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A Review on Role of Nanotechnology in Cosmeceuticals

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Abstract: Nanotechnology is a new technology that has the potential to revolutionize a variety of scientific sectors. Nanoparticles are single particles with a diameter of 1–100 nm that are part of nanomaterials. Nanotechnology is an engineering of functional system at the molecular level, covers a broad range of topics and is focused on controlling and exploiting the structure of matter on a large scale below 100 nanometers. Nanotechnology is the future of advanced development. Cosmeceuticals are regarded as the fastest growing segment of the personal care industry and the use has risen drastically over the years. Nanocosmeceuticals used for skin, hair, nail, and lip care, for conditions like wrinkles, photoaging, hyperpigmentation, dandruff, and hair damage, have come into widespread use. Novel nanocarriers like liposomes, niosomes, nanoemulsions, microemulsion, solid lipid nanoparticles, nanostructured lipid carrier, and nanospheres have replaced the usage of conventional delivery system.These novel nanocarriers have advantages of enhanced skin penetration, controlled and sustained drug release, higher stability, site specific targeting, and high entrapment efficiency. Nanoparticles have recently become a popular material for developing new cutting-edge applications in communications, energy storage, sensing, data storage, optics, transmission, environmental protection, cosmetics, biology, and medicine due to their important optical, electrical, and magnetic properties. Zinc oxide nanoparticles (ZNPs) are one of the most versatile nanomaterials due to their excellent chemical and thermal robustness.

Key words - Liposomes, Nanotechnology, Nanoparticles, Niosomes, Dendrimer, Nanocrystals.

I. INTRODUCTION

Cosmetics can be defined as the products which amplify the appearance of the skin, intensify the cleansing and promote the beauty of the skin.(1)Nanotechnology is that branch of technology which deals with the creating structures that are less than 100nm long.(2) The term nanotechnology is the combination of two words: namely, technology and the Greek numerical “nano” which means dwarf. Since 1959, nanotechnology has emerged in different fields like engineering, physics, chemistry, biology, and science and it has been virtually 40 years since nanotechnology has intruded into the field of cosmetics, health products, and dermal preparations. During the era of 4000BC, the use of nanotechnology has been recorded by the Egyptians, Greek,and Romans, with concept of hair dye preparation utilizing nanotechnology.(1) Scope of cosmetics in general in the world is the products that are mainly use for cleansing, beautifying, perfuming, or changing the appearance of human body without causing any damage to human health. (2)(3) The nanomaterial containing cosmetics highly increased in the market all over the world. Although there is still an on-going debate for definition of nanomaterials, the particle size is still accepted as the main criteria with a range between 1 and 100 nm to identify them.(3) Nanotechnology helps in reversing the aging at various cellular level. Nanotechnology is being used within in the formulation of cosmetics to shield the skin from the harmful sunlight. The different varieties of nanomaterials/nanocarriers which are used in cosmetics include Liposome, Niosome, Solid Lipid Nanoparticle(SLN), Nanosphere, Nanoemulsion, Gold nanoparticles, dendrimer etc.(2) Cosmeceuticals are rhe cosmetic products which incorporate biologically active ingredient having therapeutic benefits on the surface applied. These are utilized as a cosmetics as they claim to enhance appearance.(1)

Need of Nanomaterials in Cosmetic ;The increased usage of nanomaterials in cosmetic Products is indicative of the huge potential Nanotechnology represents for the cosmetics industry and Its consumers because of their advantages. A number of Nanomaterial types are already in use, including Nanoemulsions, and nanoparticles of minerals present in our natural environment, such as titanium dioxide (TiO2), zinc oxide (ZnO), alumina, silver, silicon Dioxide, calcium fluoride and copper. The rationale for The use of nanomaterials in cosmetic products is, of Course, that they offer added value in terms of product Performance. The unique properties and behaviour of Nanomaterials mean that nanotechnologies could Profoundly transform industry and everyday life. In Formulation of cosmetics, Titanium dioxide (TiO2) and Zinc Oxide (ZnO) nanopigments are the main Compounds used as highly efficient UV-filters, able to Reflect and scatter the visible part of solar radiation while Absorbing UV light. Given these properties, they are Extensively used in sunscreens. The nanomaterials found Its next use as encapsulated carrier for topical delivery of Photolabile and skin sensitizing compounds.(4)

