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NANOTECHNOLOGY IN COSMECEUTICAL BEAUTY CARE PRODUCTS

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Abstract:

Use of carrier system in nanotechnology has added advantage of improved skin penetration, depot effect with sustained release drug action. Nanotechnology has led to advances in the cosmetic industry and is expected to grow further soon. Nanotechnology-driven products cater to the expectations of both consumers and manufactures in terms of better quality and effectiveness along with improved stability and easy scale-up. Employing nanotechnology in cosmetic products enhances their stability, efficacy, quality, and overall performance. This review paper investigates some nanotechnologies; nanoparticles; nano carriers used in the cosmetic industry and provides an overview of recent advancements in this area, with an attention being paid to marketed products.

Keywords: *Nanotechnology, nano formulations, nanocarriers, cosmetics, liposomes, niosomes, buckyballs, dendrimers, safety and health assessment, advancements.*

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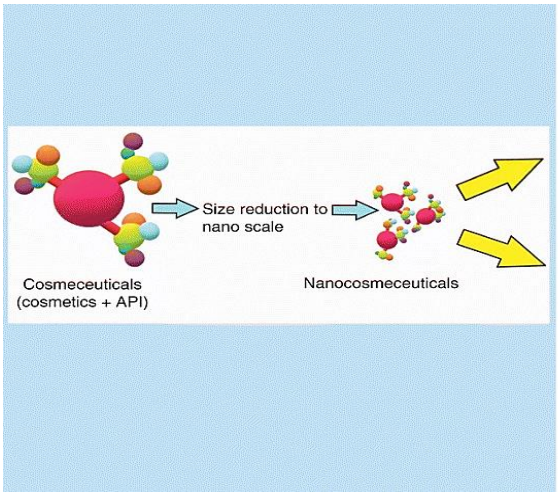
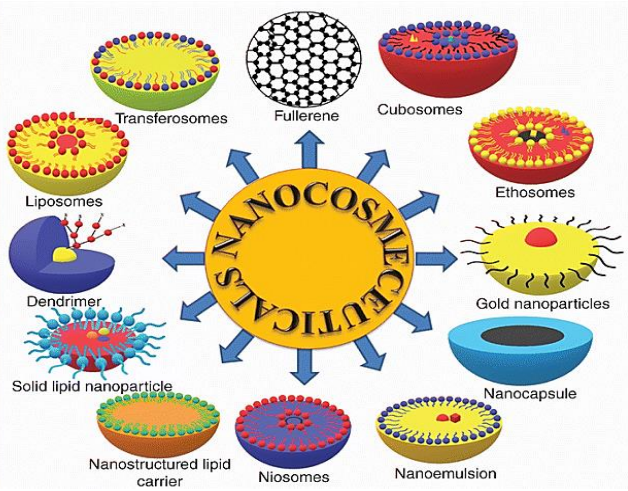
INTRODUCTION:

Nanotechnology and nano delivery systems are innovative areas of science that comprise the design, characterization, manufacturing, and application of materials, devices, the revolutionizing technologies, is extensively studied in the area of cosmetics and cosmeceuticals[1]. 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[2]. 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[3]. The loading of active pharmaceutical ingredients (APIs) within nano-sized drug delivery systems is being currently exploited to promote product innovation by developing nanoproducts. Nanoproducts used for the delivery of APIs to the skin (e.g., nano pharmaceuticals, Nano cosmeceuticals) have already proven their efficacy as several products are already available on the market for the treatment of skin injuries (e.g., atopic dermatitis. This widespread use of nanoscale materials in cosmetics is since these nanoparticles obtain newer properties which differ from the large-scale particles. These altered properties include colour, transparency, solubility and chemical reactivity, making the nanomaterials attractive to the cosmetics and personal care industries[5]. As nanotechnology continually gains attention in the field of personnel and health care, cosmetic industries are perceived to be the most advanced in incorporating nanoparticles into their products. According to market analysis done by Woodrow Wilson Project on Emerging Nanotechnology, by October 2013 more than sixteen hundred products have been created. Health and personnel care being the main category capturing almost 50% of the share. Of these 788 items, products are classified as nanotechnology products for cosmetic use and an additional 40 products under sunscreen category. The number of cosmetic nanotechnology product increased by nearly 516% between the years 2006 – 2013[8]. Although they have several benefits, at the same time, they possess limitations related to stability, scalability, toxicity, cost, etc. Moreover, the safety and toxicity profiles of nanomaterials are still debatable. The small size, increased surface area, and positive surface charge of nanoparticles improve their ability to interact with the microenvironment biologically. On the other hand, they have dose-dependent toxicity through different routes of administration. It is well known that the bioavailability of an active ingredient is better influenced by the dosage rather than the physicochemical properties of the active moiety[4] volumizers. The use of nanoparticles in lip-care products is aimed to increase the lip softness, to prevent the trans epidermal water loss, and to keep the desired styling effect (e.g., a colour) for a longer timeframe[1]. Cosmeceuticals are the cosmetic products which incorporate biologically active ingredient having therapeutic benefits on the surface applied. These are utilized as cosmetics as they claim to enhance appearance[5]. Nano emulsions which are the most advanced nanoparticulate systems for cosmetics termed as submicron emulsions (SME) are systems with uniform and extremely small droplet size (20-500 nm). They are used in cosmetics with more advancement. Nowadays, different techniques like modification in Nanocarriers, advancement in nanomedicine, use of antioxidants and some other revolutionized techniques are mainly used in cosmetics industry with less environmental hazards[6].





