INTERNATIONAL JOURNAL IN PHARMACEUTICAL SCIENCES

Journal Homepage: https://www.ijpsjournal.com

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Review Article

Nanotechnology and its Therapeutic and Cosmetic Applications: A Review

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ARTICLE INFO

Received: 05 Oct 2023
Accepted: 09 Oct 2023
Published: 11 Oct 2023
Keywords:
Nanoparticles, Nano formulations, Drug delivery, Cancer, Cosmetics
DOI:
10.5281/zenodo.8428579

ABSTRACT

The design, manufacture, characterisation, and use of structures, devices, and systems on the nanometric scale are the focus of the multidisciplinary scientific field known as nanotechnology. The design, characterization, production, and applications of structures, devices, and systems are all related to nanotechnology and can be controlled to improve patient compliance. Imaging, biosensor, and medication delivery systems are just a few examples of the pharmaceutical nanotechnology that is used in pharmacies. Pharmaceutical nanoparticles have diameters ranging from 5 nm to 300 nm and a variety of morphologies. They are sub-nanoscale structures comprised of several tens or hundreds of atoms or molecules. Drugs and bioactive substances are among them. The pharmaceutical industry's present use of nanotechnology includes the creation of biosensors, biomarkers, nanorobots, tissue engineering, and nanomedicine. Pharmaceutical nanotechnology has opportunities to enhance materials, medical equipment, and contribute to the creation of new technology in fields where more established and conventional technologies may have reached their limits. As a result, advancements in this field will open up new doors for the medical and pharmaceutical industries in the years to come. Disease detection and treatment have improved thanks to nanotechnology, which makes use of nanostructures as a tool. These particles frequently have surfactants and/or polymeric stabilizers attached to their surface, which stabilizes the pure active pharmaceutical ingredient (API) that makes up these particles. The common range of particle sizes is 1 nm to 1000 nm. This method has demonstrated promise in the treatment of AIDS, cancer, and numerous other conditions. The scope and opportunity of nanotechnology in pharmacy, the challenges and prospects for the field, and the future of nanotechnology in pharmacy are the main topics of this review article.

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Relevant conflicts of interest/financial disclosures: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

It also discusses recent advances in nanostructures and nanotechnology for medication delivery, nanomedicine, cures, drug discovery, cosmetics, and the delivery of medications.

INTRODUCTION

A thousand millionth of a meter (10^{9} ^{m}) is represented by the word nano, which is a reference to a Greek prefix that means dwarf or anything very little. Nanotechnology and nanoscience should be distinguished from one another. The technology that uses nanoscience in real-world applications, such as gadgets and other objects, is known as nanotechnology [1]. Nanoscience is the study of structures and molecules on scales of nanometers ranging from 1 to 100 nm. In a wide range of product sectors, research on nanotechnology and nanoscience has surged in recent years. It provides opportunities for the production of materials, particularly those for medical applications, whereas more conventional procedures could have their limitations. Applications of nanotechnology in pharmacy that provide intelligent and smart medicine delivery systems are predicted to become the most significant and efficient tool as a replacement for conventional dose forms. Pharmaceutical nanotechnology is a highly innovative field that is rapidly changing the pharmaceutical industry. Innovative opportunities to treat various illnesses are provided by pharmaceutical nanotechnology. According to Fulllerene Nanogears, it helps with the identification of viruses and bacteria as well as antigens connected to diseases like cancer, diabetes mellitus, and neurological disorders [2]. Nanotechnology has made substantial progress since the 1990s in a number of useful facets of health care. Nano-chips, for instance, are used in diagnostics to create self-testing and home diagnosis for a few illnesses.

The integration of numerous fields, including molecular biology, biophysics, biochemistry, and bioengineering, is what makes nanotechnology a multidisciplinary field. Nanomedicine refers to the application of nano (bio) technology in molecular diagnostics, as well as developments in the discovery, design, and delivery of drugs, including nanopharmaceuticals. Medical fields like tissue engineering, cancer, cardiology, immunology, brain targeting, gene delivery, etc. can all benefit from it. One of the areas with the most research is cancer drug targeting [2]. The design, characterization, production, and use of materials, devices, and systems at the nanoscale level (1-100 nm) are the core competencies of the cutting-edge scientific fields of nanotechnology and nanodelivery systems. In the field of cosmetics and cosmeceuticals, where nanotechnology is acknowledged as one of the revolutionizing technologies, substantial research has been done [3,4]. Global consumer demand has expanded as a result of advances in cosmetic science brought about by the inclusion of nanotechnology [5]. Due to their superior benefits to conventional cosmetic products, nanoparticles are currently drawing interest in this field. Additionally, the global growth in the market share of medicines and cosmetics has been significantly aided by the malfeasance of nanomaterials .Both sexes find pleasure in the usage of cosmetics, which have been around for a very long time and are generally employed for regenerative purposes. They can be described as preparations that are typically applied externally and that can be made from a single substance or a combination of substances that come from both natural and artificial sources [6].

