WWW.IJRPR.COM

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

COLD CREAM PREPARATION BY GREEN SYNTHESIS OF INCORPORATING NANOPARTICLS

[1] Vrushali. L.Satpute,[2] Omkar. R. Shinde, [2] Suraj G. Shirname,[2] Vaishnavi R.Swami

[1]Assistant Professor, Department Of Pharmaceutics, JBVP's Vidya Niketan College of Pharmacy, Lakhewadi, Pune.
[2]Students of JBVP's Vidya Niketan College of Pharmacy Lakhewadi, Pune.

ABSTRACT:

A classic semisolid emulsion, cold cream is frequently used for washing, moisturizing, and adding green-synthesized nanoparticles to improve sustainability and usefulness. Green synthesis of nanoparticles offers a biocompatible and environmentally acceptable substitute for traditional chemical and physical synthesis techniques by using biological resources such plant extracts, microorganisms, and biopolymers as reducing and stabilizing agents. These bio-mediated processes reduce environmental impact, remove hazardous reagents, and create nanoparticles with surface-bound phytochemicals that enhance biological performance and stability.Such nanoparticles—especially silver (AgNPs), zinc oxide (ZnO NPs), and gold (AuNPs)—offer a variety of medicinal and cosmetic advantages when added to cold creams, including antibacterial, antioxidant, UV-protective, and anti-aging qualities. To guarantee consistency, stability, and functional efficacy, the formulation method includes temperature control, controlled emulsification, and mild nanoparticle dispersion.Evaluation parameters such as pH, viscosity, spreadability, particle size, microbial resistance, antioxidant activity, and stability testing confirm the product's quality and performance.

Green-synthesized nanoparticles, typically 5–50 nm in size and capped with natural biomolecules (flavonoids, phenolics, proteins), exhibit enhanced colloidal stability and skin compatibility compared to conventionally produced counterparts. Their integration into cold creams not only improves formulation stability and bioactivity but also supports sustainability goals by reducing chemical waste and toxicity. Overall, the green synthesis and incorporation of nanoparticles in cold cream formulations represent a promising advancement in eco-friendly cosmeceutical development, aligning efficacy with environmental responsibility and consumer safety.

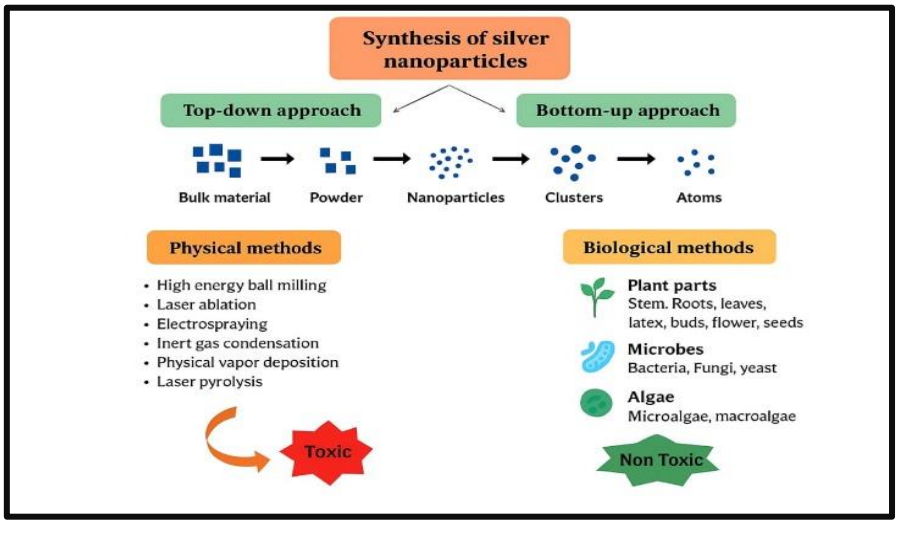
KEY WORDS: Cold cream is a traditional semisolid emulsion used for moisturizing, cleansing, and now as a base for incorporating nanoparticles.

