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Review Article

Green Nanotechnology using Ayurvedic Herbs

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ABSTRACT

Green nanotechnology employs phytochemicals found in plants to produce eco-friendly nanoparticles without the use of hazardous materials. Some of the herbal medicines that possess active principles like flavonoids, alkaloids, polyphenols found in Tulsi, Neem, Turmeric, Ashwagandha, and Guduchi can be used as reducing agents for nanoparticle production. Herbal nanoparticles provide better bioavailability, targeted delivery, and therapeutic effectiveness of herbal medicines. This paper focuses on the process of green nanotechnology, herbal nanotechnology forms, the benefits of herbal nanotechnology, recent herbal formulations of Ayurvedic medicines using nanotechnology, along with differences between herbal medicines

INTRODUCTION

Green nanotechnology has made a sustainable approach toward the synthesis of nanoparticles using plant extracts, avoiding toxic reagents that are usually used in chemical synthesis.

Ayurvedic plant extracts act as:

- Bio reductants-metal ions converted to nanoparticles
- Capping agents: agents that stabilize nanoparticles
- Bioactive drug payload: therapeutic action

It has revolutionized herbal drug delivery and tilled out multiple advanced nano-herbal formulations. Enhancement; Targeted drug delivery; Sustainable nanotechnology. and herbal nanotechnology.

Green Synthesis of Nanoparticles Using Ayurvedic Herbs

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Commonly Used Ayurvedic Herbs

- Curcuma longa (Turmeric)
- Azadirachta indica (Neem)
- Tinospora cordifolia (Guduchi)
- Withania somnifera (Ashwagandha)
- Ocimum sanctum (Tulsi)
- Emblica officinalis (Amla)

Green Synthesized Nano-Materials:

- Silver nanoparticles (AgNPs)
- Gold nanoparticles (AuNPs)
- Zinc oxide nanoparticles (ZnO-NPs)
- Iron oxide nanoparticles
- Polymeric herbal nanoparticles

Flow Chart: Green Nanoparticle Synthesis Using Ayurvedic Herbs

Ayurvedic Herb Selection
↓
Collection of Plant Material
↓
Washing, Drying & Powdering
↓
Preparation of Aqueous Plant Extract
↓
Mixing Extract with Metal Salt Solution
↓
Phytochemicals Reduce Metal Ions to Nanoparticles
↓
Nanoparticle Formation (Color change observed)
↓
Capping & Stabilization by Herbal Compounds
↓
Centrifugation & Purification
↓
Characterization (UV-Vis, TEM, DLS, FTIR)
↓
Final Nano-Herbal Formulation

Mechanism of Green Synthesis:

Plant phytochemicals such as:

- Flavonoids
- Terpenoids
- Polyphenols
- Alkaloids
- Saponins

It would act as a reducing agent, reducing metal ions (Ag^{+} to Ag^{0}) or a stabilizing agent that helps form a biological shell around nanoparticles.

Advantages of Ayurvedic Herbal Nanotechnology:

- Higher solubility of phytochemicals
- Enhanced permeability & targeted delivery
- Reduced dose & side effects
- Controlled/sustained release
- Stability during storage
- Eco-friendly synthesis without toxic chemicals

Applications of Herbal Nanotechnology:

- Antimicrobial (bacterial, viral
- Anti-inflammatory
- Antioxidant therapy
- Cancer therapy
- Drug-resistant infections
- Neuronal Protection Properties, Cardi
- Wound Healing

Current Nanoformulation Using Ayurvedic Herbs (2021-2025)

1.Nano-Curcumin (Turmeric):

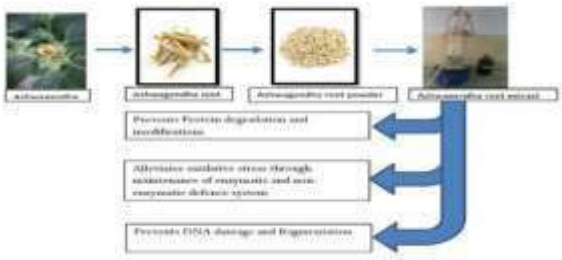
- Solid Lipid Nanoparticles
- Nano-emulsion

- Curcumin-loaded polymeric nanoparticles (PLGA)
- Applications: Antitumor agent, Anti-inflammatory agent, Anti-HIV,TB Therapy

2. Neem-Silver Nanoparticles:

- Green synthesized AgNPs using neem leaf extract
- Applications: antibacterial, wound healing, anti-viral

3. Ashwagandha Nanoparticles:



- Withanolide-loaded Nano-liposomes
- Application: neuroprotection, stress regulation, anti

4. Amla Polyphenol Nanocarriers:

- Gold nanoparticles prepared using Amla extract
- Applications: antioxidant therapy, dermatological purposes

5. Tulsi Nanoemulsion:

- Nanoemulsion of essential oil
- Applications: antimicrobial preparations, cough/cold formulations

6. Guduchi (Tinospora) Nanoparticles:

- Nano-suspension of alkaloids
- Applications: immune system support, anti-inflammatory