History_

It would be a tall order to attempt placing a timeline on the origin of cosmetics and its use because the quest to look good and remain as such (which is the driving force for cosmetic use) has been as old as man itself. Although in earlier times, cosmetics, medicine, and religious practice were closely associated and inseparable, Henri de Mondeville and Hippocrates helped to draw the thin line between these three arts[2]. Tomb paintings, frescoes, and mosaics all indicate that the use of cosmetics was widespread among people in ancient Mesopotamia and Egypt. In fact, the heavily made up, almond-shaped eyes seen on images of Egyptian women and the discovery of Pharaoh Tutankhamen's tomb not only revealed cosmetic use in the ancient world but also sparked the worldwide acceptance of eyeliner products. As at the fifth century B.C.E, Athenian women used lead to whiten their faces, while reddening their lips employing rouge made from either seaweed or plants' roots. Eyebrows were emphasized with soot, eyelids darkened with kohl (such as powdered antimony sulphide), and mascara was made from the dung of cows or from a mixture of egg white and gum. Archaeological findings in ancient Greek palaces, cemeteries, and settlements have revealed several items related to women beautification. Some of these items include mirrors, combs, hook-shaped pins, razors, and miniature vases for perfumes, creams, and pigments[3].

Role of Antioxidants_

Antioxidants are used in the cosmetic industry for prevention of the new wrinkles and reduce skin aging which is caused by UV light. These antioxidants, such as vitamin C, vitamin E and pycnogenol, have been shown to have a synergistic effect when combined for photo-protection[6]. Mostly exogenous antioxidants (like vitamin E) and endogenous antioxidants (enzymes like superoxide dismutase, catalase,) having topical applications are used for skin care formulations but they may show unfavourable physiochemical properties such as excessive lipophilicity, chemical instability, and poor penetration in the skin. So, nano-carriers (which are colloidal delivery system) like liposomes, niosomes and solid lipid nano-particles, are used for effective delivery of anti-oxidants to the dermal layers of skin as they can improve the measured performance of cosmetic products.

NANOPARTICLES IN COSMETICS_

- **Titanium Dioxide and Zinc Oxide:** It has been reported that nanoscale TiO2 and ZnO show incredible benefits over numerous materials that are larger than the nano range[1]. TiO2 and ZnO nanoparticles used as UV filters in sunscreens start at a size of 20 nm. They show better scattering and produce a superior restorative or protective effect. On the other hand, inhalation of a large amount of these nanoparticles has been shown to be harmful[1]. It has been established that ZnO is more effective for obstructing UVA, and TiO2 is better for the UVB range. Hence, the appropriate proportion of the mixture of these particles guarantees wide-range UV protection[5]. TiO2 is possibly the most broadly utilized and efficient inorganic nanoparticle for sunscreens and has a higher sun protection factor (SPF) at the nanoscale, which makes it more effective and results in a superior restorative effect due to its transparency, in contrast with its original color[7].

- **Silica (SiO2):** Silica nanoparticles have hydrophilic surfaces favouring extended distribution and low manufacturing costs, interest towards these materials has increased, particularly in the cosmetic sector. Nano silica is utilized to improve the adequacy, surface, and period of actual usability of cosmetic items. Silica nanoparticles are present as nano dispersions with a size range **of 5 to 100 nm** and can deliver both hydrophilic and lipophilic entities to their respective targets by encapsulation [1]. These nanoparticles are generally found in leave-on and wash off cosmetic items for hair, skin, lips, face, and nails, and the further expansion of silica nanoparticles in cosmetic items is expected[3].

- **Bucky Balls (Buckminsterfullerene/C60):** Chemically named alternatively as Buckminster fullerene, buckyballs are made up of odd numbered carbon atoms arranged as rings so that they resemble the structure of some footballs but diameter is in nanometers[3]. Their high hydrophobicity had discouraged their use for some time but incorporating surfactants had assisted in overcoming this limitation[10]. Fullerene is a three-dimensional spherical compound that comprises a carbon ring with an odd number of carbon atoms and is hence called "buckyballs" or buckminsterfullerene[19].