Applications of Nanotechnology in Pharmaceutical

Drug delivery using nanotechnology

It is anticipated that the use of nanotechnology in drug delivery would fundamentally alter the pharmaceutical and biotechnology industries in the near future. A number of blockbuster drugs may soon lose their patent protection, and several pharmaceutical companies pipelines are predicted to be drying up. A total of twenty nanotechnology-based medicinal products have so far been given clinical approval. Among first-generation products, polymer drug conjugates and liposomal medications are the two most often used types [7-10].The potential uses of nanotechnology in medicine are enormous [11-14].These applications include disease detection, drug administration targeted at specific locations in the body, and molecular imaging. While the full impact of these technological advancements on human health care is still unknown, recent developments suggest that nanotechnology will have a significant impact on disease prevention, diagnosis, and treatment [15-18]. Since nanotechnology can be used to deliver biotechnology-based medications like proteins, peptides, or genes to the target tissue either locally or specifically [19].There has been a lot of research into developing nanotechnology for drug delivery in recent years. The best nanoparticle drug delivery system should be able to locate, recognize, bind to, and distribute its load to particular sick tissues while reducing or eliminating drug-induced injury to healthy tissues. In order to specifically target a ligand, the most common strategy is to encapsulate it on the surface of nanoparticles. These targeting ligands could be proteins, specialized proteins, peptides, small molecules, antibodies, nucleic acid aptamers, or small molecules [20].

Nanotechnology-enabled drug delivery systems with improved physical, chemical, and biological properties can be exploited as effective delivery methods for currently available bioactive substances. Examples of nano-based drug delivery mechanisms include polymeric nanoparticles, liposomes, dendrimers, polymeric micelles, polymer-drug conjugates, and antibody-drug conjugates. These can be roughly divided into I sustained and regulated delivery systems, II stimuli sensitive delivery systems, III functional systems for distribution of bioactives, and IV multifunctional systems for combined delivery of treatments, biosensing, and diagnostics [21].Large-scale materials create substantial challenges in drug administration, including in vivo instability, poor bioavailability and solubility, poor body absorption, problems with target-specific distribution and tonic efficacy, and possibly harmful pharmacological consequences. Adopting novel drug delivery techniques to direct drugs to certain bodily regions may therefore be an alternative for tackling these fundamental issues. As a result, nanotechnology is successfully being used in targeted drug delivery, improved drug formulations, and controlled drug release [22,23].

The toxicity of the drug contained may be reduced through the use of nanoparticles as drug carriers. The results of the nanoparticles themselves are not made public, but the toxicity of the complete formulation is generally investigated. It is therefore impossible to discriminate between the toxicity of drugs and nanoparticles. Therefore, it is important to emphasize the toxicity of "empty" non-drug filled particles. This is particularly important when using slowly degrading or non-degradable drug delivery particles that may exhibit persistence and aggregation at the drug delivery site, eventually causing persistent inflammatory reactions [24].

cardiovascular disorders and nanotechnology

Around the world, cardiovascular diseases continue to be a major cause of mortality and morbidity. The inability of adult cardiomyocytes to proliferate stops the heart from growing new myocardium after a myocardial ischemia event, gradually weakening the heart and possibly resulting in heart failure and death. Cardioprotective drugs should be introduced early on to prevent further heart cell death and improve cardiac function, although delivery methods and related adverse effects of these treatments may be problematic. Researchers have been able to improve drug targeting capability thanks to advancements in nanotechnology, specifically nanoparticles for drug administration. According to research, acute myocardial infarction (AMI), hypertension, atherosclerosis, stroke, and heart failure are only a few of the lethal and severe cardiovascular disorders (CVDs) that have a significant global financial and health impact [25,26].

In the near future, cardiovascular care will depend more and more on nanotechnology. Nanotechnology, a byproduct of research and development, uses structures, devices, and systems that are nanoscale (i.e., less than 100 nm) and have novel properties and capabilities related to the size and structure. Due to recent, quick advancements in nanotechnology and nanoscience, there are several opportunities for the treatment of cardiovascular disease. Nanotechnology and nanoscience produce novel molecular assemblies and design systems of self-assembly for individual cells by focusing on materials at the atomic, molecular, and super molecular levels [27].

Cancer treatment with nanotechnology

Lives have been saved by the medications currently used to treat cancer patients, but because chemotherapeutic drugs are nonspecific, there are serious adverse effects that affect the entire body. Cancer is a biological process that is so intricate that it could be described as a sickness of many diseases. One of the characteristics that sets malignant cells apart is their capacity to proliferate quickly and expand uncontrollably [28]. The detection and treatment of cancer may be revolutionized by nanotechnology. Some of the most popular cancer therapies include radiation, chemotherapy, immunotherapy, and surgery [21,29]. Some of the nanotechnologies that can be utilized to cure cancer include nano shells, nanocantilevers, nanoprobes, nanocrystals, nano polymers, quantum dots, and dendrimers [30,31].