Difference between Conventional Herbal Medicine & Herbal Nanotechnology

Parameter	Conventional Herbal Remedies	Herbal Nanotechnology
Solubility	Low, especially hydrophobic phytochemicals	High solubility via nano-sizing
Bioavailability	Poor absorption & rapid metabolism	Significantly improved
Dose Required	High doses needed	Lower doses effective
Stability	Unstable, prone to degradation	Stable due to nanoencapsulation
Targeting Ability	Nonspecific distribution	Targeted & controlled release
Time to Onset of Action	Slow	Faster
Therapeutic Efficiency	Moderate	Highly enhanced
Side Effects	Possible gastrointestinal irritation	Reduced due to targeted delivery
Shelf Life	Shorter	Longer
Formulation	Powders, decoctions, syrups	Nanoparticles, liposomes, nanogels, nanoemulsion

Challenges in Herbal Nanotechnology:

- Lack of Standardization
- Scale-up issues
- Uncertainty related to
- Few long-term toxicity tests:
- Variability in Plant Extract Composition

Future Scope:

- AI Optimization of Green Synthesis
- Multi-herbal nano formulations
- Clinical trials of the Ayurvedic Nano Drugs
- Nanotechnology-based Ayurvedic Cosmeceuticals
- Smart (pH/temperature/enzyme-responsive) nano-herbal systems

CONCLUSION:

Green nanotechnology is an area that is gaining importance for the development of herbal nanomedicine by merging herbal therapeutics with nanotechnology. Utilization of herbal extracts as biologic reducing and stabilizing agents helps in synthesizing biodegradable nanoparticles with improved bioavailability, therapeutic potency, and low cytotoxicity. Green nanotechnology synthesized nanoparticles exhibit excellent biocompatibility with significant properties in drug delivery systems, antimicrobial, antioxidant, anti-inflammatory, and cancer applications, with better biocompatibility compared with their chemical counterparts.

Despite such benefits, issues such as batch variability, non-standardization, limited in vivo & clinical data, and regulatory issues should be attended to. Future studies should emphasis on understanding, mass production, toxicological analysis, and subsequent validation of Green nanotechnology applications for the development of herbal drugs. Conclusion: Green nanotechnology is a safe, low-cost, eco-friendly technology for the development of herbal delivery systems.

RESULTS AND DISCUSSION:

The recent studies reveal that green nanotechnology using herbal extracts is quite an efficient and eco-friendly method of nanoparticle synthesis. Phytochemicals like flavonoids, phenolics, alkaloids, terpenoids, and proteins in medicinal plants act as reducing, capping agents, and stabilizers simultaneously without the usage of toxic chemicals.

The synthesized herbal nanoparticles normally exhibit uniform size distribution, stability, and increased surface reactivity. Green-synthesized

nanoparticles, compared to conventionally synthesised NPs, have less toxicity and more biocompatibility.

The nano-formulation in herbal medicine delivery significantly improves the solubility, bioavailability, and therapeutic efficacy of plant-based drugs. Increased cellular uptake and sustained drug release have been consistently reported to enhance antimicrobial, antioxidant, anti-inflammatory, and anticancer activities.

Overall, the findings are that GNT provides a cost-effective, eco-friendly, and biologically safer platform to modernize herbal medicine. However, variability in plant composition and limited clinical studies remain challenges, hence requiring standardization and in vivo validation.

REFERENCES

1. Iravani, S. (2011). Plant-based green synthesis of metal nanoparticles. Green Chemistry, 13(10), 2638–2650. The most cited of these foundational reviews on plant-mediated nanoparticle synthesis.
2. Ahmed, S., Ahmad, M., Swami, B. L., & Ikram, S. (2016). Review on plant extracts-mediated synthesis of silver nanoparticles for application as antimicrobial agents.Journal of Advanced Research, 7(1), 17–28.
3. Singh, J., Dutta, T., Kim, K. H., Rawat, M., Samddar, P., & Kumar, P. (2018). 'Green' synthesis of metals and their oxide nanoparticles: applications for environmental remediation. Journal of Nanobiotechnology 16, 84.
4. Patra, J. K., Das, G., Fraceto, L. F., et al. (2018). Nano-based drug delivery systems: recent developments and future prospects. Journal of Nanobiotechnology, 16, 71.Useful for herbal nano-drug delivery discussion.
5. Kumar, V., Yadav, S. K. Plant-mediated synthesis of silver and gold nanoparticles and their applications. Journal of Chemical Technology & Biotechnology, 84(2), 151–157.
6. Mittal, A. K., Chisti, Y., & Banerjee, U. C. Synthesis of metallic nanoparticles using plant extracts. Biotechnology Advances, 31(2), 346–356.
7. Roy, N., Gaur, A., Jain, A., et al. (2017). Green synthesis of silver nanoparticles: an approach to overcome toxicity. Environmental Toxicology and Pharmacology, 54, 90–98.
8. Bagheri, S., Julkapli, N. M., & Bee Abd Hamid, S. (2016). Green synthesis of metal nanoparticles using plants. Research on Chemical Intermediates 42, 4527–4547.
9. Bhattacharya, R., & Mukherjee, P. (2008). Biophysical properties of "bare" metal nanoparticles. Advanced Drug Delivery Reviews, 60(11), 1289–1306.
10. Rai, M., Yadav, A., & Gade, A. (2009). Silver nanoparticles represent a new generation of antimicrobials. Biotechnology Advances, 27(1), 76–83.

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