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Exploring Nanotechnology in Cosmetics: Opportunities, Challenges, and Safety Considerations

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ABSTRACT
Nanotechnology has recently witnessed remarkable advancements, facilitating the production of sophisticated nanosized particles for a wide range of biomedical purposes. Its impact extends across various scientific domains, including pharmaceuticals, medicine, and cosmetics, where it has led to the emergence of nano cosmetics. This branch of nanotechnology has gained significant traction in the cosmetic industry owing to the remarkable properties exhibited by nanoparticles at the nano level, such as enhanced color, transparency, and solubility. Various nano dosage forms, including nanotubes, liposomes, nanoparticles, and dendrimers, have been employed in cosmetic formulations to address a myriad of skin concerns, including wrinkles, photoaging, wound healing, and fungal infections. However, the increasing utilization of nanoparticles in cosmetics has raised concerns regarding their potential to penetrate the skin barrier and pose health risks. Nanotoxicological studies have thus been initiated to assess the safety profile of nanoparticle-based cosmetic products. This review aims to provide an overview of the skin's barriers, the therapeutic applications of nanoparticles in managing various skin conditions, and the emerging concerns regarding nanoparticle toxicology in cosmetics. By elucidating the opportunities and challenges associated with nanocosmeceuticals, this review underscores the importance of further research to ensure the safety and efficacy of nanoparticle-based cosmetic formulations in promoting skin health and cosmesis.
Keywords: *Cosmetic, Nanoparticle, Toxicology, Wrinkles, Liposomes*

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INTRODUCTION

The unit of measurement employed in nanoscience-one billionth of a metre, or 10^{-9}m for the study of minuscule atomic or molecular particles [1]. Nanotechnology which derives from the Greek word for "dwarf" is the scientific study of microscopic particles, defined as those having at least one dimension between 1 and 100 nanometers. It is frequently used to describe the manipulation of materials at the nanoscale (109 m). Over 40 years ago, nanoparticles (NP) were initially created as medicine delivery systems [2-3]. Russia, China, India, Brazil, Europe, Japan, and the United States have all made significant investments in the field of nanotechnology [4]. Two broad categories of nanoparticles can be distinguished: those that are engineered and those that are not purposefully created. These include quantum dots, soil particles (0.4-0.5 µm), nanowires, fluorescent dextran beads, nanoshells, nano-emulsions, nanocapsules, noisome, nanosomes, fullerene, liposomes, nanoparticles, dendrimers, and biopolymers (2). When compared to similar materials with particles of a greater scale, nanoparticles may exhibit physical and chemical properties that are very different, providing an interesting new avenue for the use of already-existing substances [3]. In 1959, Richard Feynman initially proposed the concept of nanotechnology. Nanotechnology has advanced quickly over the past 30 years to become a significant technology. The medical, cosmetics, textile, and mechanical industries are just a few of the industries that have employed more than 1,800 distinct kinds of nanotechnology-based products. Metallic nanoparticles (NPs) metal or metal oxides are gaining popularity in the fields of dermatology and cosmetics. Since the 1980s, for instance, ZnO and TiO_2 NPs have been extensively incorporated to sunscreens to provide superior ultraviolet (UV) protection above conventional inorganic sunscreens [5]. For human (and most animal) organisms, there are several routes of absorption; the most visible and accessible is through the skin [6]. The outermost layer of the skin, known as the stratum corneum (SC), is composed of a 10-15 mm thick matrix of dehydrated and dead keratinocytes embedded in carefully arranged lipid layers that serve as a covering. Between 100 and 150 mm thick, the viable epidermis is composed of many layers of keratinocytes and other cell types. A network of lymphatic, blood, and nerve terminals can be seen in the dermis [7]. The stratum corneum, which performs the role of a strong barrier to the external environment, is one of the skin's key organ functions [8]. The skin layers that descend into the body from top to bottom are called the epidermis, dermis, and hypodermis. By the mid-1800s, scientists had established that the top layer of skin, which is composed of the stratum corneum, stratum spinosum, stratum granulosum, and stratum basale, was more resistant to chemical penetration than the dermis and that lipophilic compounds penetrated the skin more readily than hydrophilic ones by the early 1900s. The body can be shielded by this layer from potentially dangerous external stimuli such as heat, radiation, chemical compounds, pathogens, electrical barriers, and mechanical trauma [9]. Furthermore, the COVID-19 pandemic and related worldwide events have indicated that consumer perceptions have a significant influence on market trends for cosmetics, which means that these trends are dynamic. In fact, the pandemic has brought attention to the need for safer and transparent products, which has been lacking in recent years as demand has shifted towards the use of "clean" and natural products [2]. Various substances can come into touch with the skin, either in their bulk form or as nanoparticles (NPs, which are defined as particles having a diameter of 1-100 nm by the British Standards Institution,). Numerous NPs have already been applied in dermatology in a number of ways, photothermal including photoprotection, and photodynamic therapy, gene therapy, vaccination, the treatment of hair disorders, and nanodiagnostics [10]. Skin diseases include a broad spectrum of illnesses, ranging from treatable to potentially deadly. Infections produced by bacteria, fungi, or viruses can result in a variety of infectious diseases that impact the skin and hair follicles. However, the fact that hair follicles are the primary source of skin tumors both benign and malignant may be another reason to be concerned. Among the chronic inflammatory skin illnesses that result from the invasion of inflammatory T cells and increased cytokine production in the lesions are psoriasis, atopic dermatitis, and allergic contact dermatitis [11]. Sunscreens, moisturizers, formulas for anti-aging, anti-sepsis, antioxidants, hair and nail care, phototherapy, antimicrobials, and skin fillers are a few of the most important uses of nanotechnology in dermatology and cosmetics [4]. In applications where the skin is the target organ, Nanoparticles may be essential in applications such as cell labeling and targeting, skin wound healing treatments, nanomedicine, cosmetics, and sunscreens. Based on a risk assessment, nanoparticles should be considered new substances as they may penetrate the epidermis, which is the body's natural defensive system, according to 2004 research conducted by the Royal Society and the Royal Academy of Engineering [2]. Anticancer medications can now precisely target the cancer site thanks to an efficient drug delivery mechanism offered by nanoparticles, significantly enhancing the effectiveness of treatment. The use of nanotechnology in the packing of imaging agents into nanoparticles that can reach cancer has also aided in diagnosis. Nowadays, dacarbazine (DTIC), is the most widely used drug for the treatment of melanoma. It is a first-line therapy that the US (FDA) Food and Drug Administration has authorised for individuals with wild-type melanomas. Surgery to remove melanoma before it spreads can result from early detection [13]. Skin phenotype, familiarity, and ultraviolet (UV) radiation exposure are known risk factors for melanoma. Of these, UV exposure is the one that can be changed the most, which is why it has gotten the most attention. who have lower melanin levels in their skin, are less able to withstand UV radiation exposure than those with darker skin, and have a higher chance of developing melanoma [14]. Despite the benefits that NPs provide, their drawbacks include toxicity, poor removal, tissue buildup, and effective penetration. After entering the skin, nanoparticles (NPs) can cause oxidative stress, cell death, mitochondrial malfunction, cytomembrane and DNA damage, and other harmful effects [5].