INTRODUCTION:

Cold cream is a classical semisolid emulsion formulation, typically composed of an oil-in-water (O/W) base that provides moisturizing, cleansing, and protective functions for the skin and moisture of the skin. Cold creams have always been made with both natural and synthetic ingredients, but the current trend toward functional and sustainable cosmetics has sparked interest in employing bioactive nanoparticles made using green synthesis techniques. [7]

An environmentally responsible and sustainable substitute for traditional chemical and physical synthesis methods is green synthesis of nanoparticles. Green synthesis uses biological resources like plant extracts,microorganisms, or biopolymers as reducing and stabilizing agents, in contrast to conventional methods that frequently call for dangerous reducing agents, high temperatures, or toxic solvents [1,2]. In addition to reducing their negative effects on the environment, these bio-inspired techniques improve biocompatibility, sustainability, and safety—all of which are critical characteristics for cosmetic formulations that are applied directly to the skin. [3, 4]

Fig. 1.1: Nanoparticle synthesis techniques



Chemical toxicity, the production of hazardous byproducts, and the difficulties of maintaining particle homogeneity without the use of artificial surfactants are some of the problems with conventional nanoparticle creation. Therefore, the creation of green-synthesized nanoparticles offers a dermatologically safe and ecologically responsible route for next-generation formulations. [1,6]

Through phytochemical reduction, bioactive chemicals such as flavonoids, phenolics, terpenoids, and alkaloids in plant extracts work as natural reducing and capping agents, enabling the creation of nanoparticles under mild, energy-efficient conditions. [5,2,6]

Fig 1.2 : Cold cream.

GREEN SYNTHESIS OF NANOPARTICLES:

Green (or biological) production of nanoparticles uses living creatures or their extracts (plants, bacteria, fungi, algae) as reducing and capping agents to transform metal ions into stable nanoscale compounds. This method is interesting because it replaces hazardous chemical reductants and surfactants with benign biomolecules, reduces energy and solvent demands, and frequently generates biocompatible surfaces suitable for biomedical and environmental applications. [8]

1) Plant-based synthesis (aloe vera, neem, turmeric, etc.):

Many phytochemicals found in plants, such as polyphenols, flavonoids, terpenoids, sugars, and proteins, have the ability to both cap and stabilize the resultant nanoparticles and decrease metal ions, such as Ag^{+}, Au^{3+}, and Fe^{3+}, to their zero-valent form. Leaves (neem, aloe vera), roots, bark, seeds, and spice extracts (turmeric) are frequently utilized plant parts. Preparing an aqueous plant extract, mixing it with a metal salt solution at room temperature or slightly higher, and keeping an eye on color change and surface plasmon resonance (for noble metals) are typical protocol components. pH, temperature, extract concentration, metal salt concentration, and other reaction parameters.

Particle size, shape, and polydispersity are significantly influenced by incubation period. Although anisotropic forms can be achieved by adjusting settings or extracts, plant-mediated techniques typically produce spherical and quasi-spherical silver and gold NPs. Scalability, affordability, and ease of access to plant sources are practical benefits that are crucial for translational applications like environmental remediation and antimicrobial coatings. [9]

2) Microbial synthesis (bacteria, fungi, algae):

Microorganisms generate nanoparticles either intracellularly (inside cells) or extracellularly (secreted enzymes/metabolites decrease ions outside the cell). Algae, yeasts, bacteria, and fungi have all been employed. While fungi are useful for large-scale production due to their high secretion of proteins and enzymes that function as reducing/capping agents, bacteria and algae frequently permit rapid extracellular synthesis. Microbial mechanisms frequently involve reductase enzymes, electron shuttle molecules, and cell wall functional groups (carboxyl, hydroxyl, amino) that nucleate and stabilize metal atoms. Compared with plant extracts, microbes can offer better controlled synthesis (through genetic/physiological tuning), and their biomass can be reused in some process designs. [10]

3) Mechanisms of reduction:

Function of terpenoids, phenolics, flavonoids, and proteins Phytochemicals and microbial biomolecules reduce metal ions and simultaneously stabilize growing nuclei through adsorption (capping). Mechanistic points commonly observed in the literature:

Phenolics & flavonoids: donate electrons (via hydroxyl groups) to reduce metal ions (e.g., $Ag^{+} \rightarrow Ag^{0}$); oxidized phenolic products can adsorb on NP surfaces, acting as capping ligands and preventing aggregation. Terpenoids & alkaloids: can participate in redox reactions or bind metal surfaces to control growth and morphology. Proteins/enzymes (in microbes and some plant extracts): reductases can catalyze ion reduction; amino acid side chains (thiol, carboxylate, amine) serve as strong binding/capping sites that influence NP surface chemistry.Polysaccharides and sugars serve as steric stabilizers and moderate reducing agents. Followingsynthesis, spectroscopic (FTIR) examinations frequently reveal the loss or shifting of peaks linked to –OH,C=O and– NH groups,which is consistent with their participation in reduction/capping. In numerous evaluations, integrated UV-Vis, FTIR, and mass spectrometry results support these mechanistic assignments. [11]