- **Gold and Silver Nanoparticles:** Gold has a long history of usage for skin health management and beauty care products in Egypt, where gold was used to maintain skin complexion. Egyptians believed that gold improved their skin composition and flexibility. Currently, gold is incorporated into different skincare items, such as salves, creams, and skincare treatments. Gold and

silver nanoparticles display antibacterial as well as antifungal properties[1]. And are widely utilized in cosmetic formulations such as antiperspirants, anti-aging creams, and face masks. Gold nanoparticles play a substantial role in fixing skin damage and improving skin surface, grace, and flexibility[2]. The soothing properties of gold make it an exceptional agent for treating skin inflammation, sunburn, and hypersensitivity. Hence, it can be successfully used in face masks and other cosmetics. Nanogold if it is in the size range of **5 nm to 400 nm**. Its colour ranges from red to purple, depending upon the size and total surface area[11].

Nano-particles used for preparing various cosmeceuticals[1]

S. No.	Nanomaterial	Advantage	Disadvantage	Uniqueness	Type of Cosmeceutical	Commercially Available Product
1.	Inorganic particles (TiO_2, ZnO)	Hydrophilic, biocompatible, safe, and stable	Pulmonary toxicity	Absorb/reflect UV light	Sunscreen	Phytorx UV Defense Sun Block SPF 100—Lotus Professionals
2.	Silica (SiO_2)	Hydrophilic, ↓ manufacturing cost	Pulmonary toxicity	Used as filler to ↑ the bulk of the cosmetic formulation	Lipstick	Face FWD >> Blush Stick—Sugar Cosmetics
3.	Carbon black	Light weight, ↑ chemical and thermal stability, and ↓ cost	Cytotoxicity; alters the phagocytic property of macrophages	Color pigment	Facemask	Face Masque —Carbon BAE
					Mascara	Mascara Black—Lakme
4.	Nano-organic (tris-biphenyl triazine)	Powerful and photostable filter	Hazardous to the aquatic environment	Most efficient UVB and UVA 2 filter	Sunscreen	Extra UV Gel—Allie
5.	Nano-hydroxyapatite	Dental desensitizer and polish remineralization of teeth	Very brittle nature	Safe in pediatric toothpaste	Toothpaste	Kinder Karex Hydroxyapatite
						APAGARD M plus—Sangi
6.	Gold and silver nanoparticles	Uniform shape, size, and branch length; tuned pharmacokinetics and biodistribution; antibacterial and antifungal activity; and chemical stability	Damages human cells and DNA at high doses; pulmonary toxicity	Surface-enhanced Raman scattering	Facemask	Gold Radiance Peel Off Mask–VLCC
					Anti-aging cream	Nano Gold Firming Treatment—Chantecaille
7.	Buckyballs (buckminster-fullerene/C60)	Exhibits antioxidant activity, thermostability, and photostability; prevents many skin problems related to oxidative stress	Pulmonary toxicity; damages brain tissues; highly hydrophobic	Potent scavenger of free radicals	Face cream	Brightening Essence—Juva Skincare

NOVEL NANO-CARRIERS_

- **Liposomes_**
  Liposomes are concentric bilayer vesicles in which the aqueous volume is entirely enclosed by a lipid bilayer composed of natural or synthetic phospholipids which are GRAS (generally regarded as safe) products. The lipid bilayer of liposomes can fuse with other bilayers such as the cell membrane, which promotes release of its contents, making them useful for cosmetic delivery applications[8]. Liposomes are suitable for delivery of both hydrophobic as well as hydrophilic compounds. Teir size varies from 20 nm to several micrometres and can have either multilamellar or unilamellar structure[2].
  To protect the drug from metabolic degradation, liposome encapsulates the drug and releases active ingredients in a controlled manner[14]

- **Niosomes_**
  Niosomes are defined as vesicles having a bilayer structure that are made up by self-assembly of hydrated non-ionic surfactants, with or without incorporation of cholesterol or their lipids[2]. Composition: Made up of non-ionic surfactants (the tweens and span), cholesterol and an aqueous medium. Specifically, the non-ionic surfactants form either from a mix of polysorbate 80 (HLB value = 15) and tween 20 (HLB value = 16.7) on addition of optimum level of cholesterol or from only tween 20 using same concentration of cholesterol[3]. Niosomes properties are like those of liposomes except for their better stability and flexibility. The surfactants self-arrange as a bilayer that encloses the aqueous solution within it.[6]

- **Dendrimers_**
  Dendrimers are three-dimensional nanostructured macromolecules that are extensively branched, and this assembly accounts for their great adaptability. They are generally polymers, and because of their stability, they are helpful in delivering active ingredients through the skin[1]. Dendrimers, unlike linear polymers, are monodisperse macromolecules produced by specifically controlled polymerization methods. star-shaped large molecules with nanometer-scale dimensions are described by three components: a central core, an interior dendritic structure (the branches), and an exterior surface having functional surface groups[3]. Unilever, developed dendrimers hydroxyl-functionalized to produce formulations to be used in different ways, such as sprays, gels, or lotions. Due to new film forming property of it, they are used in artificial tanning, hair, skin care and nails. They can be used as anti-acne agents.[6]