SKIN: THE BARRIER

The human body's biggest organ is the skin. It makes up 16% of the body mass and has a surface area of around 1.8 m^3 [15]. The outer (epidermis) and inner (dermis) layers of the skin are respectively 50 Am (<100 Am) and 250 Am (<4000 Am) thick. The epidermis' uppermost layer, known as the stratum corneum (SC) in Latin, is the skin's horny layer. It serves as the main barrier against chemicals and germs penetrating the skin and can endure mechanical pressures. This makes the skin one of the finest biological barriers. In addition, the SC is in charge of regulating trans epidermal water loss (TEWL), the process by which water is expelled from the body and into the atmosphere [16]. The body's initial defence against infections, viruses, bacteria, allergies, and physical injury is the skin's barrier. It also keeps the body from becoming dehydrated. Its physiologic characteristics and structural integrity are therefore essential to preserving its protective function [17]. The immune system and the regulation of body temperature are two further functions that skin is crucial for. Langerhans cells, which may digest antigens and initiate the inflammatory response in response to external assaults, are responsible for this latter function [10]. In addition to providing physical defence, the skin's defensive mechanism also provides immunological, metabolic, and UV protection [11]. Despite the skin's huge surface area, medication molecules are difficult to transfer into the skin because of the skin's strong barrier. Skin is made up of four distinct layers that are identifiable from a physiological perspective: the viable epidermis, dermis, subcutaneous connective tissue, and stratum corneum (SC) [7]. The keratinocyte and non-keratinocyte primary cells make up the stratified squamous keratinized epithelium that makes up the epidermis. The second type of cells has immune system and UV light protection capabilities (melanocytes, Merkel cells, and Langerhans cells), whereas the former are arranged in several layers (stratum spinosum, stratum Basale, stratum granulosum, stratum corneum, and stratum lucidum). The outermost layer, the stratum corneum, serves as the body's first line of defence against outside substances and controls the absorption of chemicals, medications, and particles into the skin's deeper layers. The diameter of each stratum corneum cell is roughly 30 µm, and its thickness varies between 0.5 and 0.8 µm [10]. The three layers that comprise the dermis are the hypodermis, reticular dermis, and papillary dermis. The bulk of the upper dermis is made up of fibroblast-produced collagen and other extracellular matrix components. The hypodermis is the lowest layer that contains subcutaneous fat. Numerous secondary structures, including sweat glands, hair follicles, nerve fibres, and blood/lymphatic arteries, are also parts of the dermis. Sweat glands and hair follicles in the dermis both control body temperature [18]. Moreover, absorption can occur via three different pathways: transcellular (by corneocytes), intercellular (via extracellular space), and trans appendageal (via follicular apertures and other auxiliary structures). Through the use of detergents and other permeability-enhancing chemicals, depolarization of the material to be absorbed, and moisturization, topical treatments can change permeability [19]. Drugs can be delivered locally and systemically through the skin, where they may also be delivered as nanoparticles. Although the skin has long been utilised for topical drug delivery, systemic delivery through the skin has only become increasingly common since the introduction of transdermal patches in the 1970s. Delivery of nanoparticles to the skin is becoming more and more common to support local therapies [16]. The impact of inflammation on the epidermal barrier has been highlighted by research on inflammatory diseases. For instance, TH2-predominant immune responses characterise atopic dermatitis, a chronic inflammatory skin disorder. Filaggrin, a protein essential for the cross-linking of keratin fibres, ceramides, and Corne desmosomes are deficient in patients with this illness. There is direct evidence linking the deficiency of these components to increased production of several pro-inflammatory cytokines [19]. Introducing structural alterations into the skin through the addition of chemical enhancers such as surfactants, alcohols, polyalcohols, amides, sulphoxides, esters, terpenes, fatty acids, alkanes, amines, and phospholipids, pyrrolidones, is one of the most significant and well researched ways to improve drug delivery through the skin.

