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A review on nanotechnology in cosmetics

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Abstract
Nanotechnology is the technology, that deals with the particles of size less than 100nm. It is a combined field of Chemistry, Electronics, Biology, Materials science, chemistry and Engineering. It is the fastest growing area for the maintenance of skin health as well as for diagnosis and management of cutaneous diseases. Nanotechnology is applied for manufacturing of materials, electronic chips, for medical diagnosis and healthcare, biotechnology, space exploration, textiles, sports equipment, etc. However, use of nanotechnology in cosmetics is not new and has been introduced since 1961 with the advent of liposome technology used to market some moisturising creams. This widespread influence of nanotechnology in the cosmetic industries is due to enhanced properties that are attained by the particles at nano levels including color, transparency, solubility etc. Its progress will also give opportunity for cosmetic industry to develop new bio compatible and bio degradable products and will yield products of better quality.

Keywords: Nanotechnology, cosmetic industry, dendrimers, hydrogels, nanocosmeceuticals

1. Introduction
It is a combined field of Chemistry, Physics, Electronics, Biology, Materials science and Engineering. Nanotechnology is the fastest growing area for the maintenance of skin health as well as for management of cutaneous diseases. In actuality, the science of very small things is nanotechnology.
Nanoparticles, i.e, particle sized between 1nm to 100nm, can have significantly differ properties than the same materials at larger forms because they have relatively larger surface area to mass ratio, therefore more atoms may come into contact at the surface.
Nanotechnology is applied for manufacturing of materials, electronic chips, for medical diagnosis and healthcare, biotechnology, space exploration, textiles, sports equipment, etc.
Nanoparticles are widely used because of its desirable properties in industrial, medical and cosmetic fields. Cosmetic products in any substance or mixture intended to be placed in contact with the external parts of the human body.
For decades, scientists have pursued the production of nanoparticles to enhance the bioavailability and stability of drugs and cosmeceuticals. Owing to their vanishingly small particle sizes, so-called “nanomedicines” possess significantly higher dissolution rates than their macro analogues. This characteristic is especially desirable when the molecule in suffers from poor water solubility. In the recent years, drug and cosmetics manufacturers have worked to develop drug-delivery vehicles that are used to overcome many of the challenges related to stability, targeted delivery and bioavailability.

1.1 Advent of Nanotechnology (Nanoparticles)
The word nanotechnology comes from the greek word prefix nano (symbol n) in the SI system of units. The history of nanotechnology begin with Erin Schrodinger, a physicist who received the noble prize in the year 1933 for discovering new forms of atomic energy. The technology was subsequently hypothesized in 1959, when Richard Feynman, the brilliant noble laureate physicist, delivered his now famous lecture,"There is plenty of room at the bottom".
In modern scientific parlance, 1nm is one-billionth of meter. To provide a comparison, the diameter of a single atom is 1/4th of a nanometer and the diameter of a human hair is 10,000nm.
Nanoscience, broadly encompasses both Nanoscience and nanomedicine. The use of nanotechnology for both the prevention and treatment of diseases is known as nanomedicine.
Nanoparticles are the precursors of the next technological revolution of the 21st century as people will not suffer from any of the ailments they're suffering from today because the

nanoparticles will be guarding, fighting, and evading most of the infections of the body.

1.2 Front-Running Brands of Nanocosmetics

From various surveys, it has been found out that almosot all major cosmetic industries use nanotechnology in their various products. One example is the well known cosmetic manufacturers Estee Lauder, who have been reported to enter the nanomarket in the year 2006, with a wide range of products that contain nanoparticles. Another example is of L'Oreal, which is the world's largest cosmetics company which has patented the use of dozens of nanosome particles.

2. Applications of Nanotechnology in Cosmetics

Generally speaking, nanotechnology can be defined as the application of scientific and engineering principles to make and utilize very small things. Nanotechnology is moving into the centre of world-wide public attention because of its broad range of applications which could dramatically impact both the scientific community and the commercial marketplace.

a. Sunscreens

Sunscreens contain insoluble micro-particles like ZnO "TiO2.These physical sunscreens block both UVA and UVB radiations.

Advantages: Texture changes making them appear invisible and hence cosmetically more acceptable.

Nanoparticles such as liposomes or SLNs are added as penetration enhancers that improve stability and tolerance.