4) Characterization methods

What they tell you about UV-Vis, FTIR, SEM, TEM, XRD, and DLS Surface plasmon resonance (SPR) peaks (Ag ~ 380–450 nm, Au ~ 500–550 nm depending on size/shape) are monitored by—

- FTIR (Fourier-transform infrared) — detects functional groups from extracts /microbes that are bound to NP surfaces (evidence for capping ligands; e.g., shifts in –OH, C=O, –NH bands).
- SEM (Scanning Electron Microscopy) — surface morphology and approximate particle shape; useful for supported or aggregated samples.
- TEM (Transmission Electron Microscopy) — high-resolution imaging of individual nanoparticles: accurate size distribution, shape, lattice fringes (crystallinity).
- XRD (X-ray Diffraction) — crystallographic phases, crystal structure and average crystallite size (via Scherrer equation).
- DLS (Dynamic Light Scattering): hydrodynamic diameter and zeta potential (stability/colloidal charge); take note that because of solvation and capping layers, DLS reports hydrodynamic diameters that are frequently larger than TEM sizes. [12]

Fig 1.3 : Cold cream

Cold cream is a traditional semisolid emulsion used for moisturizing, cleansing, and now as a base for incorporating nanoparticles.Green synthesis of nanoparticles uses plant extracts, microbes, or biopolymers as reducing and stabilizing agents.

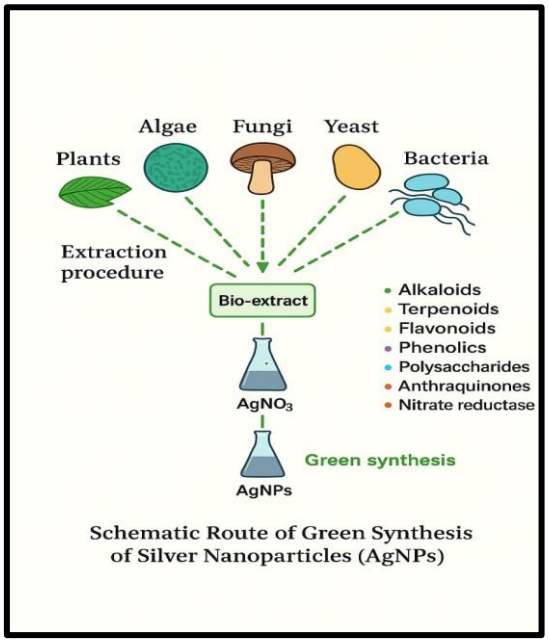


Fig 1.4 :- Schematic Route of green synthesis of AgNP.

INCORPORATION OF METAL NANOPARTICLES INTO COLD CREAM:

1.Short introduction:

In order to add antibacterial, UV-protective, antioxidant, and anti-aging properties while utilizing enhanced skin delivery at the nanoscale, metal nanoparticles (AgNPs, ZnO NPs, and AuNPs) are increasingly being added to topical vehicles. Cold cream, a conventional water-in-oil (W/O) emulsion,

is a helpful matrix for dispersing metal nanoparticles for topical applications because it offers an emollient, occlusive barrier, and cooling sensation upon application.

applications in dermatology and cosmetics. In addition to discussing formulation problems, such as particle aggregation, emulsion destabilization, photoreactivity, and safety evaluation, recent reviews detail advancements in nanoparticle production (including green approaches) and their cosmeceutical applications. [13]

2. Practical formulation process:

Below is a standard protocol optimized for adding nanoparticles into a W/O cold cream while minimizing aggregation and preserving nanoparticle function.

- **prepare oil phase:**

• Mix mineral oil (emollient), beeswax (thickener/structure), stearic acid (co-emulsifier/emulsifier), and any oil-soluble actives.
• Heat to 70–75 °C while gently stirring until the waxes are completely melted and homogeneous.(Stearic acid typically requires heat to melt and to interact with emulsifiers; if using it as an emulsifier you may neutralize it or pair it with a surfactant as discussed below.)

- **Prepare aqueous phase:**

• Weigh distilled water beforehand, then dissolve cool-stable actives and water-soluble additions (humectants, glycerin, and preservatives, if applicable). Raise the temperature of the aqueous phase to approximately 70 to 75 degrees Celsius.

- **emulsifier choice & addition:**

• Stearic acid functions as a co-emulsifier and fatty acid; for stable W/O cold creams, it is frequently combined with a lipophilic emulsifier made for W/O systems (such as sorbitan esters, polyglyceryl-based W/O emulsifiers, or silicone-based emulsifiers) or a neutralizing base (such as triethanolamine for O/W systems). Select an emulsifier system that works with nanoparticles and W/O types. Describe in writing how the emulsifier class and formulation route (W/O) have a significant impact on the distribution of nanoparticles (inside oil phase vs. at interface).

