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#### **Review Paper**

# Nanocosmeceuticals- The Subsequence of Sophisticated Skincare

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ARTICLE INFO	ABSTRACT
Published: 14 May 2025 Keywords: Nanocosmeceuticals, Liposomes, Niosomes, Green Nanotechnology DOI: 10.5281/zenodo.15400742	This review article provides an insight into the basics of cosmeceuticals, their role in the pharmaceutical market, along with the incorporation of nanotechnology in cosmeceuticals. Cosmeceuticals are the marketed preparations which are intended to be used on skin, hair, nails and teeth for personalised use, varying according to individuals. On the other hand, nanotechnology is the science related to engineering materials at the nanoscale of 1 to 100 nanometers. The smaller size of these particles will allow for targeted delivery, assisting in the controlled release of the active ingredients. It also helps in the deeper penetration of the formulation for higher pharmacological activity. Nanocarriers like liposomes, niosomes, fullerenes, ethosomes, solid lipid nanoparticles, etc. are elaborated here. This review also gives knowledge about the best suitability of a particular nanocarrier, along with the intended active skincare ingredient, along the future innovations of nanocosmeceuticals in the upcoming ages.

#### **INTRODUCTION**

Cosmeceuticals are the pharmaceutical formulations that enhance the appearance, texture and feel of the skin, hair, teeth and nails. It is widely classified into many types based on the need, ingredients and form. [1] It may or may not contain bio-active ingredients, which may react with the skin surface and produce some changes accordingly. These lie between the intersection of cosmetics and pharmaceuticals. These can be used for treating various issues like pigmentation, ageing, scarring, acne and UV protection. Skin Brightening agents like

- Kojic acid
- Alpha arbutin
- Vitamin C
- Tranexamic acid
- Azelaic acid

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Anti-ageing agents like

- Peptides
- Coenzyme Q10
- Retinoids

Anti-acne cosmeceuticals like

- Benzoyl peroxide
- Niacinamide
- Salicylic acid

Photoprotective blockers like

- Avobenzone
- Oxybenzone
- Zinc oxide
- Titanium oxide

These can be classified into two basic types, namely skincare and makeup. Skincare is a type of cosmetic that helps clear skincare issues like acne, pigmentation, and wrinkles. These are incorporated as serums, ampoules, creams, moisturisers, etc. On the other hand, Makeup helps to hide and conceal scars and skin issues. It is also helpful in brightening the skin for a temporary purpose.[2] These are available as lipsticks, mascaras, foundation, etc. Nanotechnology is the field of science and engineering that designs, produces, and uses structures, devices, and systems by manipulating atoms and molecules at the nanoscale, typically 1-100 nanometers. This small scale allows for the manipulation of matter and can lead to novel materials with unique properties. The incorporation of nanotechnology in cosmeceuticals can make a huge impact in the cosmeceutical industry. It will penetrate deeper layers of skin while delivering active ingredients more precisely, and can enhance the product's performance. The active ingredients, like retinol, peptides and antioxidants, can help in deeper penetration for the activity of anti-ageing. Nanoarbutin and nano-vitamin C can help in alleviating skin tone and anti-pigmentation.[3] even Encapsulation of nano-biotin and minoxidil can help with better hair growth. The consumer

demand for the nuance of nanotechnology is shifting towards a greater demand, which eases the absorption, enhances bioavailability of actives, better the feel of aesthetics, increases product stability and provides a non-greasy feel and longlasting effect[4].

#### Nanocarriers Used in Cosmeceuticals

The brainchild of nanotechnology in the domain of cosmeceuticals includes,

#### Liposomes

Based on the need and the features, the liposomes are classified into several types, including Ultrasomes. Ultrasomes are particles, and oil-inwater (o/w) emulsions consist of a lipid-based structure featuring a hydrophobic core within the o/w emulsions, which is encased by one or more phospholipid bilayers of liposomes. These are helpful in the delivery of Vitamin C, Coenzyme Q10 and Retinol, which improve the stability of active ingredients and skin penetration.[5]

#### Niosomes

They are similar to Liposomes but composed of non-ionic surfactants instead of phospholipids like Liposomes. They are more suitable for dermal drug delivery and are more stable and less expensive than liposomes. These are helpful in the delivery of Herbal extracts, Azelaic acid and Niacinamide [6]