Types of Nanomaterial used in Cosmetics

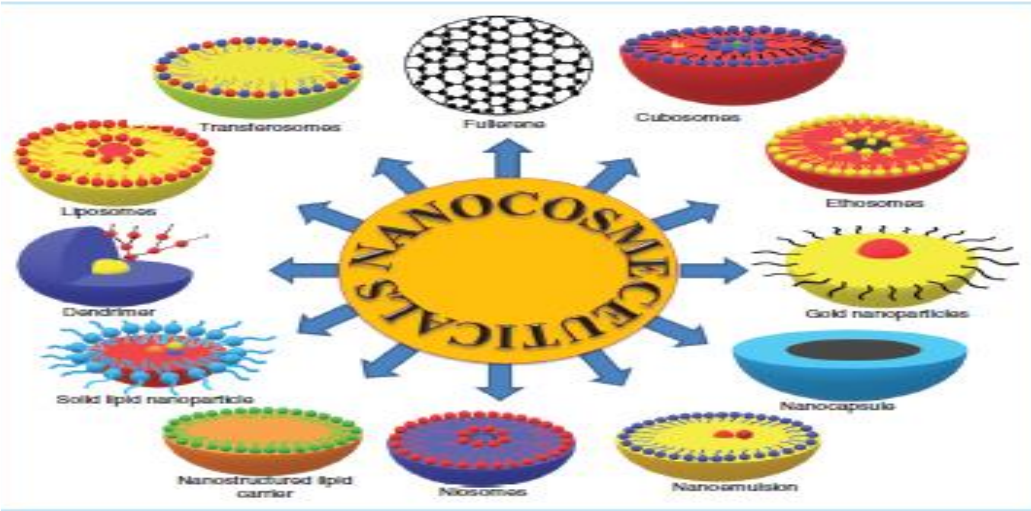

Figure 1: Types of Nanomaterial used in cosmetics

Liposomes

Liposomes are vesicular structures with an aqueous core surrounded by a hydrophobic lipid bilayer, created by the extrusion of phospholipids. They are most widely known cosmetic delivery systems. Liposomes can vary in size, from 15 nm up to several μm and can have either a single layer (unilamellar) or multilayer (multilamellar) structure. The first liposomal cosmetic product to appear on the market was the anti-ageing cream 'Capture' launched by Dior in 1986. Phosphatidylcholine, one of the main ingredients of liposomes, has been widely used inskin care products and shampoos due to its softening and conditioning properties.(5)

Nanoemulsions

Nanoemulsions can be defined as "ultrafine emulsions" because of the formation of droplets in the submicron range. The average droplet size of nanoemulsions has been ranging from 50 to 1000 nm. They are dispersions of Nanoscale droplets of one liquid within another. They are metastable systems whose structure can be manipulated based on the method of preparation. The components used for their preparation are GRAS products and are safe to use. Their smaller particle size provides higher stability and better suitability to carry active ingredients; they also increase the shelf life of the product.(6) They are mostly used in deodorants, sunscreens, shampoos, and skin and hair care products. Nanoemulsions are considered as the kinetically or thermodynamically stable dispersion of liquid. The nanoemulsions are easily valued in skin care because of their good sensorial properties i.e. rapid penetration, merging textures and their biophysical properties especially, hydrating power. A significant improvement in dry hair aspect (after several shampoos) is obtained with a prolonged effect after a cationic nanoemulsion use. Nanoemulsions are widely used as medium for the controlled delivery of various cosmeceuticals like deodorants, sunscreens, shampoos, lotions, nail enamels, conditioners, and hair serums.(7)(8)