- **emulsification (mixing):**

• While keeping the temperature at around 70 °C, gradually incorporate the aqueous phase into the oil phase under high-shear mixing or homogenization. Mix continuously until the emulsion is homogenous and formed (usually 5 to 10 minutes with a rotor-stator homogenizer).
• Before adding temperature-sensitive ingredients (such as peptides and many NPs stabilized with biomolecules), gently swirl the emulsion until it is below about 40 °C. [14]

- **cooling and finishing:**

• Add any preservatives and heat-sensitive ingredients (fragrances, volatile actives) when the batch reaches about 40 °C. To prevent trapping air, gently stir. To prevent phase inversion, keep cooling to ambient temperature while gently mixing.
• Timing: To avoid thermal instability of nanoparticle capping agents and to reduce NP aggregation, add nanoparticles at the conclusion of cooling (≤40 °C). Pre-disperse nanoparticles made in an aqueous medium (like green AgNPs) in the aqueous phase of the formulation or in a tiny amount of water that will be added later; for oil-dispersible NPs, carry out a phase transfer or apply suitable surface coatings.
• Dosage and mixing: To provide uniform distribution, add the well-characterized NP dispersion gradually with little shear and stir gently. Common loadings for cosmetics: 0.1–0.5% w/w AgNPs.
(antimicrobial/preservative impact), ZnO 1–5% (UV protection), however lower percentages of nano

ZnO may be useful for SPF contributions; in vitro SPF tests will optimize this. Because of their efficacy and expense, AuNPs are usually utilized at very low concentrations (<<1%).[15]

- **final homogenization & qc:**

• To guarantee consistent NP dispersion without disrupting the W/O structure, use a low-speed homogenization if desired. package in a clean environment. Verify the following: pH, spreadability, viscosity, particle size (DLS), zeta potential, and microbiological testing
Silver nanoparticles (AgNPs): These antibacterial and preservation adjuncts have broad-spectrum antimicrobial activity through a variety of mechanisms, including membrane disruption, production of reactive oxygen species (ROS), interaction with protein thiol groups, and disruption of DNA activities. When evenly distributed in topical formulations, AgNPs can lower microbial load and biofilm development; green-synthesised AgNPs frequently contain phytochemical capping agents that can improve stability and biocompatibility. Use low concentrations (0.1–0.5% w/w) and use challenge tests to confirm the effectiveness of the preservative. [15]
Zinc oxide nanoparticles (ZnO NPs): calming and UV protection. In certain formulations, nano-ZnO has modest antibacterial, anti-inflammatory, and calming effects in addition to being a physical UV screen that scatters and absorbs UVA and UVB. SPF contribution and cosmetic feel are determined by particle size, surface coating, and dispersion in the oil phase. Sunscreen claims and labeling are subject to safety and regulatory issues.
Gold nanoparticles (AuNPs): Anti-aging and antioxidant When functionalized or coated with antioxidant compounds like gallic acid or resveratrol, AuNPs themselves can exhibit antioxidant activity and may improve the delivery of other activities. AuNP-carried actives may boost cellular antioxidant defenses and alter aging indicators, according to a number of in-vitro and animal studies; human data are scarce and further safety assessment is necessary. [16]

3. Compatibility and stability studies:

• ph :

Check the pH before and after storage (1, 3, and 6 months). NPs containing biological capping agents have the potential to change pH, which affects emulsion stability and skin compatibility. For skin-friendly formulas, aim for a pH of about 5 to 6 unless specific activities need it.

• viscosity / rheology :

Use a Brookfield rotating viscometer to measure at regulated temperatures and shear rates.

NPs can alter rheology by decreasing viscosity when the network is disrupted or thickening through Pickering effects. Monitor viscosity changes following centrifugation and under accelerated aging (40 °C).

• particle size / aggregation (np characterization in final cream) :

After extracting or dispersing a representative sample, measure the NP hydrodynamic size (DLS); if feasible, use TEM/SEM to analyze the morphology. For AgNPs and AuNPs, UV-Vis spectroscopy can identify plasmon changes that signify aggregation.

• physical stability :

Centrifugation, room temperature storage, accelerated aging (40 °C ± humidity), and freeze-thaw cycles (−5 °C to 40 °C). Keep an eye out for changes in color, odor, creaming, and phase separation. Depending on NP wettability, Pickering stabilization by NPs can either stabilize or destabilize W/O emulsions.