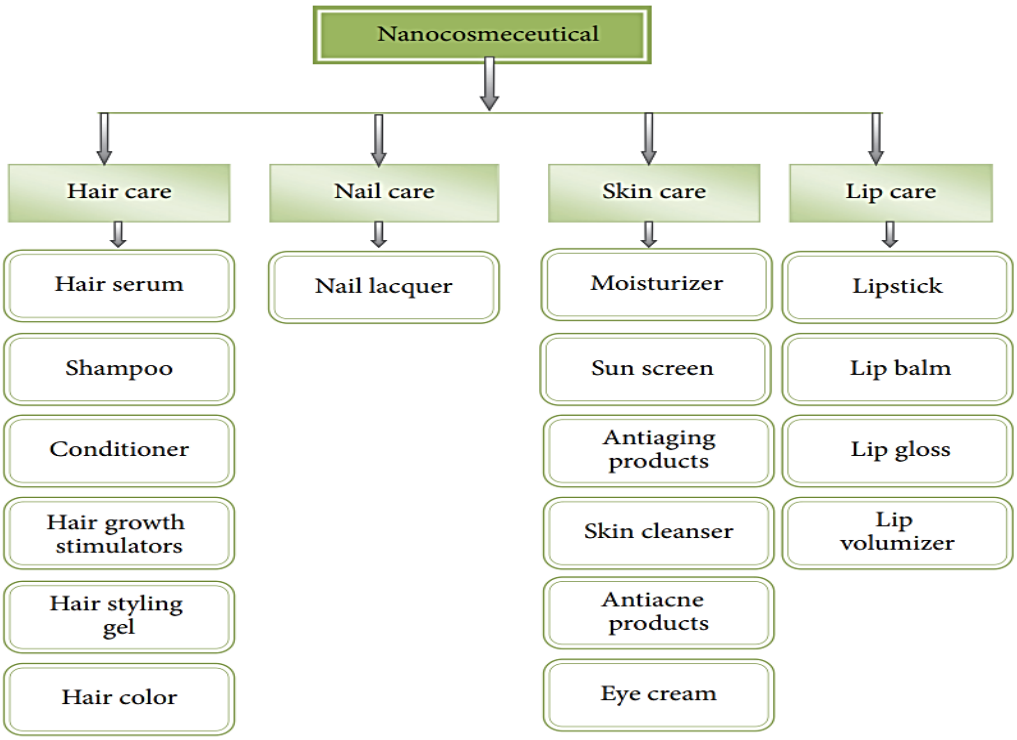
- **Cubosomes_**
  Cubosomes are defined as discrete nanoparticles of continuous cubic liquid crystalline phase comprising much larger specific surface area as compared to the parent cubic phase. It also has high heat stability and have ability to moisturize the skin[6]. Cubosomes offer a large surface area, low viscosity and can exist at almost any dilution level[8]. They exhibit size range from 10 to 500 nm in diameter. They have ability to encapsulate hydrophilic, hydrophobic, and amphiphilic substances. Cubosomes have relatively simple preparation methods; they render bioactive agents with controlled and targeted release, possess lipid biodegradability, and have high internal surface area with different drug loading modalities. Cubosomes are an attractive choice for cosmeceuticals, so for this reason several cosmetic giants are investigating cubosomes.[13]

- **Nano-Emulsions_**
  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.[8]

S. No.	Nanoformulation	Advantage	Disadvantage	Uniqueness	Type of Cosmeceutical	Commercially Available Product
1.	Nanoliposomes	Biodegradable, biocompatible, amphiphilic, and ↑ skin penetration	May trigger an immune response, ↓ medication stacking, ↓ reproducibility, and physicochemical flimsiness	Ability to compartmentalize and solubilize both hydrophilic and lipophilic materials	Moisturizer	Dermosome—Microfluidics
					Anti-wrinkle cream	Capture Totale—Dior
2.	Niosomes	↑ Efficiency, penetration, bioavailability, and stability of drugs	↑ Cost of production, physical and chemical instability, leakage of the drug, time-consuming production	Surface development and alteration are extremely simple due to presence of useful functional groups on the hydrophilic head	Anti-aging cream	Lancome®—Loreal, Paris
3.	Ethosomes	↑ Efficiency and penetration of cosmetic delivery into the skin	Poor yield problems, ↓ stability, and possibility of coalescence	Consist of a relatively high percentage of ethanol	Moisturizer	Supravir Cream—Trima, Israel
4.	Sphingosomes	Reestablishment of barrier function of skin and repair of dehydrated and damaged skin	Poor entrapment efficiency and expensive	Consist of sphingolipid, which makes them more stable than phospholipid liposomes	Anti-cellulite cream	Noicellex—NTT, Israel
5.	Solid lipid nanoparticles (SLNs)	↑ Duration of action, ease of large-scale production, ↑ bioavailability and biodegradability	↓ Shelf life, decreased drug encapsulation	Crystalline in nature, ↑ drug loading matrix; consists of solid lipid	Perfume and cream	Chanel Allur
6.	Nanostructured lipid carriers (NLCs)	↑ Shelf life, ease of large-scale production	↓ Duration of action, higher drug encapsulation	The matrix consists of a blend of solid and liquid lipids	Face spa cream	Dr. Rimpler—Cutanova
7.	Nanocapsules	Protection of ingredients, masking of undesirable odors, resolution of incompatibility issues between formulation components, sustained release formulation	Additional purification step is required after nanocapsule formulation	Formation of micelles and amphiphilic in nature	Anti-wrinkle cream	Primordiale Intense—L'Or'ea
					Hair care	Nano Collagen—Braziliss