There are several ways in which chemical enhancers work, including: (a) breaking down the highly ordered structure of SC; (b)removing and dissolving the lipids and/or keratin from SC; (c) fluidizing the crystalline structure of SC; (d)straightforward hydration brought on by skin occlusion; and (e) better drug, co-enhancer, or solvent partitioning into SC. However, because macromolecules have a limited permeability and Chemical enhancer usage is limited since it is sometimes necessary to employ a higher concentration of enhancer than what the skin can tolerate in order to get pharmacologically effective medication concentration [7]. It is anticipated that current developments in nanotechnology will lead to the development of novel drug carriers with therapeutic, diagnostic, and protective uses [6]. There are four primary classes of nanosized carrier systems: polymer systems (polymeric nanoparticles, polymeric micelles, dendrimers), nanostructured lipid carriers (NLCs), self-assembled lipid systems [liposomes, nano emulsions, micelles, solid lipid nanoparticles (SLNs), microemulsions, pro-colloidal and nanosuspensions (self-emulsified and liquid crystalline systems) [17]. To improve the skin penetration of different drugs, there are a number of physical, mechanical, and active transport strategies available. These include iontophoresis, microneedles, electroporation, iontophoresis, photomechanical waves, ultrasound, jet injectors and skin abrasions. Some drawbacks of microneedle-based delivery include: (a) the needles' minuscule size, which is smaller than that of hair, making it possible for the tip to break off and remain under the skin, potentially causing localised inflammation; and (b) the need for correct application and difficulty with self-administration. The intrusive techniques of electroporation and microneedles, which are used to deliver molecules impermeable to skin, have the potential to harm the skin's protective layer. Micro and nanoparticles are being created to solve the shortcomings of chemical and physical enhancers; these particles not only improve the medicines not only absorb through the skin but also release the substance over an extended length of time in a regulated manner [7]. Recently many nanomaterials-based cosmetics have been commercialized (Table 1). Transdermal patches have been used for topical drug administration since the late 1970s, and in recent years, nanoparticles have been created to offer easily accessible local medicines. In the SC layers of humans, desquamation of the skin is a normal process. It's vital to remember that the rejuvenation process takes about 14 days to complete; this time depends on both age and anatomy. The infection, solid particles, and cancer cells can all be eliminated by the corneocytes using this natural process [20].

Table 1. Commercialized nanomaterials formulation for use in cosmetics

S.No.	Brand name	Composition	Company name	Indications
1	Myocet	Liposomal doxorubicin	Zeneus pharma	Breast cancer
2	Abelet	Liposomal amphotericin B	Enzon	Fungal infection
4	Acticoat	Silver nanoparticle	Nucryst (USA)	Antimicrobial care
5	Mbisome	Liposomal amphotericin B	Giled(foster city a USA)	Fungal infection
6	Emend	Nanocrystalline aprrepitant	Melan ,merck	Antiemetic
7	Tricor	Naocrystalline fenofibrate	Melan, abbet	Antihyperlipidemic
9	Rapamune	Nanocrystalline sirolimus	Elan, Wyeth	Immunosuppressant

NANOPARTICLES IN COSMETOLOGY AND DERMATOLOGY

As a result of the swift advancement of nanotechnology research being conducted at academic institutions across the globe, nanoparticles (NPs) are finding more and more utility as an adjuvant or substitute for previously prescribed medications [21]. Because of the widespread use of nanotechnology in cosmetics, worries about its possible risks to the environment and public health have increased dramatically [22]. Nanoparticles are incredibly small materials that behave and react collectively. Their sizes range from 1 nm to 100 nm. Based on their dimensions, surface, form, and physicochemical characteristics, they can be classified into different kinds (Fig. 1) [1].