• microbial stability / preservative efficacy test (challenge test) :

Run approved challenge tests (such as ISO 11930 or pertinent pharmacopeial procedures) to verify antibacterial efficacy at the intended NP concentrations if AgNPs are supposed to offer preservation. AgNPs may not completely replace approved preservative systems in all regulatory areas, although they can lower bacteria counts.

• photostability & spf (for zno) :

Measure in vitro SPF and photostability when making claims about sunscreen; ZnO particle dispersion and coating determine UV performance and photoreactivity. [14, 15, 17]

4. Example formulation table:

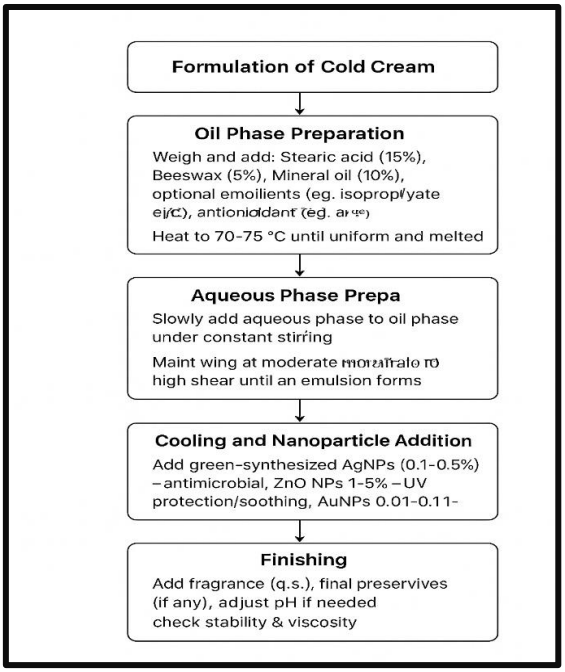


Table No. 1.1 : - Formulation process of cold cream

EVALUATION PARAMETERS FOR COLD CREAM PREPARED VIA GREEN SYNTHESIS:

Physicochemical, microbiological, antioxidant, safety, and stability investigations are all part of the interdisciplinary evaluations of cold cream formulations that contain green-synthesized nanoparticles. These assessments guarantee the long-term performance, safety, and effectiveness of the formulation.

1. Physicochemical evaluation:

a. ph:

To avoid irritation and preserve the skin's natural acid layer, topical preparations should have a pH between 4.5 and 6.5. Because of variations in ionic interactions or dispersion medium properties, the addition of nanoparticles may affect the pH.

b. appearance:

Color, uniformity, and texture are determined by visual inspection. Depending on plant-mediated capping agents or particle concentration, green-synthesized nanoparticles (such as Ag, ZnO, TiO_2, Au, etc.) may give a distinctive color.

c. spreadability:

This metric represents user acceptability and application ease. The diameter of the cream spread under particular weight and time parameters is measured in order to assess it. By altering rheology or particle–emulsion interactions, nanoparticles might improve spreadability and facilitate smoother application.[18]

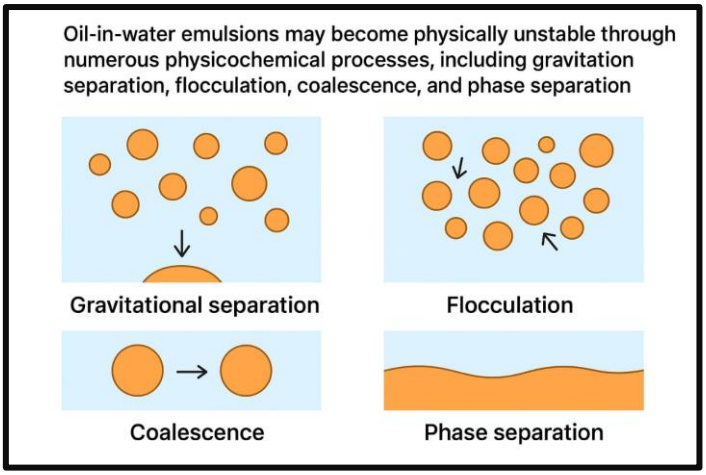


Fig. 1.5: A variety of physicochemical processes, such as phase separation, flocculation, coalescence, and gravitation separation, can cause oil-in-water emulsions to become physically unstable.