Nanocapsules

Nanocapsules are submicroscopic particles that are made of a polymeric capsule surrounding an aqueous or oily core. It has been found that the use of nanocapsules decreases the penetration of UV filter octyl methoxycinnamate in pig skin when compared with conventional emulsions. (9)

Solid lipid nanoparticles

They are oily droplets of lipids which are solid at body temperature and stabilized by surfactants. They can protect the encapsulated ingredients from degradation, used for the controlled delivery of cosmetic agents over a prolonged period of time and have been found to improve the penetration of active compounds into the stratum corneum. In vivo studies have shown that an SLN containing formulation is more efficient in skin hydration than a placebo. They have also been found to show UV-resistant properties, which were enhanced when a molecular sunscreen was incorporated and tested. Enhanced UV blocking by 3, 4, 5-trimethoxybenzoylchitin (a good UV absorber) was seen when incorporated into SLNs.(9)(10)

Nanocrystals

Nanocrystals are crystals having size less than 1μm. They are aggregates comprising several hundred to tens of thousands of atoms that combine into a "cluster". Typical sizes of these aggregates are between 10-400 nm.(11) Nanocrystal technology offers consumers cutting-edge and effective products and exhibits enormous development potential in the beauty business as a new delivery method to address the issue of low solubility and low permeability of sensitive chemicals. In this review, we described the processes for making NCs, along with the impacts of loading and the uses of different carriers. Among them, nanocrystalline loaded gel and emulsion are widely used and may further improve the stability of the system.(12)

Nanosilver and Nanogold

Cosmetic manufacturers are harnessing the enhanced antibacterial properties of nanosilver in a range of applications. Some manufacturers are already producing underarm deodorants with claims that the silver in the product will provide up to 24-hour antibacterial protection. Nano-sized gold, like nanosilver, is claimed to be highly effective in disinfecting the bacteria in the mouth and has also been added to toothpaste.(13)(14)

Dendrimer

Dendrimers are unimolecular, monodisperse, micellar nanostructures, around 20 nm in size, with a well-defined, regularly branched symmetrical structure and a high density of functional end groups at their periphery. A dendrimer is typically symmetric around the core, and often adopts a spherical three-dimensional morphology. One of the very first dendrimers, the new kome dendrimer, was synthesized in 1985.(15) Dendrimers have also been considered for use in the cosmetic industry. Several patents have been filed for the application of dendrimers in hair care, skin care and nail care products. Dendrimers have been reported to provide controlled release from the inner core. However, drugs are incorporated both in the interior as well as attached on the surface. Due to their versatility, both hydrophilic and hydrophobic drugs can be incorporated into dendrimers.(16)

Cubosomes

Cubosomes are discrete, sub-micron, nanostructured particles of bi-continuous cubic liquid crystalline phase. It is formed by the self assembly of liquid crystalline particles of certain surfactants when mixed with water and a microstructure at a certain ratio. Cubosomes offer a large surface area, low viscosity and can exist at almost any dilution level. They have high heat stability and are capable of carrying hydrophilic and hydrophobic molecules. Combined with the low cost of the raw materials and the potential for controlled release through functionalization, they are an attractive choice for cosmetic applications as well as for drug delivery.(17)

Niosomes

Niosomes are vesicles composed of nonionic surfactants. The niosomes have been mainly studied because of their advantages compared with the liposomes: higher chemically stability of surfactant than phospholipid, require no special conditions for preparation and storage, they have no purity problems and the manufacturing costs are low.(18) The advantages of using niosomes in cosmetic and skin care applications include their ability to increase the stability of entrapped drugs, improved bioavailability of poorly absorbed ingredients and enhanced skin penetration.(19)