#### Solid Lipid Nanoparticles

Solid Lipid Nanoparticles (SLNs) are mostly made up of solid lipids like glyceryl monostearate, stearic acid, which are mostly solid at body temperatures. They are prominent in the controlled release of active constituents and have persistent occlusive properties. They are ideal in the delivery of Anti-ageing ingredients, Barrier repair creams and UV protection serums.[7]

#### **Nanostructured Lipid Carriers**

They have higher drug loading capacity compared to SLNs, which is compatible due to reduced drug leakage and improved stability. These are the second-generation lipid nanoparticles. These are used in the delivery of Kojic acid, Tranexamic acid, Retinoic acid and Coenzyme Q10, They are mostly useful in the formulation of night masks, serums and eye creams.[8]

#### Nanoemulsions

These are fine w/o or o/w emulsions, which are made stable by the addition of surfactants. They have higher transparent and translucent nature. They also have Higher Thermodynamic stability. They are utilised in the compounding of fragrances, hair serums, anti-ageing and lotions which are ideal in delivering essential oils and Tocopherol.[9]

#### Dendrimers

These got their name due to their resemblance to Dendrimers of neurons, being highly branched synthetic macromolecules with a strong core and layered environment. They have high drug encapsulation efficiency and can also be engineered for targeted delivery. It is used in the formulation of antioxidants and antimicrobials. It has a high potential in treating ageing and acnerelated issues.[10]

#### Ethanosomes

These are phospholipid vesicles containing a higher content of ethanol up to 20-40%. Since

ethanol disrupts the skin bilipid barriers, it is easier for skin penetration, which makes it suitable and perfect for dermal drug delivery. It is used in the delivery of minoxidil, herbal extracts and peptides. It is predominantly in hair growth serums and antiscarring creams.[11]

### Transferosomes

It is the ultra-development of Liposomes with added edge activators like Tween 80. It can push itself through narrow channels of the skin, making it excellent for transdermal drug delivery. It is used in the delivery of peptides, anti-inflammatory agents and hormone delivery via dermis.[12]

# Fullerenes

These are carbon-based spherical molecules(C60) shaped like a ball. They have outstanding antioxidant activity, which has a high capacity to neutralise the free radicals. It can be used in the delivery of day creams and high-end skincare.[13]

#### **Gold and Silver Nanoparticles**

These are nanoparticles which are composed with metallic bases ranging from 1-100 nm. They are highly beneficial in the implementation of antimicrobial and skin-clearing properties by improving skin tone and reducing allergies. Mostly incorporated in the formulations of antiinflammatory and anti-acne ingredients, which makes them popular in implementing in face masks, eye cream and serums.[14]

# NANOCARRIERS IN COSMECEUTICALS



S.no	Nanocarriers	Suitable for	Reference
1	Liposomes	Vitamin Delivery, Moisturization	viet univer viet
2	Niosomes	Stable Best for Herbal actives	Phylophilic Non-contactual Phylophylic Non-contactual Phylophylic Idlia of and factor Phylophylic natural compound or drug Chalantel Phylophylic natural compound or drug Phylophylic natural compound or drug Phylophylic natural compound or drug
3	Solid Lipid Nanoparticles	Anti-ageing Skin protection	Solid lipid nanoparticles Drag is dissolved or dispersed Lipid Surfactant and phospholipid Figure 3 : Solid Lipid Nanoparticles
4	Nanostructure Lipid Carriers	Enhanced skin delivery	Solid lipid core Liquid lipid core Figure 4 : Nanostructure Lipid Carriers
5	Nanoemulsions	Quick absorption	Hydrophilic head Hydrophobic tail Hydrophobic tail Figure 5 : Nanoemulsions
6	Dendrimers	High precision delivery	

#### **Table 1: Nanocarriers in cosmeceuticals**







Active Ingredients Delivered Through Nanocarriers

#### • Antioxidants

Antioxidants play an important role in the world of skincare, as they help protect skin from oxidative

stress caused by free radicals. Free radicals are unstable molecules caused by UV radiation, stress, and ageing. They pollute skin cells, causing inflammation, pigmentation, and ageing.