2. Microbial stability:

Agar Diffusion Method/Zone of Inhibition: Microbial examination guarantees that the formulation has antibacterial activity (where relevant) and is resistant to microbial contamination. The antibacterial potency of the formulation against common skin infections such Staphylococcus aureus, Escherichia coli, and Candida albicans is assessed using the agar diffusion technique. Because of their inherent antibacterial qualities and their synergistic effects with plant phytochemicals, metal or metal oxide nanoparticles frequently improve the zone of inhibition surrounding the sample disc or well, indicating antimicrobial efficiency. [19]

3. Antioxidant activity:

DPPH or ABTS Radical Scavenging Assays:

Because it reduces oxidative stress and delays skin aging, antioxidant potential is a crucial component of skin compositions. Two commonly used spectrophotometric techniques to measure free radical scavenging activity are the DPPH (2,2-diphenyl-1-picrylhydrazyl) and ABTS (2,2′-azino-bis(3-ethylbenzothiazoline-6-sulfonic acid)) tests. Because they contain bioactive substances including flavonoids, phenolics, and terpenoids, green-synthesised nanoparticles capped with phytoconstituents frequently show improved antioxidant activities. [20]

4. Safety assessment:

Patch Tests and Skin Irritation Studies: To guarantee dermatological compatibility, safety assessment is crucial. Erythema, edema, or irritation are evaluated using patch testing on a small section of human or animal skin. Because phytochemicals function as natural reducing and stabilizing agents, lowering harmful residues, formulations containing green-synthesized nanoparticles are typically safer than those employing chemically generated ones. It is advised to adhere to normal dermatological procedures or OECD standards. [21]

5. Stability testing:

a. temperature stability:

Accelerated stability tests assess color, odor, viscosity, and phase separation at different temperatures (e.g., 4°C, 25°C, and 40°C). These studies forecast shelf life and simulate long-term storage.

b. centrifugation test:

This quick test evaluates the stability of the emulsion under mechanical stress. Samples are centrifuged (usually 3000–5000 rpm for 30 minutes) to detect phase separation or creaming, indicating instability.

c. shelf-life studies:

The product's longevity and the impact of nanoparticles on formulation integrity can be ascertained through prolonged storage under regulated environmental conditions (humidity, light, and temperature). By offering antibacterial and antioxidant protection, green-synthesized nanoparticles frequently extend shelf life. [22]

RESULT AND DISCUSSION OF COLD CREAM PERFORMANCE:

1. Nanoparticle properties (green-synthesized):

Green syntheses (plant/microbial extracts) usually produce metal and metal-oxide nanoparticles (NPs) with spherical to quasi-spherical shape and narrow size distributions, such as Ag, ZnO, and TiO_2.

(often 5–50 nm), as well as biomolecules' surface capping (polyphenols, proteins, sugars). Improved colloidal stability (less aggregation), changed surface charge (zeta potential), and functional groups (–OH, –COOH, $–NH_2$) that can enhance interaction with cream excipients and active payloads are all provided by the biomolecular corona from extracts. Reviews of green synthesis and experimental investigations consistently describe these characteristics. [23]

Consequences for cold cream: smaller, monodisperse NPs with biomolecule capping reduce sedimentation, promote uniform dispersion in the oil-in-water (or water-in-oil) matrix of cold creams, and can alter the release kinetics of incorporated actives (sustained release or burst depending on NP–matrix interactions). [24]

2. Cream performance: stability, rheology, and bioactivity:

The following effects have been documented when green-synthesised NPs are added to cold creams:

Physical stability: Reduced phase separation and better NP dispersion as compared to weakly stabilized NPs; creams containing green-capped NPs exhibit steady pH and viscosity during normal storage periods and less creaming and sedimentation.

Rheology and spreadability: Depending on the particle-to-lipid ratio, NP loading somewhat raises apparent viscosity and yield stress; this can improve ointment-like retention while maintaining suitable spreadability for topical administration.

Performance (antibacterial, wound healing, and antioxidant): When compared to chemically

produced equivalents, Ag and ZnO NPs made via green methods frequently exhibit similar or improved antimicrobial and antioxidant properties in gels and creams. This is probably because surface phytochemicals have a synergistic effect. Antimicrobial cold/medication creams and wound-healing compositions are two examples. [24]

3. Green-synthesized vs conventional nanoparticle:

Synthesis and reagents: Green routes employ plant extracts or microbes as reducing/capping agents, avoiding many hazardous chemicals, while conventional chemical/physical routes frequently require hazardous reducing/stabilizing agents (e.g., hydrazine, sodium borohydride, citrate under harsh conditions) and produce toxic byproducts.

Material characteristics: Green NPs often exhibit a surface layer formed from biomolecules that might enhance stability and biological interactions; however, because of the diversity of natural extracts, batch-to-batch variability may be higher. Excellent reproducibility and size/shape tunability are typically provided via controlled chemical syntheses, albeit at the expense of a greater environmental load and occasionally leftover hazardous chemicals.