Pharmaceutical Nanomaterials

In case of particle size approaches in the range between 1-100 nm; there May be an important change in the crystal structure due to an exponentially Growing number of atoms being localized at the surface and it is suggested To complement the current size range with a limiting volume specific surface Area value of not less than 60 m2 /cm3.(20) Understanding of nanomaterial interaction with the environment in combination with the route of exposure will provide useful information on nanoparticle biological fate and toxicity. For instance, the penetration of nanoparticles through the skin, their biodistribution, rate of excretion
and toxicity are determined by the nanoparticle's characteristics (e.g., shape, size, surface charge, surface composition, coating, type of materials, and other components in the nanoparticle's formulations).(21) In general particles size of 50–500 nm is widely used in cosmetics and The concentration of nanoparticles in formulations is less than 3%. In Addition to concentration, their dispersion in the product makes nanoparticles More active and when agglomerated their properties result from their size Such as color and transparency have changed. Therefore it is important to Control their agglomeration behavior and dispersed nanoparticles are needed In order to retain their specific properties for the technological applications.(22)(23) Such a technological application, widely used multiphasic nanoemulsions (micellar nanoparticle formulations in particular) prepared by mixing and Milling process (high-shear or high-pressure mixing) resulted as active Pharmaceutical ingredient (API) which can be an active cosmetics. application to the Skin The World Health Organization (WHO), non-governmental organizations, political institutions And agencies have raised concerns about the safety of NMs and their use in consumer goods.(24) Nanoparticles also have the benefit of being more adequate for intravenous administration than conventional microparticles. The smallest body capillaries have a diameter of 5–6 m. To make sure that particles do not cause embolism, the size of particles dispersed in the circulation should be substantially less than 5 m.(25) All companies that manufacture, use, or import nanoforms should have a REACH Registration compliant (REACH is a regulation of the European Union, and stands for Registration, Evaluation, Authorization, and Restriction of Chemicals). The purpose of this is for companies to offer End users adequate information regarding the safety of the products. This applies to all registrations of all nanoforms within the scope of REACH. NMs that fall within the scope of REACH but are not Registered are considered illegal. Based on the recent catalogue of NMs, the EC asked the Scientific Committee on Consumer Safety (SCCS) for a priority list of nanomaterials used in cosmetics for the Purpose of risk assessment.
The types of nanomaterials that are currently used in Cosmetics are also discussed, followed by the recent status and advances regarding production and Characterization of nanomaterials.(26)
Further more Nanoparticles provide improved stability of chemically unstable active Ingredients, controlled release of active ingredients, pigment effect and Improved skin hydration and protection through film formation on the skin. Due to their good physical stability and compatibility nanoparticles can be Added with other ingredients to cosmetic formulations without any problem. Accordingly by using nanotechnology amount of molecular sunscreen could Be decreased by 50% while maintaining the protection level as compared To a conventional emulsion.(27) Such an example, larger particles of Titanium dioxide and zinc oxide are white and opaque but at the nanoscale, These substances become transparent thus enables their use in moisturizers And foundations having sunscreen effect.(28) Some of the most common soft and rigid nanoparticles proposed in dermal applications and cosmetics are described below.

Soft particles

Oils and amphipaths in polar solvents (including water) spontaneously form a plethora of structures: micelles, cubic phases, microemulsions, hexagonal phases, vesicles, etc. as soft particles. Liposomes are typical soft deformable particles. They are vesicular structures composed of a phospholipid bilayer and a hydrophilic core.(29)

Rigid particles

Typical rigid particles are colloidal structures of various shapes and made Of various materials such as metals (e.g gold, silver), metal oxide (e.g., Iron oxide) or ceramics (e.g., silica). The encapsulation of active substance In the nanoparticle core or their adsorption on nanoparticle surface allows The transfer and delivery of them avoiding metabolism degradation in Tissue. (22)(30)

Major Classes in Nanocosmeceuticals

Cosmeceuticals are contemplated as the fastest growing segment of personal care industry. A plethora of nanocosmeceuticals are assimilated in nail, hair, lip, and skin care. Major classes in nanocosmeceuticals are depicted in below figure.,