Antioxidants are used topically and also ingested to get rid of free radicals. The persistent antioxidants include[15]

S.No	Antioxidants	Favourable Nanocarriers	Benefits of Nanocarriers
1	Vitamin C	Liposomes,	Prevents Oxidation
	(Ascorbic Acid)	SLNs Ethanosomes Nanoemulsions	
2	Vitamin E	NLCs Nanoemulsions	Repair the lipid barrier
	(Tocopherol)		
3	Coenzyme Q10	SLNs, NLCs Liposomes	Firms skin
	(Ubiquinone)		
4	Glutathione	Liposomes, Ethanosomes	Detoxification
5	Curcumin	SLNs, Dendrimers	Fights Inflammation
6	Resveratrol	Ethanosomes, SLNs, Dendrimers	UV Protection
7	Green Tea Polyphenols	Niosomes	Acts as an antioxidant shield
		Liposomes	
8	Lycopene	NLCs	UV Protection
		Nanoemulsions	
9	Astaxanthin	SLN	Super-antioxidant
		Liposomes	

Table 2: I	Nanocarriers	s as Antioxidants
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#### • Anti-ageing

Anti-ageing products share an extensive area in the cosmeceutical world. Due to the stress that mostly

prevails in today's generation. The products which help in reducing fine lines have occupied a larger share of the skincare industry. There are many active constituents, including [16]

S.No	Active Ingredient	Role in Anti-ageing	Nanocarrier used
1	Retinol	Boosts Collagen	Liposomes
	(Vitamin A)		NLCs
			SLNs
2	Vitamin C	Fights wrinkles	Liposomes Ethosomes
	(Ascorbic acid)		
3	Peptides	Stimulates Collagen	Nanoemlusions
	(Matrixyl Argirline)		Liposomes
4	Coenzyme Q10	Skin energy production	Liposomes
	(Ubiquinone)		Nanoemulsions
5	Bakuchiol	Natural retinol	Nanostructured lipid carriers
	(Retinol alternative)		_
6	Resveratol	Protects Collagen	NLC
			Liposomes
7	Ceramides	Strengthens skin barrier	Nanocapsules
		-	Liposomes

 Table 3 : Nanocarriers in Anti-ageing



#### • Anti-Acne

Acne is caused due to genetics, poor hygiene and other microorganisms. These treatments include the following[17]

S.No	Active Ingredient	Nanocarrier used	Role
1	Benzoyl Peroxide	Nanocapsules	Antibacterial
		SLNs	Keratolytic
2	Salicylic acid	Liposomes	Unclogs pores
		Niosomes	Exfoliation
3	Clindamycin	Liposomes	Antibiotic against
		Nanoemulsions	acne
4	Tea Tree oil	Nanoemulsions	Natural antimicrobial
		Liposomes	
5	Zinc Oxide	Nanoparticles	Anti-bacterial
			Anti=inflammatory
6	Green Tea Extract	Liposomes	Anti-inflammatory
		Niosomes	Anti-oxidant
7	Niacinamide	Niosomes	Sebum regulation
		Nanoparticles	Anti-inflammatory

eatment

#### • Anti-pigmentation

Hyperpigmentation happens due to overproduction of melanin. They can be caused due to UV exposure, scarring and genetic factors. Traditional skin-lightening agents couldn't help in achieving skin depigmentation, which can cause poor penetration, skin irritation or instability. Nanocarriers improve the delivery, performance and effectiveness in treating pigmentation. It can be treated using the following[18]

	Tuble e . Multiculture as this pignetication agents					
S.No	Active Ingredient	Nanocarrier used	Role			
1	Kojic acid	Nanocapsules	Tyrosinase inhibitor			
		Liposomes				
2	Alpha arbutin	Liposomes	Natural melanin			
		SLN's	inhibitor			
3	Azelaic acid	Nanoemulsions	Melanin Inhibitor			
		Nanocapsules				
4	Glutathione	Liposomes	Skin brightening			
		Niosomes				
5	Tranexamic acid	Liposomes	Blocks UV-induced			
		Nanoparticles	pigmentation			
		_	pathways			

Table 6 : Nanocarriers as Moisturisers

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I able 5	: mano	carriers	as Anu-	pigmentai	ion agents

#### • Moisturising Agents

Moisturization is the key factor to overall skin health. The skin, which is thoroughly moisturised, can fight against other skin damage issues. When the skin lacks moisture, it tends to dry up and crack, leading to new skin ailments. It can be treated by the following[19]