Efficacy and safety: While full toxicological profiling (skin penetration, systemic exposure) is still limited and needs to be handled case-by-case, several head-to-head studies report comparable or superior antimicrobial/antioxidant performance for green NPs, and some indicate reduced eco-toxicity in certain bioassays. [25]

4. Sustainability and safety evidence & caveats:

Life-cycle and environmental impact: When compared to some conventional pathways, well-designed green syntheses have fewer environmental burdens, according to LCAs and comparative environmental assessments (reduced hazardous waste, lower energy use when aqueous, ambient conditions are used). However, LCAs stress that in order to prevent underestimating consequences, downstream purification, drying energy, and scalability must be taken into account.[26]

Human safety and ecotoxicology: Although the use of hazardous reductants is reduced by green protocols, metal NPs can still have ecotoxic effects, and capped surfaces can minimize or alter toxicity but need empirical testing. Local skin irritation, dermal penetration (ex vivo human skin or validated in vitro models), and chronic exposure studies are important safety objectives for topical creams. While many green-NP research claim satisfactory acute safety, long-term data are still few. [27]

CONCLUSION:

Incorporating green-synthesized nanoparticles into cold cream formulations is a potent way for modern cosmeceuticals to combine sustainability, safety, and improved functional performance. Green NPs can significantly improve the preservative and skin-protective properties of cold cream, according to studies like the one on biosynthesized zinc oxide nanoparticles (ZnO NPs) using Adhatoda vasica leaf extract, which when infused into cold cream show strong antimicrobial, antifungal, and antioxidant activity. In a similar vein, "Green Synthesis of Silver Nanoparticles and Its Combination with Pyropia

columbina Extracts for a Cosmeceutical Application" shows that phytochemicals and metal nanoparticles can be combined to create photoprotective, antioxidant creams with minimal cytotoxicity and good stability. Additionally, the latest research on Ag–TiO_2 nanocomposites made from neem and mango leaf extracts emphasizes cutaneous safety.

REFERENCE:

1. Radulescu DM, Surdu VA, Ficai A, Ficai D, Grumezescu AM, Andrones E. Green Synthesis of metal and metal oxide nanoparticles,A review of principle and biomedical application.International Journal of molecular Science. 2023; 24: 15397.
2. Ying S, Guan Z, Ofoegby PC, Clubb P, Rico C, He F, Hong J.Green Synthesis of nonoparticles,curent developments and limitations.Environmental technology and innovation. 2020-22; 26: 102336.
3. Bhardwaj B, Singh P, Kumar A, Kumar S, Budhwar V.Ecofriendly greener synthesis of nanoparticles.Dept. of pharmaceuticals science. 2020; 10(4): 566-576.
4. Vijayaram S,Razafindralamba H, Sun YZ, Vasantharaj S,Ghafarifarsani H,Hoseinifar SH,Raeesadeh M.Application of green synthesized metal nanoparticles Biological trace element research. 2023; 23: 03645.
5. Singh H, Desimone MF, Pandya S,Jasani S,George N,Adnan M,Aldarhami A, Bazaid AS,Aldethami SA.Revisiting the green synthesis of nanoparticles :Uncovering influences of plant extracts as reducing agents for enhanced synthesis efficiency and its biomedical applications.International journal of nanomedicine. 2023; 18: 4727-4750.
6. Dhaka A, Mali SC,Sharma S, Trivedi R. A review on biological synthesis of silver nanoparticles and their potential applications.Result of chemistry. 2023; 6: 101108.
7. Yadav A,Yadav GK,Wasiullah M, Maurya S.A review articles on formulation and evaluation of cold cream.International journal pharmaceuticles researches and application. 2023; 8(3): 739-743.
8. Dikshit PK,Kumar J,Das AK, Sadhu S,Sharma S,Singh S,Gupta PK,Kim BS,Green synthesis of metallic nanoparticles :applications and limitation.Catalystes. 2021; 11: 902.
9. Jaison JP, Balasubramanian B,Gangwar J,James N,Pappuswamy M,Anand AV,AI-Dhabi NA,Arasu MV,Liu WC,Sebastian JK.green synthesis of bioinspired nanoparticles mediated from plant extract of asteraceae family for potential biological application.Antibiotics. 2023; 12: 543.
10. 10.Koul B,Poonia AK, Yadav D, Jin JO.Microbe-mediated biosynthesis of nanoparticles: applications and future prospects .Biomolecules. 2021; 11: 886.
11. 11.Singh H, Desimone MF, Pandya S,Jasani S,George N,Adnan M,Aldarhami A, Bazaid A.S,Aldethami S.A.Revisiting the green synthesis of nanoparticles :Uncovering influences of plant extracts as reducing agents for enhanced synthesis efficiency and its biomedical applications,International journal of nanomedicine. 2023; 18: 4727-4750.
12. 12.Fahim M,Shahzaib A,Nishant N, Jahan A,Bhat t.A,Inam A,Green synthesis of silver nanoparticles : A comprehensive review of methods.Influencing factors and applications,JCIS Open. 2024; 16: 100125.
13. 13.Cardoza C,Nagtode V,Pratap A,Mali S.N,Emerging application of nanotechnology in cosmeceutical health science:latest updates.Health science review. 2022; 4: 100051.
14. 14.Deveci E.Nanoemulsion in cosmetics : enhancing efficacy and stability,journal of dermatologic science and cosmetics technology. 2025; 2: 100107.
15. 15.Rodrigues AS,Batista JGS,Rodrihues MAV,Thipe VC, Minarini LAR,Lopes PS,Lugao AB.Advances in silver nanoparticles : a comprehensive review on their potential as antimicrobial agents and their mechanism of action elucidated by proteomics,Frontiers in microbiology. 2024; 15: 1440065.
16. 16.Wu YZ,Tsai YY, Chang LS,Chen YJ..Evaluation of garlic acid coated gold nanoparticles as an anti- aging ingredients.Pharmaceuticals. 2021; 14(11): 1071.
17. 17.Xiao T,Ma X,Hu H,Xiang F,Zhang X,Zheng Y,Dong H,Adhikari B,Wang Q,Shi A.Advances in emulsion stability : A review on mechanism role of emulsifiers and application in food,Food chemistry: X. 2025; 29: 102792.
18. 18.Muresan EI, Pui A, Cernatescu C, Cimpoesu R, Horhogea CE, Istrare B, Rimbu CM,Green synthesis of nanoparticles containing zinc complexes and their incorporation in topical creams with antimicrobial properties.Applied science. 2024; 14: 4612.
19. 19.Nandhini J,Karthikeyan E, Rajeshkumar S.Green synthesis of zinc oxide nanoparticles: eco-friendly advancements for biomedical marvels. *Resources Chemicals and Materials.* 2024; *3*(4): 294-316.
20. 20.Keskin M, Kaya G, Bayram S, Gorecka A.K,Olczyk P,Green synthesis ,characterization antioxidant ,antibacterial and enzyme inhibition effects of chestnut (Castanea sativa) Honey-mediated silver nanoparticles.Molecules. 2023; 28: 2762.
21. 21.Gupta V, Mohopatra S, Mistra H, Farooq u, Kumar K, Ansari MJ, Aldawasari MF,Alalaiwe AS, Mirza MA, Iqbal Z, Nanotechnology in cosmetics and cosmeceuticals – a review of latest advancements.Gels. 2022; 8: 173.
22. 22.Dey S,Mohanty DL, Divya N, Bakshi V, Mohanty A, Rath D, Das S, Mondal A, Roy S, Sabui R.Acritical review on zinc oxide nanoparticles:synthesis ,properties and biomedical application. 2025; 3: 53-70.
23. 23.Ying S, Guan , Ofoegbu P.C, Clubb P, Rico C, He F, Hong J, Green synthesis of nanoparticles:current developments and limitation s,Environmental technology and innovation, 2022;26; 102336.
24. 24.Bouafia A, Laouini SE, Ahmed ASA, Soldatov AV, Algarni H, Chong K.F, ali G.A.M, The recent progress on silver nanoparticles :synthesis and electronic application, Nanoparticles, 2021;11:2318.
25. 25.Yadav R, Preet S. Comparative assessment of green and chemically synthesized glutathione capped silver nanoparticles for antioxidant,mosquito larvicidal and eco-toxicological activities.Scientific reports. 2023; 13: 8152.

26. 26.Rodríguez-Rojas MDP, Terrones VB , Díaz-Cárdenas MY, Vélez VE, Martínez H. Life Cycle Assessment of Green Synthesis of TiO2 Nanoparticles vs. Chemical Synthesis.Sustainability. 2024; 16: 7751.

27. 27.Nizam NUM, Hanafiah MM, Woo KS. A Content Review of Life Cycle Assessment of Nanomaterials: Current Practices, Challenges, and Future Prospects. Nanomaterials. 2021; 11: 3324.

28. 28.Sonia S, Ruckmani K, Sivakumar M. Antimicrobial and antioxidant potentials of biosynthesized colloidal zinc oxide nanoparticles for a fortified cold cream formulation: a potent nanocosmeceutical application.*Materials Science and Engineering.* 2017; *79:* 581-589.