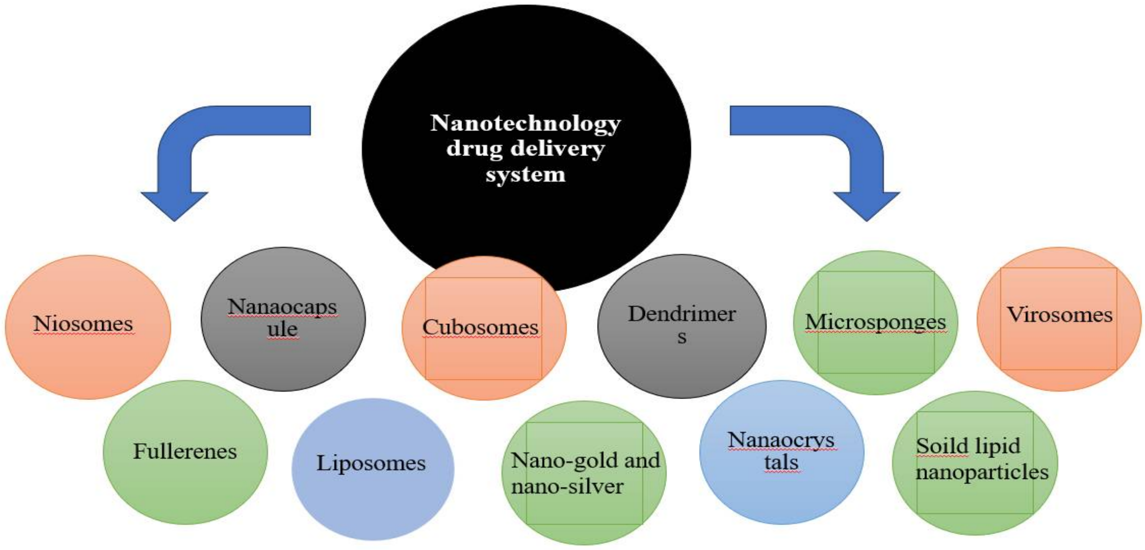

Fig 1: Several kinds of medication delivery systems based on nanotechnology used in dermatology and cosmetics applications

Liposomes

Mezei and Gulasekharam have demonstrated the efficacy of liposomes as a topical medication delivery device [1]. Early in the 1970s, researchers invented a type of nanocarriers called liposomes for the delivery of drugs. These vesicles are biocompatible, non-hazardous, and biodegradable, flexible, and they are excellent at encapsulating active substances [22]. One of the primary ingredients of liposomes is phosphorylcholine, which is a hydrating and emollient ingredient in many skin and hair care products. Nano-liposomes are used in cosmeceuticals that contain both synthetic and phytoactive active ingredients, such as sunblock, hair lotions, and skin moisturizers [4].

Niosomes

Niosomes are tiny, unilamellar nanostructures that range in size from 10 to 100 nm. They are made up of layers of non-ionic surfactant in lamellar phase surrounding a core aqueous hollow. Antioxidants like ascorbic acid, resveratrol, and ellagic acid can be safely delivered via the skin using niosomes [4]. It resembles liposomes but is stable and possesses both hydrophilic and hydrophobic ends. Thus, the first product released by the L'Oreal corporation was Lancôme in 1987.Drugs that are lipophilic and amphiphilic are transported by niosomes [22]. Niosomes have improved chemical stability, increased penetration, and an effective trapping quality. Additionally, their production costs are significantly less than those of liposomes [1].

Solid-lipid nanoparticle (SLN)

Oily lipid droplets that are solid at body temperature and have a size range of 50 to 1000 nm are known as solid lipid nanoparticles [4]. They are stabilised by surfactants [22]. Both hydrophilic and lipophilic chemicals are frequently delivered using them [4]. The cosmeceutical industry uses SLNs extensively due to their intrinsic qualities, which include enhanced skin penetration, low toxicity, controlled-release qualities, and a smaller size that allows for close contact with the skin. Stabilization of the active ingredients, achieving the appropriate level of occlusion and consequent skin hydration, extending the product's shelf life, increased bioavailability, and site-specific action are just a few benefits of using SLNs and NLCs [22].

Nanospheres

Nanospheres are tiny (about 100 nm) polymeric matrix systems that are formed by joining and assembling predetermined amount of porous material that are adsorbed on active substances like minerals, chemical compounds, amino acids, or plant extracts. These materials are dispersed as they come in contact with suitable hydrophilic polymer. Typically, poly (alkyl cyanoacrylate) and its derivatives are used to create nanospheres [21].

Nano capsule

Nanocapsules are structures that have the ability to contain an active ingredient within their structure and release the material when it's timed [19]. The active substance is placed into a cavity in a liquid or solid core of a nano-capsule, which is then sealed with a polymer membrane made of either natural or synthetic polymers [22]. A nano capsule can range in size from 10 nm to 1000 nm [1]. To increase the impact of their cosmetics, the French corporation L'Oreal produced a cosmetic product in 1995 that was based on nanocapsules and may have dermatological applications [4].

Cubosomes

These are discrete, nanostructured, bicontinuous cubic liquid crystalline phase particles that are arranged in a cube-like way are called cubosomes [1]. Additionally, it has a high thermal stability with moisturises ability [22], and is employed as an absorbent for pollutants in cosmetics and as stabilisers for oil-in-water emulsions [4].

Dendrimers

Dendrimers are organic materials with a semi-polymeric tree-like structure. Given the quantity of nanoparticles [1] in their branch terminals, they offer a rich supply of nanoparticles. Dendrimers are very tiny organic chemical particles that range in size from 2 to 10 nm and feature a semi-polymeric tree-like structure [4]. Its size and M.W. allow it to be utilized in many different cosmetic products similar to nail polish and mascara. They are employed in artificial tanning, nails, skin care, hair and because of their ability to produce new films. They have anti-acne properties [22].

Fullerenes

Carbon fullerenes and other new materials made with nanotechnology are called fullerenes. "Buckyballs" is another term for fullerenes [22]. In addition to its strong scavenging abilities against oxygen free radicals, carbon fullerene has antioxidative qualities. These characteristics have allowed for their use in the creation of cosmeceuticals for skin renewal [1]. Recently, ascorbic acid and vitamin E were added to a fullerene nanocapsule that demonstrated improved skin protective activity against premature ageing due to its antioxidant properties [4].