Nano-carriers used for preparing various cosmeceuticals[1]

NANO-COSMECEUTICALS

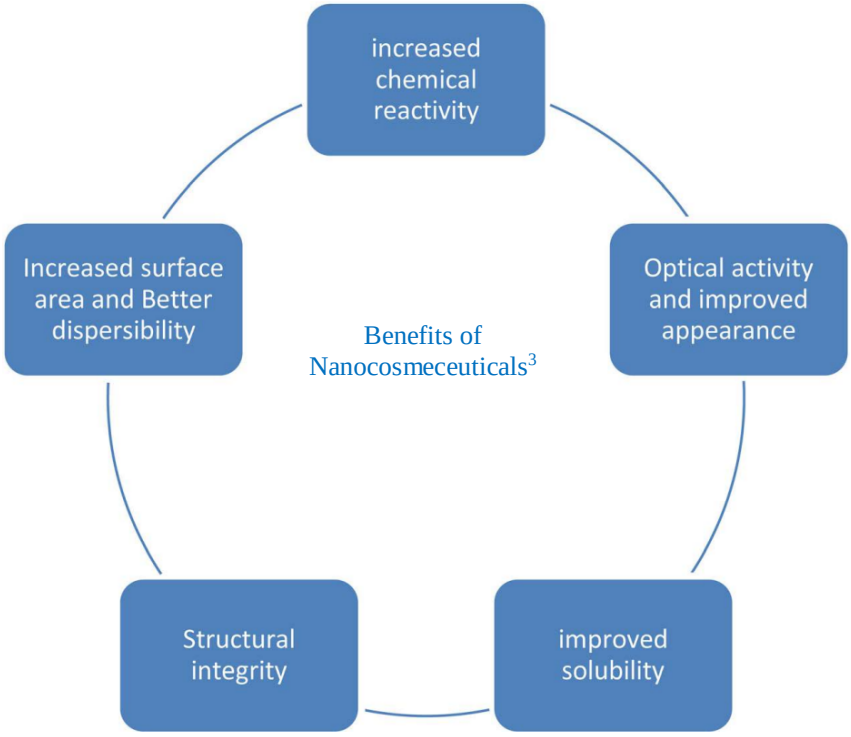


1. **Skin Care:** Cosmeceuticals for skin care products ameliorate the skin texture and functioning by stimulating the growth of collagen by combating harmful effect of free radicals. They make the skin healthier by maintaining the structure of keratin in good condition.[2]

2. **Hair Care:** Hair nano cosmeceutical products include shampoos, conditioning agents, hair growth stimulants, colouring, and styling products. Hair follicle, shaft targeting, and increased quantity of active ingredient are achieved 12 Journal of Pharmaceutics by intrinsic properties and unique size of nanoparticles. Nanoparticles subsuming in shampoos seals moisture within the cuticles by optimizing resident contact time with scalp and hair follicles by forming protective film[2].

3. **Lip Care:** Lip care products in nano cosmeceuticals 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 prevent the pigments to migrate from the lips and maintain colour for longer period.[2]

4. **Nail Care:** Unlike the earlier known acrylic nail products, nail polishes impregnated with nanomaterials have been patented and reported to be tough and resistant to scratches and damage. Nano lab Corp has produced a nail polish with lacquer containing nanoparticles which offers ease of application yet resists shock, scratch, or a crack. This patent and similar marketed product offers a unique opportunity to incorporate nanoparticles (such as nanogold and nano silver) with biocidal activities into nail care product.[3]



NANO-FORMULATED COSMETIC PRODUCTS [4]

Product	Origin	Manufacturer	Nanomaterial/ Nanotechnology	Active	Category
Diorskin Extreme Fit	France	Cristian Dior	Nano-Stretch Network™	-	Foundation
Acnel Lotion N	USA	-	Nanoparticles	Organics	Lotion
Arouge Deep nanomoisture Care Set	Japan	Zenyaku Kogyo Co., Ltd.	Nanoparticles (nanomoisture®)	Organics	Lotion
Alusion Alumina Powders	Australia	Advanced Nanotechnology Limited	Nanoparticles	Aluminum oxide	Powders
Lyphazome and Celazome Cosmetics and Sunscreens	USA	Dermazone Solutions	Nanoparticles, nanospheres	Vitamin E	Nanocapsules
Nano Gold 24 Hour Cream	Deutschland	Joyona International Marketing Ltd.	Nanoparticles	Gold	Cream
Clearly It!	USA	Kara Vita	Nanosphere	Origanum and Salicylic Acid	Lotion
Diorskin Forever - Extreme Wear Flawless Makeup FPS 25	France	Dior	Nano-stretch network	-	Foundation
Nano-in Deep Cleaning	China	Nano-Infinity Nanotech Co., Ltd	Nano micelles, Zinc oxide	Zinc oxide	Lotion

