The Most Extensively Explored. These Studies Consistently Demonstrate The Efficacy Of *Vinca Rosea* And, To A Lesser Extent, *Vinca Minor* Extracts In Reducing Metal Ions To Form Stable Nanoparticles. Across The Reviewed Literature, AgNps Synthesized From *Vinca* Extracts Generally Exhibit Spherical Morphology With Particle Sizes Ranging Between 10 And 100 Nm. The Reaction Conditions—Such As Ph, Extract-To-Metal Salt Ratio, And Temperature—Greatly Influence Particle Size Distribution And Stability.[29]Zinc Oxide Nanoparticles (Zno Nps), Although Less Frequently Studied, Have Been Successfully Synthesized Using Zinc Acetate And *Vinca* Extracts, Typically Requiring Post-Synthesis Calcination To Achieve Crystalline Structures. Gold Nanoparticles (AuNps) And Bimetallic Combinations Like Ag-Zn And Ag-Au Represent Emerging Research Areas, Indicating The Versatility Of *Vinca* Species In Reducing Different Metal Ions.[30] Characterization Studies Across These Experiments Consistently Use UV–Vis Spectroscopy, XRD, FTIR, SEM/TEM, And EDX, Confirming The Formation, Composition, And Morphology Of The Nanoparticles. Notably, The Presence Of Bioactive Compounds In The Extracts Not Only Mediates Reduction But Also Provides Natural Capping Agents, Enhancing Nanoparticle Stability And Bioactivity.[31] Biological Assessments In Some Studies Reveal Antimicrobial, Antioxidant, And Cytotoxic Properties Of The Synthesized Nanoparticles, Suggesting Potential For Pharmaceutical And Biomedical Applications. However, Variations In Methodology, Extract Composition, And Characterization Approaches Limit Direct Comparison Between Studies. This Underscores The Need For Standardization In Experimental Protocols And More Extensive Exploration Of Lesser-Studied Metal Nanoparticles.[32]

**Conclusion:**

*Vinca* Species Offer A Green And Efficient Platform For The Synthesis Of Metal Nanoparticles. With Improved Understanding And Optimization Of Synthesis Parameters, These Plant-Based Methods Hold Potential For Large-Scale Production And Biomedical Applications.

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