Micro sponges

Microporous beads intended for the regulated release of topical actives make up microsponge [4]. They include a lot of active agents with characteristics like minor water solubility, inertness with monomer, and sufficient stability in interaction with the catalyst for polymerization. The active medication in the Micro Sponge Delivery System (MDS) is delivered on demand and in reaction to various skin stimuli, such as temperature, rubbing, pH, and wetness. Among these characteristics are formulations for prolonged release that cause less discomfort and enhance patient compliance; stability between 1 and 11 pH values as well as heat stability up to 130°C [1].

Nanocrystals

Crystal aggregates with a crystalline cluster made up of thousands of atoms with a size ranging from 10 to 400 nm are called nano-crystals. They are intended especially for the administration of poorly soluble active ingredients [4]. The features of nanocrystals, such as their improved gastrointestinal wall penetration, greater adhesion, and increased penetration into membranes, were utilised to apply the material topically. Toothpaste that contains nanotechnology is quite beneficial in avoiding damage to tooth enamel [22]. When Juvena released its rutin-containing product Juvedical on the market in 2000, it became the first firm to use nanocrystals in cosmetics. Later, it was shown that rutin molecules prepared using nanocrystals have 500 times more bioactivity than rutin glucoside, which is soluble in water [1].

Silver and gold nanoparticles

The antifungal and antibacterial properties of nanogold and nanosilver are similar. In cosmeceutical products like face packs, anti-aging lotions, and deodorants, they are frequently utilised. Moisturiser creams and face masks have been made with them [22]. It has been suggested that ointments containing silver nanoparticles have antibacterial qualities, making them effective skin disinfectants [1]. They are widely utilized in cosmeceuticals, where they are used to make anti-aging lotions, face packs, and deodorants. Nowadays, soaps, clothes, face creams, toothpastes, home appliances, food packaging, disinfectants, and wound dressings include silver nanoparticles [4].

Virosomes

Virosomes are proteins and viral hybrid liposomes that are employed in vaccinations against certain viruses which are used into vaccinations designed to prevent the human papilloma virus (HPV) and the hepatitis B virus (HBV) [1].

Nanocarriers

Another type of nanosystem used in pharmacology and pharmacotherapy is called a nanocarrier (niosome). Since liposomes and nanocarriers are made of synthetic, non-ionic surfactants and have chemical-specific receptors that allow them to bind to specific sites on the body, there has been a surge in interest in the use of nanocarriers in sunscreens, nutrient preparations, and moisturising creams. The active components that are transferred by nanocarriers include peptides, antioxidants, vitamins, and hyaluronic acid [21].

Nanoparticles as Carrier

As delivery systems for anti-tumor therapies, nanoparticles have enormous potential. Chemotherapeutic medications or nucleotide fragments can encapsulate or be adsorbed onto the surface of nanoparticles via chemical bonding, hydrophilic–hydrophobic characteristics, or electrostatic force. Therefore, to increase the stability and bioavailability of medications or genes, nanocarriers can shield them from deterioration. Therapeutic medicines can be delivered via nanocarriers, which allow them to enter tumor tissue with specificity and efficiency through passive or active targeting. This minimizes the negative effects on healthy tissue [23].

The usage of nanoparticles in consumer goods has increased throughout the past several decades (Table 2). Since the 1990s, sunscreens and cosmetics containing zinc oxide and titanium dioxide nanoparticles have been used to shield skin from damaging UV rays. More recently, fullerenes and silica nanoparticles have been added to certain cosmetic formulations to serve as free radical scavengers and desiccants, respectively. Although these formulations' nanoparticles aren't meant to pierce skin, their utilization indicates a move towards nano-enabled items in the realms of consumer products and biomedical science [18]. With their self-antioxidative properties and cosmetic formulations, lipid nanocarriers made from vegetable resources (RSO & RBO) have less negative effects. Vegetable oil's antioxidative and UV absorptive qualities are enhanced by the entrapment of 90% of octocrylene and 79% of butyl-methoxydibenzoyl methane [22].

Table 2:- The way that individuals use cosmetics on a regular basis [26]

Variable	Female (N=288)(%)	Males (N=212)(%)	Total no. of people (N=500) (%)
Why do people use cosmetics? (Multiple responses)			
Attraction	50(17%)	45(21%)	95(19%)
Protection	197(68%)	123(58%)	365(73%)
Fashion	118(41%)	66(31%)	184(37%)
Other	8(3%)	8(4%)	16(3%)
While buying cosmetics, people take pricing into consideration.			
Yes	199(69%)	137(65%)	336(62%)
No	89(31%)	75(35%)	164(33%)
People who believe that wearing makeup enhances your beauty			
Yes	185(64%)	126(59%	311(62%)
no	103(36%)	86(41%)	189(38%)
Rupees per month spent on cosmetics			
<500	216(75%)	167(79%)	385(77%)
500-1000	63(22%)	32(15%)	95(19%)