SAFETY & HEALTH CONCERNS_

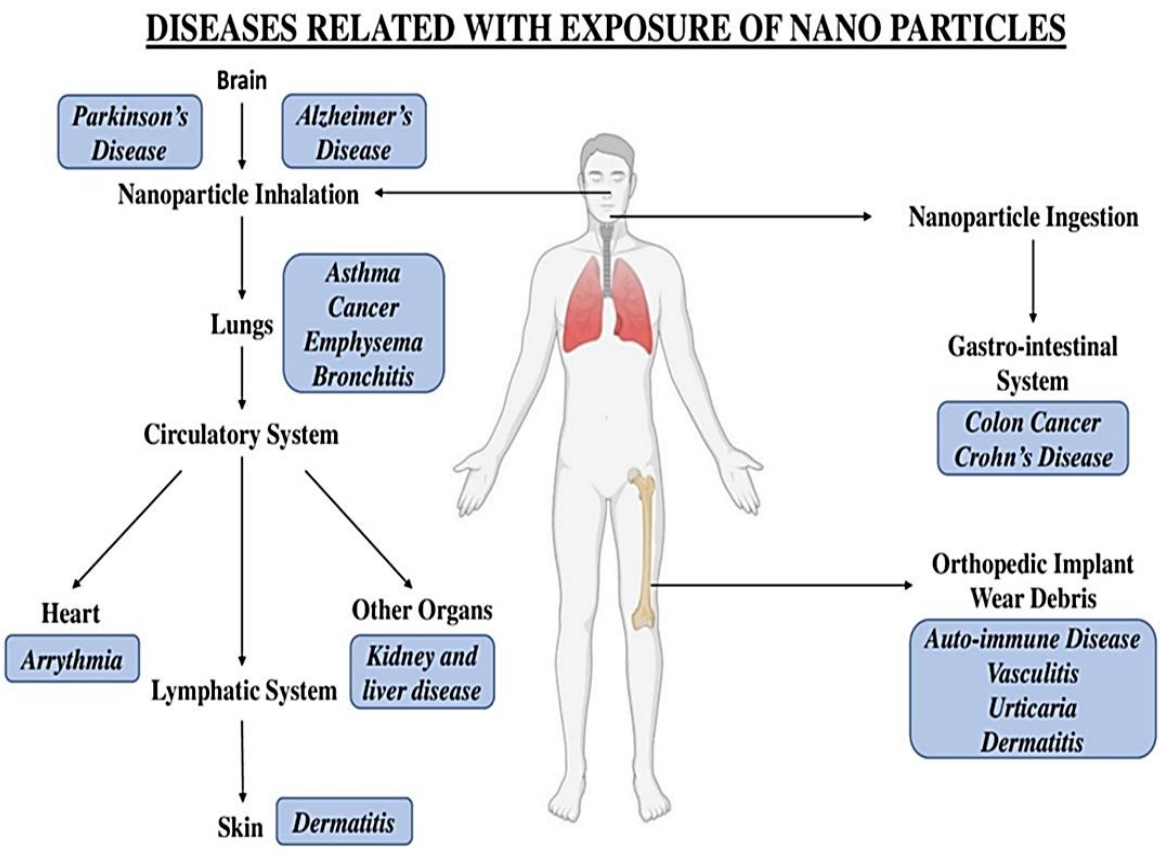
Safety concerns associated with nanosized particles in cosmetic products are mainly about whether they can get into the bloodstream during production or through use. If they do, what harmful effect can result. The need for safety of nanomaterials came to the fore in the USA when the Food Drug Administration (FDA) nanotechnology taskforce made recommendations for regulatory consideration with particular emphasis on the safety and non-adulteration of cosmetic products. When nanomaterial is of low Molecular size and weight; Nano-sized dendrimers of 2.9 nm but 3256 Da (Daltons) was observed not to penetrate intact skin while particle size of 10 nm but of lesser weight in Da have been shown to occasionally reach viable epidermal layers of the skin through the hair follicles and stratum corneum[3]. The safety issues are related to both topical and systemic toxicity. Ingredients meant for topical use may start showing systemic effects, mostly of unknown and undesirable nature. Although the unique properties of nanomaterials make them desirable as they can perform certain cosmetic functions, they may also represent a risk for consumer health. The concern that a potential health risk may be caused by insoluble nanoparticles is indeed a much-debated topic in scientific literature, and this is mainly due to conflicting results and a lack of long-term toxicological studies.