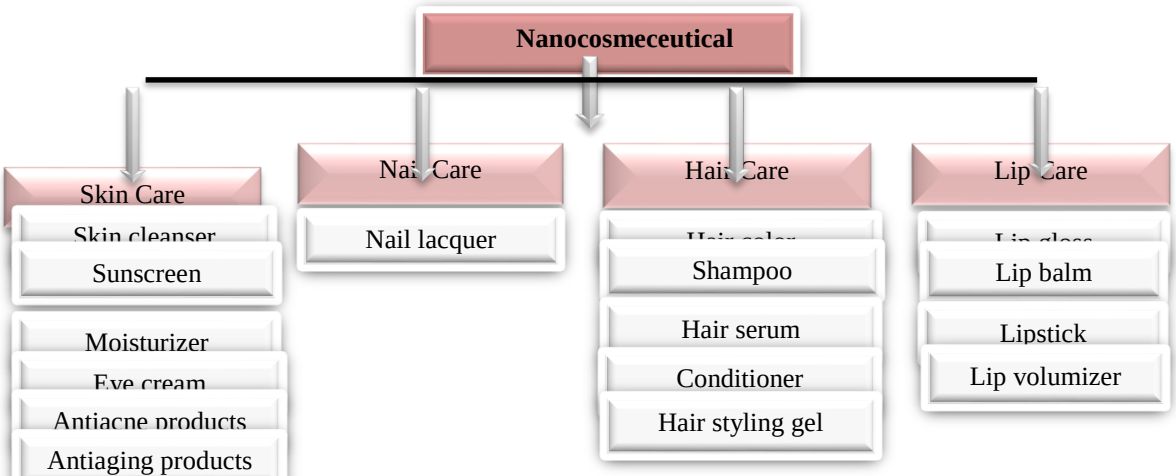

Figure 2: Major classes in Nanocosmeceuticals

Hair Care

Hair nanocosmeceutical products include shampoos, conditioning agents, hair growth stimulants, coloring, and styling products. Hair follicle, shaft targeting, and increased quantity of active ingredient are achieved by intrinsic properties and unique size of nanoparticles.(31)

Skin Care

Cosmeceuticals for skin care products ameliorate the skin texture and functioning by stimulating the growth of collagen by combating harmful effect of free radicals. They make the skin healthier by maintaining the structure of keratin in good condition. In sunscreen products zinc oxide and titanium dioxide nanoparticles are most effective minerals which protect the skin by penetrating into the deep layers of skin and make the product less greasy, less smelly, and transparent.(32)

Lip Care

Lip care products in nanocosmeceuticals comprise lipstick, lip balm, lip gloss, and lip volumizer. Variety of nanoparticles can be coalesced into lip gloss and lipstick to soften the lips by impeding trans-epidermal water loss and also prevent the pigments to migrate from the lips and maintain color for longer period of time.(33)

Nail Care

Nanocosmeceuticals based nail care products have greater superiority over the conventional products. The nail paints based on nanotechnology have merits such as improved toughness, fast dryness, durability, chip resistance, and ease of application due to elasticity.(34)

Toxicity of Nanoparticles Used in Cosmeceuticals

Number of workforce and customers exposed to nanoparticles are escalating because of increasing production and application of the wide diversity of cosmeceuticals products that contain nanomaterials. Despite their huge potential benefit, little is known about the short-term and long-term health effects in the environment and organisms.(35)

Routes of exposure of nanoparticles

Inhalation

According to the National Institute of Occupational Health and Safety, the most common route for exposure of airborne nanoparticles is inhalation.(36)

Ingestion

Nanomaterials may be ingested in the body from unintentional to intentional transfer from hand to mouth. Nanoparticles can be ingested from cosmeceuticals that are applied on lips or mouth like lipsticks, lip balms, lip gloss, and so on.(37)