Disadvantages: It requires a greasy vehicle for dissolution, leave chalky white residues on skin, and thick "dense texture.
Nanoparticles of TiO2 and ZnO reflect, adsorb or disperse UV-radiation.

b. Moisturizers

These are the used in the management of various skin disorders viz., atopic dermatitis, psoriasis, dryness etc.
Main drawback of these conventional emollients is there inability to sufficiently deliver components such as ceramides to the active site.
They are used externally on the skin. Since their therapeutic effects are prolonged, nano-emulsions, SLNs and liposomes are widely employed for making moisturizers.
Nano-emulsions contain a lipophillic interior which makes them a good delivery system for transporting hydrophobic substances in aqueous environments. This technique is being employed in gamma amino butyl acid (GABA), which is an inhibitory neurotransmitter with muscle relaxing properties, as anti-aging formulation for wrinkle reduction.

c. Phototherapy

Phototherapy is a type of medical treatment that involves exposure to fluorescent light bulbs or other sources of light like halogen lights, sunlight, and light emitting diodes (LEDs) to treat certain medical conditions.
Targeting melanosomes with short pulses of lasers has been used in dermatology for treating hyperpigmentation disorders of skin like melasma. Immune conjugates of gold nanoparticles and iron oxide microparticles are being studied as light absorbers for specific cell targeting.
When a laser pulse is generated, these particles absorb light and liberate this absorbed energy in the form of radiation which causes a high temperature in the tissue leading to microscopic tissue rupture and cell damage.
Another field of application is photothermal therapy (PTT). It involves use of agitated gold nanoparticles to inhibit tumor cell growth.
The use of nanoparticles is also emerging in photodynamic therapy whose mechanism is based on the principle of optical activation of a photosensitiser leading to the generation of local tissue oxygen free gradicle which cause local tissue damage like tumor cells.

d. Antiseptics

Antiseptics are antimicrobial substances that are applied to living tissue/skin to reduce the possibility of infection or sepsis.
Nanoparticles have been introduced in the field of antiseptics. Various substances have been employed as antiseptics in nano- formulations like Chlorhexidine gluconate, naked TiO2, silver, etc.
Nano-formulation of Chlorhexidine gluconate exhibits immediate as well as sustained antibacterial effects due to fast absorption from the capsular wall.

e. LIP Cosmetics

Lipstick is a cosmetic product containing pigments, oils, waxes, and emollients that apply color, texture, and protection to the lips.
Nanoparticle based lipstick and lip gloss keep the lips soft and supple by preventing trans-epidermal loss of water.
E.g. Silica nanoparticles gives a homogenous distribution of pigment in the formulation migration of pigment into the fine lines of lips is prevented, giving a better cosmetic outlook.

f. Hair Formulations

Nanoparticle formulations are better than aqueous and alcohol based formulations in the treatment of hair disorders like alopecia areata and androgenic alopecia.
Encapsulated hair growth medicaments have 2.0 to 2.5 time’s longer permanence in hair follicular regions in comparison to aqueous solutions.
E.g. Minoxidil Encapsulated in 40-130 nm polyethylene glycol nanoparticles have shown improved permanence in the hair follicle region.

g. Toothpastes

By using nanotechnology in toothpastes it is ver helpful for preventing damage to the tooth enamel. Hydroxyapatite is a key component of tooth enamel as nano crystals. It is also the main component of bone and teeth. The nano form of hydroxyapatite is used in toothpaste that forms a protective film around tooth enamel and even restores the surface in damaged areas and it also reduces the pain. This is the worlds first reminerilizing toothpaste.

h. Nail Formulations

Nano-based cosmeceuticals are being developed for nail care. Nail paints based on nanoparticles improve the toughness and resistance of the nails. They have many advantages like drying to a very hard state, resisting chipping, cracking and scratching. It can also be used for therapeutic purpose to treat onychomycosis.

3. Nanoparticles Used In Cosmetics

Nanoparticles are mainly used for UV filters and Therapeutic agents delivery.

The function of the delivery system is to supply appropriate concentration of the active ingredients to appropriate site in the body for the correct period of time.

Thus, different novel delivery systems have been widely used in cosmetic products.

3.1. Inorganic Nanomaterials

Nanoscale TiO2 and ZnO provide longer protection from UV-A and UV-B radiation compared with other sunscreen agents. They minimize the undesirable white color and sticky feel of the materials with the decrease of their particle size.

Nano-gold has been used in 'energizing' moisturizer creams and in facial masks.

Nano-Silver is used because of its anti-bacterial properties.

3.2. Other Nanoscale Materials Used In Cosmetics

3.2.1. Vesicular Delivery Systems

When vesicles are applied on skin, they act as carrier to deliver entrapped molecules to the right site for sustained release of active compounds.

They enhance the skin tolerance of ingredients, such as unsaturated fatty acids, vitamins or anti-oxidants.

Following are some examples of these types of delivery systems:

Types of Vesicular Delivery Systems

Liposomes

Contains an internal aqueous volume that is surrounded by concentric layers of phospholipids which are generally regarded as safe.

Used extensively in the cosmetic industry due to their ease of preparation and the ability to improve the absorption of active ingredients by skin.

Used in: sunscreens, anti-aging creams, moisturizing cream, and hair loss treatment.

Hydrogels

Hydrophilic gels that are usually referred to as hydrogels are networks of polymer chains that are sometimes found as colloidal gels in which water is the dispersion medium.

Hydrogels are Hydrophilic polymers with 3D network structures which can absorb and retain significant amount of water.

Used in: sunscreen, shampoo, soap, and shaving

Nano Emulsions

The nano emulsions are Oil-in-water type emulsions. They are transparent, possess higher stability, and have better ability to carry active ingredients due to the smaller size of the emulsions.