>1000	9(3%)	13(6%)	20(4%)
regularly applying makeup (many responses)			
Hair oil	20(7%)	25(12%)	45(9%)
Shampoo	237(82%)	181(85%)	418(84%)
Hair jells	10(3%)	75(35%)	85(17%)
Moisturiser	149(52%)	51(24%)	200(40%)
Hair spray	4(1%)	8(4%)	12(2%)
Sunscreen	100(35%)	36(17%)	136(27%)
Soap	269(93%)	201(95%)	470(94%)
Perfume	111(39%)	108(51%)	219(44%)
Fairness cream	49(17%)	39(18%)	88(18%)
Deodorant	114(40%)	118(56%)	232(46%)
Hair oil	203(70%)	151(71%)	354(71%)

Toxicity of Nanoparticles

The potential harmful consequences of nanoparticles, if any, must be evaluated, just like with any other therapeutic under development. Before any treatment based on nanoparticles can be considered effective, the highest dose that can be tolerated must be compared to its effectiveness [1]. Research on nanotoxicology spanning two decades has demonstrated the great complexity of the interactions that exist between nanomaterials, cells, animals, humans, and the environment. Scholars are now endeavouring to comprehend how the physicochemical or other characteristics of nanomaterials govern these interactions and ascertain the ultimate impact of nanomaterials on the environment and human health. Computational techniques are becoming more necessary to prioritise safety investigations as novel nanomaterials are created and the use of animals for evaluation decreases. Because nanoparticles are being used more often in everyday life, it is important to weigh the potential hazards against the greater prospects [24]. The production process may change and manage a number of aspects that affect a nanoparticle's toxicity, including its size, capacity to aggregate, coating, structure, and surface characteristics. It has been demonstrated that poorly soluble nanoparticles can induce cancer and can display more obvious harm [25]. Although scientific research has demonstrated the potential toxicity of some nanoparticles to humans and the environment, there is presently no oversight over items made from nanomaterials (Fig. 2). The primary parameters in nano cytotoxicity, apart from particle-related aspects, are the provided dosage, mode of administration, and extent of tissue dispersion. Numerous investigations on inhaled solid particles have been carried out to examine the cytotoxic impact of nanoparticles with the same chemical structure, but varied sizes and fits of dose response relationships [24]. The surface area of nanoparticles may be harmful to human health when compared to large particles with the same mass concentration. The toxicity of the nanoparticles that are absorbed via the skin is also influenced by their chemical composition [25].

The level of exposure and the mode of entry of nanoparticles into the body dictate the potential health risks that individuals face. Humans may consume, breathe in, or have skin penetration come into touch with the nanoparticles [25].

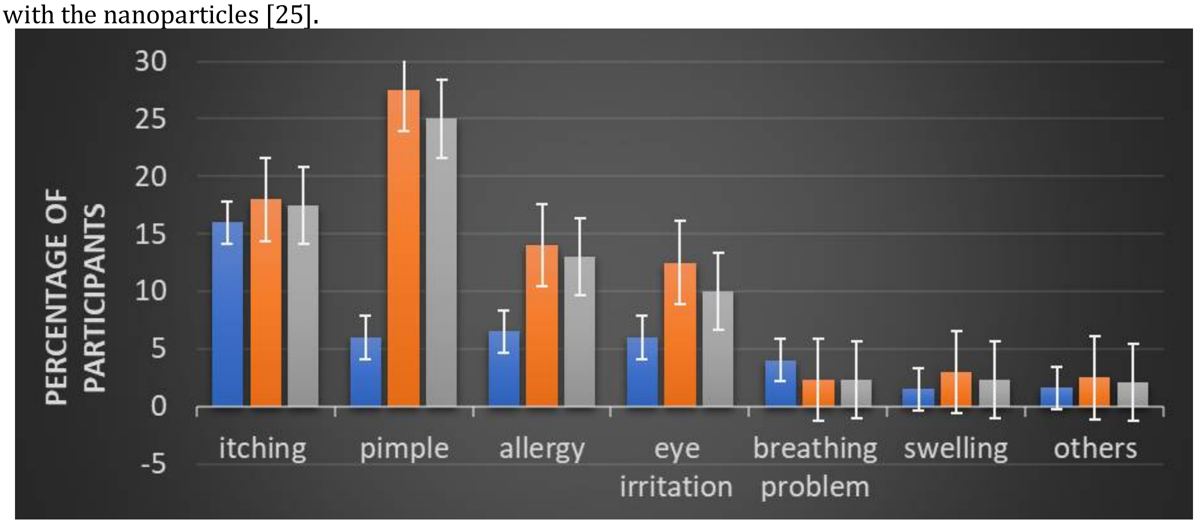

Fig. 2: Adverse reactions associated with cosmetics.