S.No	Active Ingredient	Nanocarrier Used	Role
1	Hyaluronic Acid	Nano capsules	Powerful Humectant
		Niosomes	
2	Ceramides	Liposomes	Strengthens skin
		Nano capsules	barrier
3	Squalene	SLNs	Emollient
		NLCs	Traps moisture
4	Panthenol	Niosomes	Skin barrier
		Liposomes	supporter
5	Urea	Nano capsules	Keratolytic agent
			Moisturizer
6	Aquaporin Stimulators	Nano capsules	Boosts water
		Liposomes	channels in skin
			cells
7	Shea Butter	NLCs	Rich emollient
		SLNs	
8	Linoleic acid	NLCs	Maintains lipid
		Liposomes	barrier
9	Aloe Extract	Nano emulsions	Soothing
		Liposomes	
10	Glycerin	Nano emulsions	Humectant

#### **Safety Challenges**

Nanocarriers are great in their use in many domains, particularly in cosmetics. Their benefits are boundless, providing deeper skin penetration, better stability and longer-lasting effects. They also have unique concerns about safety and regulatory hurdles compared to those of conventional cosmetic formulations.[20]

#### Safety Concerns

The main issue of nano cosmeceuticals is that they may have toxicity, especially metal-based nanoparticles like silver, gold, titanium dioxide, which can generate Reactive oxygen species (ROS). which can cause cell damage, inflammation and oxidative stress, leading to several conditions of metal toxicity. Some nanoparticles can accumulate in tissues when used for a long time if it is properly metabolised. The nanocarriers can also deliver to off-target sites, providing altered biodistribution. When used for a prolonged time, it can have long-term effects on human health. Nanoparticles may tend to accumulate or agglomerate in tissues if used for a chronic period, leading to instability issues. Some nanoparticles, like titanium dioxide or zinc oxide,, can be photo-reactive in UV light, leading to oxidative damage.[21]

#### **Recent Innovations in Nanocosmeceuticals**

There has been a rise in modern technology focusing on innovations in the cosmeceutical industry, which has played a vital role in the controlled release and targeted delivery in designing nanoparticles for Enhanced penetration, antioxidants and Sun protection. There are also emerging applications in the domain of skincare, haircare and anti-ageing. Even though nanotechnology provides numerous benefits, there are still safety concerns which should be addressed in the long run, ensuring the safety and toxicity of the formulations. Recently, the innovations that have grasped the idea of Nanocosmeceuticals include

#### Smart nano-carriers



Smart nano-carriers are a rising up technology of advanced drug delivery systems which can release loads in response to external stimuli. They help to reduce the systemic toxicity and enhance therapeutic efficacy. They also do provide targeted and controlled release of active ingredients. Among all widely studied types, the advanced ones are pH-responsive and thermo-sensitive nanocarriers. They both have demonstrated significant promise in changing the future of cosmeceutical and pharmaceutical applications.[22]

# • pH-Stimulated Nanoparticles

The pH- Stimulated Nanocarriers are a significant class of drug delivery which are formulated to release their payload in response to the changes in pH, depending on whether the pH is acidic or basic. Depending on that, the release cargo activates. They can be shaped from polymers, which can also change their physico-chemical properties of the drug. This type of release reduces the off-target effects and increases therapeutic activity.

**For example**, the external pH of skin without barriers is more acidic (pH~6.5) compared with healthy skin( pH~7.4). Comparatively, the inner compartments containing mitochondria and the Golgi apparatus have even lower pH values. (pH~5.0-6.0)

These types of formulations are constructed with polymeric materials which can swell, degrade or change in their solubility at specified pH values. Polymers such as chitosan, polyhistidine and polyacrylic acid are most commonly used in these systems. When these polymers are introduced in acidic environments, they undergo conformational changes which lead to the release of the encapsulated drug. Concerning Cosmeceuticals, pH- prone delivery can be highly prevalent as it can particularly release the drug on the inflamed acne-prone skin, which has a varied pH compared to that of normal skin, making it beneficial in ensuring the availability of active agents like salicylic acid, niacinamide and retinoids being released only in problem areas.[23]

#### Heat-Sensitive Nanoparticles

Heat-sensitive nanocarriers are a class of nanocarriers which act pharmacologically when there is a thermal change in the environment, which triggers the release of the load. Conveniently, the nanomaterials should retain the drug at a body temperature of  $37 \,^{\circ}C[24]$ 

And also at the variational margins of the temperature. These are engineered to release their content when exposed at temperature thresholds in the range of 40–45°C, which is mainly acclaimed in the treatment of cancer. Materials like poly(N-isopropylacrylamide), which show a lower critical solution temperature (LCST). When the polymer is hydrophobic, it collapses, resulting in drug release. When it comes to insight into dermatology, it can be used to develop skincare products which are active to body heat, like external steaming.