SAFETY ASSESSMENT_

The opinions of the Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR) deals with the risk assessment methodologies available for evaluating the possible adverse health and environmental effects of nanotechnology products and on the investigation of nanomaterials. The specific characteristic of nanomaterials will require new test strategies to determine the mechanisms of potential injury that they may cause. The main parameters that are evaluated for the safety of nanomaterials are the following:[8]

Physical-chemical properties:

Physical properties like size, shape, specific surface area, agglomeration state, size distribution, surface morphology, structure, solubility and chemical properties like structural formula/molecular structure, composition of nanomaterial, phase identity, surface chemistry, hydrophilicity/lipophilicity must be analyzed.[8]



Mathematical modelling: These predictive models range from simple, empirical algorithms to complex mathematical equations which sometimes require knowledge and estimation of experimentally inaccessible parameters. But, since, in none of these models, data relating to macromolecular compounds or particle structures have been included, they cannot be used with any confidence to predict what might happen when such entities contact the skin.[8]

Microscopic techniques: More useful information from the in vitro studies can be obtained by microscopic examination of the skin posttreatment. While absolute quantification may not be possible, visualization of the tissue to which an active has been applied can provide valuable insight.[8]

FUTURE ASPECTS & DEVELOPMENT_

Nanotechnology is becoming increasingly popular as a part of modern era cosmetics. Constantly more and more innovative application of materials resulting from the use nanotechnology is being recognized. A few of the sophisticated applications that possibly will revolutionize cosmetics market in the future are discussed in this section. Sustained and controlled release of sunscreens, with improved moisturizing capacity along with antiaging properties could possibly be established.[4]

Some very promising delivery systems are being investigated for an array of practical applications. While some may not find their way out of laboratory others will bring great transformation in cosmetic world. An exceptionally unique nanomaterial, carbon nanobuds have been identified with combined properties of carbon nanotubes and fullerenes. They are prepared by combining two most common allotropes of carbon, fullerenes, and carbon nanotubes. Carbon nanotubes are specifically covalently bounded to fullerene like “sprouts/ buds ". They possess remarkably good field emitting properties. This may be used in lipsticks and mascaras.[4]

Furthermore, new nano sized metal pigments, in addition to the most known titanium dioxide and zinc oxide should be continuously investigated and proposed for coloured cosmetics. In addition, if appropriately explored, nano cosmetics may open new vistas in therapy of complex skin problems and disorders.[4]

CONCLUSION:

The application of nanocarrier technology in functional cosmetics not only improves the stability and solubility of efficacy components but also overcomes the barrier effect of cuticle, which enables the active cosmetic ingredients to enter the target site of the skin and realize the functions of sustained release, controlled release, and long-term release, thus solving various skin problems and skin diseases. Nanotechnology is the most promising and revolutionizing field. Over the last dozens of years, nanotechnology is widely being used and is beneficial in the field of dermatology, cosmetics, and biomedical applications as well. By the increase in use of cosmeceuticals, the conventional delivery systems are being replaced by the novel delivery systems. Novel nanocarriers which are currently being used are liposomes, niosomes, NLC, SLNs, gold nanoparticles, nano emulsion, and nanosomes in various cosmeceuticals. Tere are huge controversies regarding the toxicity and safety of the nanomaterials; various researches are being carried out to determine the possible health hazard and toxicity. Meticulous studies on the safety profile of the nanomaterials are required. Nanoproducts should be fabricated in such a way that their value and health of the customers are improved.

REFRENCES:

1. Gupta, V.; Mohapatra, S.; Mishra, H.; Farooq, U.; Kumar, K.; Ansari, M.J.; Aldawsari, M.F.; Alalaiwe, A.S.; Mirza, M.A.; Iqbal, Z. Nanotechnology in Cosmetics and Cosmeceuticals—A Review of Latest Advancements. Gels 2022, 8, 173.
2. Shreya Kaul, Neha Gulati, Deepali Verma, Siddhartha Mukherjee, and Upendra Nagaich- Role of Nanotechnology in Cosmeceuticals: A Review of Recent Advances. Hindawi Journal of Pharmaceutics Volume 2018, Article ID 3420204, 19 pages
3. Effiong, D.E., Uwah, T.O., Jumbo, E.U. and Akpabio, A.E. (2020) Nanotechnology in Cosmetics: Basics, Current Trends and Safety Concerns—A Review. Advances in Nanoparticles, 9, 1-22.
4. Mohammad Ajazzuddin1, Gunjan Jeswani*,2 and Arvind Kumar Jha- Nanocosmetics: Past, Present and Future Trends. Recent Patents on Nanomedicine, 2015, Volume 5, No. 1.
5. Eliana B. Souto 1,2, Ana Rita Fernandes 1, Carlos Martins-Gomes 3,4, Tiago E. Coutinho 3,4, Alessandra Durazzo 5, Massimo Lucarini 5, Selma B. Souto 6, Amélia M. Silva 3,4 and Antonello Santini 7*- Nanomaterials for Skin Delivery of Cosmeceuticals and Pharmaceuticals. Appl. Sci. 2020, 10, 1594; doi:10.3390/app10051594
6. Awais Hameed, Gull Rida Fatima, Kainat Malik, Ayesha Muqadas, M.Fazal-ur-Rehman- Scope of