Used in: nail polish, conditioners and lotions.

Dendrimers

Dendrimers are highly branched, star-shaped macromolecules with nanometer-scale dimensions. Dendrimers are defined by three components: a central core, an interior dendritic structure (the branches), and an exterior surface with functional surface groups. The varied combination of these components yields products of different shapes and sizes with shielded interior cores that are ideal candidates for applications in both biological and materials sciences.

Phytosomes

They are used in sun care products to protect the sun exposed skin by releasing a photo reactivating enzyme obtained from a marine plant, Anacystis Nidulans.

Transfersomes

They are more elastic than liposomes and have a greater efficiency. They are used in anti-wrinkle cream.

Ultrasome

It is also used in anti-wrinkle cream. It helps to prevent the damage of collagen and elastin production.

Ethosomes

These are soft, malleable vesicles used for enhanced delivery of active agents.

Nanosome and Fullersomes

Both of these are used in skin cream for different purposes; former is used to upgrade skin to a healthy and younger looking feature, while the latter is used to refresh dark circles under the eyes.

4. Methods of Preparation

There are many methods for the preparation of nanoparticles, they are:

- Solvent Emulsification Evaporation
- Salting Out
- Emulsification Diffusion
- Spontaneous Emulsification, Solvent Diffusion
- Solvent Displacement
- High Pressure Homogenization
- Micro Emulsion Technique
- Ultrasonication or High Speed Homogenization
- Double Emulsion Method

a. Solvent Emulsification Evaporation

In this technique, the performed polymer and the drug are dissolved in a water immiscible organic solvent, which is emulsified in an aqueous solution containing a stabilizer.

This crude emulsion is then exposed to a high energy source such as an ultrasonic sonicator or passed through homogenizers, colloid mills or microfluidisers to reduce the globule size.

The subsequent removal of the organic solvent by heat and vacuum results in the formation of a fine aqueous dispersion of nanoparticles

b. Salting Out

This method is based on the separation of a water miscible solvent from aqueous solutions through a salting out effect.

Acetone is generally chosen as the water miscible solvent because of its solubilising properties and its well known separation from aqueous solution.

The performed polymer and the drug are dissolved in acetone and this solution is emulsified under vigorous magnetic stirring in an aqueous gel containing the salting out agent and a colloidal stabilizers.

The resulting emulsion is then diluted with a sufficient volume of water to enhance the diffusion of acetone into the aqueous phase, thus inducing the formation of nanoparticles.

c. Double Emulsion Technique

In double emulsion technique hydrophilic drugs was

dissolved in aqueous solution, and then was emulsified in melted lipid.
In this method the drug is encapsulated with a stabiliser to prevent drug partitioning to external water phase during solvent evaporation in the external water phase of w/o/w double emulsion.
Stabilized primary emulsion was dispersed in aqueous phase which contains hydrophilic emulsifier after that the double emulsion was stirred and was isolated by filtration.

d. Solvent Displacement
In this process, the polymer, the drug and optionally a lipophillic stabilizer are dissolved in a semi polar water miscible solvent such as acetone or ethanol. This solution is poured or injected into an aqueous solution containing a stabilizer under magnetic stirring. Nanoparticles are formed instantaneously by rapid solvent diffusion, which is then eliminated from the suspension by heating under reduced pressure.

Advantages
This technique is very simple and does not involve the use of a homogenizer and can hence be scaled up easily in an industrial set up

5. Storage Stability of Nanoparticles
The physical properties of solid lipid nanoparticles during prolonged storage can be determined by change in particle size, zeta potential, viscosity and appearance.
4℃ - Most favorable storage temperature
20℃ - Long term storage not results in SLN aggregation or loss of drug
50℃ - A rapid growth of particle size was observed

6. Risks of Nanotechnology in Cosmetics
- Nanoparticles have been found to cause a large number of risks both to humans as well as to the environment.
- The toxicity of nanomaterials is affected by their properties which are attributed to their.
- Smaller size
- Chemical composition
- Surface structure
- Solubility
- Shape

7. Route and Extent of Exposure
Nanomaterials enter the body mainly through three routes:

a) Inhalation
From products containing nanomaterials, such as spray versions of sunscreens containing nanoscale TiO2.

b) Ingestion
Due to unintentional/intentional hand-to-mouth transfer of nanomaterials from products containing them. E.g. lipsticks.

c) Through Skin
Studies by the US Government Accountability Office have raised concerns that nanomaterials in sunscreens could penetrate damaged skin.

8. Conclusion
- Nanotechnology is one of the key technologies of the 21st century.
- Cosmetic companies use nanoscale versions of 32 ingredients to provide better performance of their cosmetics and personal care products.
- But along with their enormous technological and economic potential, a debate about risks related to the use of nanoparticles has started.
- To conclude, the use of nanoparticles in cosmetics is a relatively new concept with vast potential, but more research is needed to understand all the benefits and harms involved.

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