For example, cleansers, anti-ageing and moisturisers can be altered in their formulations by releasing their actives upon skin warming, which can result in leading to absorption and nourishment.[25]

#### Green nanotechnology

Green nanotechnology uses environmentally sustainable approaches to create nanoparticle formulations. The importance of green technology can be understood by understanding the essence of a few articles listed below

Green Nanotechnology: Recent Research on Bioresource-Based Nanoparticle Synthesis and Applications



It provides attention to the growing interest in replacing dangerous chemical synthesis methods with biological resources, such as plant extracts, microbes, and enzymes. This environmentally friendly method improves the biocompatibility of the generated nanoparticles while simultaneously lessening their negative effects on the environment. The synthesis processes and biomedical uses of metal and metal oxide nanoparticles, such as titanium dioxide (TiO<sub>2</sub>), zinc oxide (ZnO), silver (Ag), and gold (Au). These bio-nanoparticles show great promise in environmental remediation, cancer treatment, and antimicrobial therapy. It also promotes the use of synthesis techniques in sustainable green nanomedicine by highlighting their affordability and scalability. It also highlights difficulties, including control over particle size and shape, purification, and reproducibility.[27]

# Green nanotechnology—An innovative pathway towards biocompatible and medically relevant gold nanoparticles

A focus on how it can help alleviate the health and environmental issues related to traditional nanomaterial creation. It describes how green nanotechnology combines sustainable engineering and green chemistry concepts to create ecologically friendly and efficient nanomaterials. techniques plant Green use extracts. microorganisms, and biodegradable polymers to create nanoparticles in mild, environmentally friendly circumstances, in contrast to standard methods that frequently use toxic solvents and significant energy usage. The study of bio-inspired synthesis pathways for metal and metal oxide nanoparticles—specifically, silver, gold, and zinc oxide-which are extensively employed in and environmental industrial. medical. applications—is one of the main highlights. The review also looks at the environmental benefits of nanomaterials, including green their low

environmental impact, enhanced biodegradability, and decreased toxicity.[28]

# Green Nanotechnology: Advancement in Phytoformulation Research

The relationship between green nanotechnology and phytoformulations-plant-based medicinal formulations improved by nanotechnological innovation. It emphasize how using natural including plant resources extracts. polysaccharides, essential oils, and biopolymers, green nanotechnology provides a sustainable path to creating safer and more efficient nanocarriers. By acting as both stabilizing and reducing agents during the creation of nanoparticles, these biologically derived compounds replace the hazardous reagents frequently employed in traditional procedures. The green-synthesised nanoparticles can improve the pharmacokinetic characteristics of phytochemicals, which frequently have low bioavailability, fast metabolism, and restricted solubility, is one of their strongest points. The detail on different nanoformulations that enhance the controlled release and targeted delivery of herbal actives, such as liposomes, nanoemulsions, and nanocapsules. The usage of these green nanoparticles in fields ranging from dermatology and wound healing to antibacterial and anticancer treatments<sup>[29]</sup>

# CONCLUSION

The role of cosmeceuticals play an indispensable role in the human community, which helps people to conceal their insecurities by incorporating cosmeceuticals into the form of makeup and skincare. The conventional cosmetics have been used all over the world for centuries inform of remedies and natural pigments. Even in the 1900s, they splurged on the market, attracting women for the benefits they would produce if purchased. A



century has marked the end of conventional cosmetics. As more for the future, the market will splurge on more cosmeceuticals, which would provide a greater insight into much greater skin health, aiming for overall skin wellness. Considering all the innovations from the research expertise. Nanocosmeceuticals have paved their way in an intellectual proving to be a smart and effective approach to increase the efficacy of active ingredients  $10\times$ , which, with a good marketing strategy and great formulation, can become the face of the future cosmetic world.

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