Nanotechnology in Cosmetics: Dermatology and Skin Care Products. J. Med. Chem. Sci. 2019, 2, 9-16
7. Aziz ZAA, Mohd-Nasir H, Ahmad A, Mohd. Setapar SH, Peng WL, Chuo SC, Khatoon A, Umar K, Yaqoob AA and Mohamad Ibrahim MN (2019) Role of Nanotechnology for Design and Development of Cosmeceutical: Application in Makeup and Skin Care. Front. Chem. 7:739.
8. Silpa Raj, Shoma Jose, Sumod U. S., Sabitha M-Nanotechnology in cosmetics: Opportunities and challenges. Journal of Pharmacy and Bioallied Sciences July-September 2012 Vol 4 Issue 3
9. Cosmetics—Overview. Available online: https://www.fda.gov/industry/regulated-products/cosmetics-overview (accessed on 15 January 2022).
10. Dhawan, S.; Sharma, P.; Nanda, S. Cosmetic nanoformulations and their intended use. In Nanocosmetics; Elsevier: Amsterdam, The Netherlands, 2020.
11. Souto, E.B.; Fernandes, A.R.; Martins-Gomes, C.; Coutinho, T.E.; Durazzo, A.; Lucarini, M.; Souto, S.B.; Silva, A.M.; Santini, A. Nanomaterials for skin delivery of cosmeceuticals and pharmaceuticals. Appl. Sci. 2020, 10, 1594. [CrossRef]
12. Metrics, P. Fullerene is effective against wrinkles. J. Am. Acad. Dermatol. 2010, 62, AB22. [CrossRef]
13. Banerjee, A.N. The design, fabrication, and photocatalytic utility of nanostructured semiconductors: Focus on TiO2 -based nanostructures. Nanotechnol. Sci. Appl. 2011, 4, 35–65. [CrossRef] [PubMed]
14. Sudhakar, C.K.; Upadhyay, N.; Jain, S.; Charyulu, R.N. Ethosomes as non-invasive loom for transdermal drug delivery system. In Nanomedicine and Drug Delivery; Apple Academic Press: Point Pleasant, NJ, USA, 2012; ISBN 9781466560079.
15. Hong Zhou1 Dan Luo2 Dan Chen2 Xi Tan1 Xichen Bai1 Zhi Liu1 Xiangliang Yang1,2 Wei Liu1,2- Current Advances of Nanocarrier Technology-Based Active Cosmetic Ingredients for Beauty Applications. Clinical, Cosmetic and Investigational Dermatology 2021:14 867–887
16. *Nirvesh Chaudhri, Girish C. Soni, S. K. Prajapati-Nanotechnology: An Advance Tool for Nano-cosmetics Preparation. International Journal of Pharma Research & Review, April 2015; 4(4):28-40 ISSN: 2278-6074
17. Gunjan Jeswani, Swarnali Das Paul, Lipika Chablani and Ajazuddin- Safety and Toxicity Counts of Nanocosmetics
18. Jamie Rosen 1, Angelo Landriscina 1 and Adam J. Friedman 2,3*- Nanotechnology-Based Cosmetics for Hair Care. Cosmetics 2015, 2, 211-224; doi:10.3390/cosmetics2030211
19. Madan Kumud and Nanda Sanju-Nanotechnology Driven Cosmetic Products: Commercial and Regulatory Milestones. Applied Clinical Research, Clinical Trials & Regulatory Affairs, 2018, Vol. 5, No. 2
20. Palanivel Ganesan1,2 Dong-Kug Choi1,2-Current application of phytocompound-based nanocosmeceuticals for beauty and skin therapy. International Journal of Nanomedicine 2016:11 1987–2007
21. Chiara Ferraris, Clara Rimicci, Sara Garelli, Elena Ugazio * and Luigi Battaglia- Nanosystems in Cosmetic Products: A Brief Overview of Functional, Market, Regulatory and Safety Concerns. Pharmaceutics 2021, 13, 1408.
22. Georgios Fytianos 1,2*, Abbas Rahdar 3 and George Z. Kyzas 1*-Nanomaterials in Cosmetics: Recent Updates. Nanomaterials 2020, 10, 979; doi:10.3390/nano10050979
23. Moazzam M, Mehboob T, Bashir I, Aslam R, Tabassam N, Jamshaid M. Constituents of Cosmeceuticals and Implication of Nanotechnology in Cosmetics. RADS J. Pharm. Pharm. Sci. 2018; 6(4): 270-281.
24. Indu P. Kaur* and Rumjhum Agrawal-Nanotechnology: A New Paradigm in Cosmeceuticals. Recent Patents on Drug Delivery & Formulation 2007, 1, 171-182
25. Gajbhiye, S. and Sakharwade, S. (2016) Silver Nanoparticles in Cosmetics. Journal of Cosmetics, Dermatological Sciences and Applications, 6, 48-53.