Dermal Routes

Intracellular, transcellular, and transfollicular are the three pathways by which infiltration across the skin occurs. The dermal exposure of lesser size particles <10 nm can penetrate more easily and are disastrous than greater ones >30 nm.(38)

Global Scenario of Nanocosmeceuticals

Drugs are subjected to the stringent scrutiny requirements imposed by FDA for their approval but there are no such requirements for cosmetics. Cosmeceuticals are the products which are on the borderline between cosmetics and pharmaceuticals. (3

NANOMATERIALS USE IN COSMETICS

By the reason of sun exposure and UV radiation have been correlated with The increased incidence of epithelial skin cancer and melanoma, sunscreens Have become important skin cancer prevention tools and their protective Effect against UV radiation-induced oxidative stress make them important Components of cosmetic anti-aging products. In this respect available Photoprotecting methods can be use of antioxidants, stimulators of repair Mechanisms and physical photon blockers.(22)(40)

Barrier function of the stratum corneum reported that could be insufficient In protecting the skin and frequent exposure to water is an important risk Factor for the development of irritant hand eczema. Therefore emulsions Have been used so far to satisfy protection and the better homogeneity of Substances' distribution achieved with the use of particulate formulations. Enabling the coverage of the skin with a thin protective film nanoparticles Have been used in new generation cosmetics.(22) In summary active ingredients like vitamins, sunscreens, fragrances, and Essential oils have been widely used as nanoparticles. They provide improved

Stability of chemically unstable active ingredients, controlled release of Active ingredients, achieved pigment effect, and improved skin hydration and protection through film formation on the skin. The preparations have Low viscosity, are nongreasy, and have high bioavailability. As compared With liposomes, the payload of lipophilic substances by nanoparticles is Much higher.(41)(42)

Opportunities in cosmetic industries:-

1. Liposomes and nanoemulsions do not disturb the integrity of the skin lipid bilayerbilayers and are not washed out while cleansing the skin. So these formulations are believed to have a great future in the cosmetic science.
2. Encapsulation techniques and trigger releasemechanisms have been developed for the active delivery of cosmetic molecules. However there is need for reliable, cost effective triggers for controlled release.
3. Better understanding of how lipid nanoparticles modify drug penetration into the skin, how they affect the drug penetration and how they interact with lipids of the stratum corneum is required.
4. Further in vivo studies on the effect of cosmetics that contain nanomaterials.(4)

Present Status & Future Prospects

Nanotechnology is the fastest developing area of research involved in resolving science based solutions for innovative therapeutics and cosmetics. In future, it is going to become a big prospect for cosmetics and consumer care product manufacturers. As this area of technology is still relatively new, researchers have to look into solubility and bio-persistence of the nanomaterials very carefully.(4) The most commonly used nanopigments in cosmetics are titanium dioxide, zinc oxide and aluminium oxide. Nano-aluminium oxide is used in concealers and mineral foundations because it diffuses light, giving a 'soft focus' effect that disguises wrinkles.(43) Nowadays, Gold nanoparticles are included in facial masks, being used in beauty clinics and saloons. It is believed to work by improving the blood circulation, skin elasticity, and reducing the formation of wrinkles & they do not produce toxicity in human skin. (44) Incorporation of nanotechnology with phytocompounds is an innovative approach to overcome these challenges and is expected to achieve a huge demand because the cosmetic industry constantly pursues ground-breaking technological products. According to the reviews, the capability of each nanocarrier to enhance the skin permeability rate of phytocompounds resulted in enhanced pharmacological activities, specifically for cosmeceutical applications.(45)

CONCLUSION

Having importance in consumer aspects and economy, nanotechnology seems to be greater in cosmetics field. Due to their widely use in cosmetics the concerns about their risks for health and environment have gain much more importance. Consequently researches about their improvement, identification and safety will show an increase in the following years. These novel delivery systems have remarkable potential in achieving various aspects like controlled and targeted drug delivery, site specificity, better stability, biocompatibility, prolonged action, and higher drug-loading capacity.

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