Limitations and Risks

In order for the surface area of a smaller particle to match its mass, less space is needed. Surface groups are now much more available for biologic interaction, which might result in the emergence of new allergies, haptens, irritants, and particle-particle interactions that weren't expected. According to this theory, a decrease in particle size has an exponentially large impact on a drug or material's potential for toxicity [17]. The characterisation and design of these materials come with a number of restrictions. These include our capacity to consistently create precise nanoparticle sizes and shapes, to load drugs into carriers in the best possible way, to control the administration and release of drugs and to create stable materials that don't produce harmful breakdown products [27-28]. Particle shape has been proposed as a major factor in the action transport and intracellular absorption of nanoparticles. However, our capacity to synthesise specially shaped particles has been constrained because of a dependence on emulsion-based technologies that often result in spherical, polydisperse particles. The capacity to induce the "triggered release" of medications from particle carriers at a particular target site for example, in reaction to a pH shift is another emerging field [27]. Particles that have size 7000 nm or less have ability to pass through skin, including damaged skin. Skin conditions that cause increased permeability include psoriasis, acne, seborrhoeic dermatitis, atopic dermatitis, and contact dermatitis. Simple actions like shaving or wounds like cuts, scrapes, or sunburns can make the skin more permeable. Shaving creams, toothpastes, sunscreens, and shampoos, Cosmetics are examples of skin care products that contain nanoparticles or nano emulsions; these products are frequently designed with penetration enhancers [17].

Critical determinants have a significant impact on penetration and toxicity in experimental studies. These include physicochemical factors such as shape, type, surface coating, size, stability, charge, and protein corona; they also include formulation factors like dispersing vehicles and experimental factors like concentration and exposure time. Additionally, external factors including UV exposure, heat fatigue, and NP aggregation must be considered. These factors might be the cause of the contradictory findings in last few researches [5]. Lastly, DNA and cell membranes may be harmed by nanoparticles. Nanomaterials have the potential to be poisonous or allergic at several cellular and subcellular levels once they get under the skin's surface [17, 28].

CONCLUSION AND FUTURE PROSPECTIVES

These days, a lot of sectors in the biomedical, dermatological, cosmetic, and cosmeceutical domains are appreciating and using nanotechnology as a promising and revolutionary technique. Nowadays, the world has increased its use of engineered nanomaterials. The improved qualities of it have also drawn interest from the dermatology sector. They changed their focus from cosmeceuticals to nanocosmeceuticals by implementing nanotechnology into their production procedures. These days, new nanocarriers such as ethosomes, liposomes, cubosomes, nanoemulsions, NLC, SLNs, niosomes, etc., are used to create beauty products and cosmeceuticals that work better. Through a variety of methods, nanosystems transport and distribute these formulations throughout the skin, performing a number of tasks like moisturising, UV protection, wrinkle reduction, and more. Though these nanoproducts have gaining inspiring market value, but there is tremendous argue regarding their safety and toxicity required more investigations. Therefore, the laws governing cosmetics should include a detailed list of requirements along with substances that won't have a negative environmental impact. Yet, there are now many questions about how safe these nanocosmetics are for the environment and for people. Therefore, strict laws should be implemented regarding the production, distribution, importation, and storage of cosmeceuticals and the nanoparticles that are used in them. To create uniform guidelines and regulations for the use of nanosystems in cosmetics and to help close the current gaps in the relevant data, researchers from all over the world must collaborate with regulatory bodies worldwide. In order to improve safety, efficacy, and marketing rules, it is necessary to harmonise laws across international borders. This will ultimately benefit the cosmetics industry and safeguard consumers from potential risks.

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Conflict of Interest

None

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REFERENCES
1. Youns M, Hoheisel JD, Efferth T. (2011). Therapeutic and diagnostic applications of nanoparticles. Curr Drug Targets. , 12(3), 357-65. http://dx.doi.org/10.2174/138945011794815257.
2. Salvioni L, Morelli L, Ochoa E, Labra M, Fiandra L, Palugan L, Prosperi D, Colombo M. (2021). The emerging role of nanotechnology in skincare. Adv Colloid Interface Sci. 293, 102437. http://dx.doi.org /10.1016 /j.cis.2021.102437.
3. Arif T, Adil M. (2016). Nanotechnology Dermatological Perspective. Int J Nanomed Nanosurg, 2(2). http:// dx.doi.org/10.16966/2470- 3206.112.
4. Sharma N, Singh S, Kanojia N, Grewal AS, Arora S. (2018). Nanotechnology: a modern contraption in cosmetics and dermatology. Appl Clin Res Clin Trials Regul Aff, 5(3), 147-158. https://doi.org/10.2174/ 221347 6x05666180 528093905
5. Wang M, Lai X, Shao L, Li L. (2018). Evaluation of immunoresponses and cytotoxicity from skin exposure to metallic nanoparticles. Int J Nanomedicine, 13, 4445-4459. https://doi.org/10.2147/ijn.s170745
6. Schneider M, Stracke F, Hansen S, Schaefer UF. (2009). Nanoparticles and their interactions with the dermal barrier. Dermato-endocrinology, 1(4), 197-206. https://doi.org/10.4161/derm.1.4.9501
7. Desai PR, Patlolla RR, Singh M. (2010). Interaction of nanoparticles and cell-penetrating peptides with skin for transdermal drug delivery. Mol Member Biol,27(7), 247-259. https://doi.org/10.3109/ 09687688.2010.522203.
8. Papakostas D, Rancan F, Sterry W, Blume-Peytavi U, Vogt A. (2011). Nanoparticles in dermatology. Arch Dermatol Res. 303(8), 533-550. https://doi.org/10.1007/s00403-011-1163-7
9. Michniak-Kohn B, Kohn J. (2023). Overcoming the barrier of skin to drug permeation for localized dermatological therapies. J Med Sci, 92(3), e926. https://doi.org/10.20883/medical.e926.
10. Filon FL, Mauro M, Adami G, Bovenzi M, Crosera M. (2015). Nanoparticles skin absorption: New aspects for a safety profile evaluation. Regul Toxicol Pharmacol, 72(2), 310-322. https://doi.org/10.1016/j.yrtph.2015.05.005
11. Gupta M, Agrawal U, Vyas S. (2012). Nanocarrier-based topical drug delivery for the treatment of skin diseases. Expert Opin Drug Deliv, 9(7), 783-804. https://doi.org/10.1517/17425247.2012.686490
12. Gautam, A., PhD, Singh, D., Vijayaraghavan, R., (2019). Acute Toxicity and Efficacy of Nanomaterial based Decontamination Formulation Developed for Personal Decontamination against Chemical Warfare Agents. Open Biomark J. 9(1), 40-54. https://doi.org/10.2174/1875318301909010040
13. Chen J, Shao R, Zhang XD, Chen C. (2013). Applications of nanotechnology for melanoma treatment, diagnosis, and theranostics. Int J Nanomedicine, 2677. https://doi.org/10.2147/ijn.s45429
14. Cassano R, Cuconato M, Calviello G, Serini S, Trombino S.(2021). Recent advances in nanotechnology for the treatment of melanoma. Molecules, *26*(4), 785. https://doi.org/10.3390/molecules26040785.
15. Krishnan V, Mitragotri S. (). Nanoparticles for topical drug delivery: Potential for skin cancer treatment. Adv Drug Deliv Rev, 2020, 153, 87-108. https://doi.org/10.1016/j.addr.2020.05.011
16. Khater D, Nsairat H, Odeh F, Saleh M, Jaber A, Alshaer W, Bawab AA and Mohammad S. Mubarak MS. (2021). Design, Preparation, and Characterization of Effective Dermal and Transdermal Lipid Nanoparticles: A Review. Cosmetics, 8(2), 39. https://doi.org/10.3390/cosmetics8020039
17. Saraceno R, Chiricozzi A, Gabellini M, Chimenti, S. (2011). Emerging applications of nanomedicine in dermatology. Skin Res Technol, 19(1). https://doi.org/10.1111/j.1600-0846.2011.00601.x
18. Palmer B C, DeLouise LA. (2016). Nanoparticle-Enabled transdermal drug delivery systems for enhanced dose control and tissue targeting. Molecules, 21(12), 1719. https://doi.org/10.3390/molecules21121719
19. Landriscina A, Rosen J, Friedman A. (2015). Nanotechnology, inflammation and the Skin Barrier: Innovative approaches for skin health and cosmesis. Cosmetics,*2*(2), 177–186. https://doi.org/10.3390/ cosmetics2020177
20. Naves LB, Dhand C, Venugopal JR, Lakshminarayanan R, Ramakrishna S, Almeida L. (2018). Nanotechnology for the treatment of melanoma skin cancer. Prog Biomater, 6(1-2), 13-26. https://doi.org/10.1007/s40204-017-0064-z
21. Niska K, Zielińska E, Radomski MW, & Inkielewicz-Stępniak I. (2010). Metal nanoparticles in dermatology and cosmetology: Interactions with human skin cells. Chemico-Biological Interactions. 295, 38-51. https://doi.org/10.1016/j.cbi.2017.06.018

22. Hameed A, Fatima GR, Malik K, Muqadas A, Fazal-ur-Rehman M. (2019). Scope of nanotechnology in cosmetics: dermatology and skin care products. J Med Chem Sci. 9-16. https://doi.org/10.26655/jmchemsci.2019.6.2
23. Tang JQ, Hou XY, Yang CS, Li YX, Xin Y, Guo WW, Wei ZP, Liu YQ, Jiang G. (2017). Recent developments in nanomedicine for melanoma treatment. Int J Cancer. 141(4): 646-653. doi: 10.1002/ijc.30708.
24. Hashempour S, Ghanbarzadeh S, Maibach HI, Ghorbani M, Hamishehkar H. (2019). Skin toxicity of topically applied nanoparticles. Ther Deliv. 10(6): 383-396. doi: 10.4155/tde-2018-0060.
25. Kaul S, Gulati N, Verma D, Mukherjee S, Nagaich U. (2018). Role of Nanotechnology in Cosmeceuticals: A Review of Recent Advances. J Pharm (Cairo). 3420204. doi: 10.1155/2018/3420204.
26. Rohilla S, Rohilla A, Narwal S, Dureja H, Bhagwat DP. (2023). Global Trends of Cosmeceutical in Nanotechnology: A review. Pharm Nanotechnol. 11(5), 410-424. https://doi.org/10.2174/2211738511666230508161611
27. Prow TW, Grice JE, Lin LL, Faye R, Butler MK, Becker W, Wurm EMT, Yoong C, Robertson TA, Soyer HP, Roberts M S. (2011). Nanoparticles and microparticles for skin drug delivery. Adv Drug Deliv Rev, 63(6), 470-491. https://doi.org/10.1016/j.addr.2011.01.012
28. Narwal S, Rohilla **S**, Rohilla A, Bhagwat DP.(2023). Role of Herbal Drugs in Treatment of Dermatologic Disorders: A Review. Int J Pharm Sci Nanotechnol, 16(3), 6575-6583. https://doi.org/10.37285/ijpsn.2023.16.3.11