The ability to detect tumors and get to the intended tumor site without damaging healthy cells are two key components of the development of nanomaterials for cancer therapy. Many nanoparticles have the potential to identify highly sensitive and particular cancer cells through a variety of ways. Due to their unique characteristics, these nanoparticles distinguish themselves from other cancer therapies [32]. Nanotechnology has completely changed the way that cancer is detected and treated. According to research, it is capable of recognizing even one malignant cell I*n vivo* and delivering drugs that are incredibly destructive to the diseased cells. When compared to free drug, nanocarriers have a significant impact on the biodistribution and pharmacokinetic characteristics of an anticancer agent. This is due to the nano size of the carrier [33]. The treatment of abnormal cells with these nanotools includes thermotherapy using carbon nanotubes and silica nano shells; chemotherapy using nanostructured polymer nanoparticles, dendrimers, and nano shells; and radiotherapy using carbon nanotubes and dendrimers. These nanotools also identify biomarkers or detect mutations in cancer cells [21,34].

Utilization of Nanotechnology for Cancer Treatment

Nanotechnology has shown tremendous potential for transforming cancer therapy by offering revolutionary techniques for the detection, treatment, and monitoring of cancer (Figure 1). A brief summary of a few significant uses is provided below:

Photothermal Therapy: By absorbing light energy and converting it to heat when exposed to laser light, nanoparticles can precisely target cancer cells. The treatment provided by this technique, known as photothermal therapy, is targeted and does little damage to surrounding tissues.

Nanoparticle-Mediated Radiotherapy: Nanoparticles can enhance the effects of radiation therapy by selectively aggregating in tumor cells and increasing their radiation sensitivity.

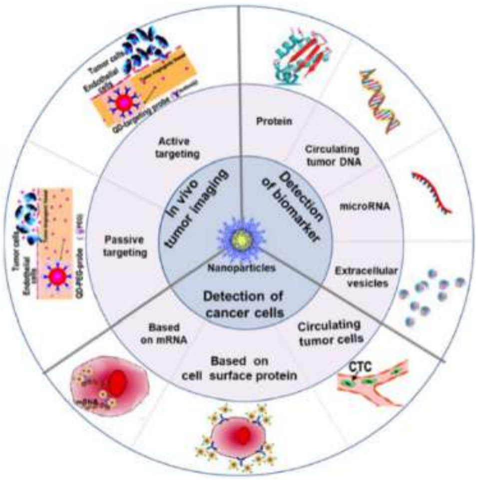

Figure 1: Nanotechnology applications for cancer diagnostics shown schematically.

Biosensors: Biosensors based on nanotechnology can detect substances linked to cancer at incredibly low quantities, assisting in the early diagnosis of illness and monitoring the course of disease.

Drug Resistance Mitigation: Nanotechnology approaches can help overcome drug resistance by employing several therapeutic compounds that simultaneously target different pathways within cancer cells.

Targeted Drug Delivery: Nanoparticles can be used to deliver chemotherapy drugs directly to tumor sites, minimizing side effects and harm to healthy cells. Engineering these nanoparticles to release the medication under controlled circumstances can enhance the therapeutic impact.

Hyperthermia: Nanoparticles can treat cancer by killing cancer cells while sparing healthy ones. The application of hyperthermia enhances the effectiveness of traditional treatments like radiation and chemotherapy.

Diagnostic imaging: Nanoparticles can be used as contrast agents in procedures like positron emission tomography (PET), computed tomography, and magnetic resonance imaging (MRI). These compounds help to make tumors and their characteristics easier to see.

Early detection: Nanotechnology allows for the development of extremely sensitive and narrowly targeted diagnostic instruments for the early identification of cancer biomarkers, which may lead to earlier intervention and better patient outcomes.

Individualized Medicine: Nanotechnology enables the development of individualized treatment plans by tailoring nanoparticles to each patient based on their unique genetic and molecular profiles. This could lead to drugs that are less harmful and more effective.

Theranostics: Theranostic nanoparticles combine therapeutic and diagnostic properties. They have the ability to deliver therapeutic chemicals to tumors while also providing immediate imaging feedback on the treatment's efficacy.

Gene delivery: It is feasible to deliver genetic material, such as siRNA or tools for gene editing, to cancer cells by altering nanoparticles. Using this approach, it may be feasible to target specific genes associated with the onset of cancer.

Enhancing Immunotherapy: Nanoparticles can enhance the immune system's response to cancer cells by facilitating the direct delivery of immunotherapeutic medicines, such as checkpoint inhibitors or cancer vaccines, to the tumor microenvironment.

But it's important to remember that many nanotechnology-based cancer treatments are still in the experimental or early clinical stages. More research, testing, and development are needed to properly understand their therapeutic impact.

Nanotechnology in cosmetics

The conventional cosmetics form has developed over time by incorporating changes and is now approved as a result of technical and scientific research. Research conducted *In vivo and In vitro* has demonstrated that cosmetic products are widely accepted, and the cosmetics industry provides innovative alternatives to this tendency with a selection of cutting-edge skin products [35]. Cosmeceuticals are cosmetics with physiologically active chemicals that have therapeutic effects on the surface applied. They are utilized as cosmetics because they promise to enhance beauty. There is a gap between personal care products and prescription drugs that is known as cosmetics. Since they are used to treat a wide range of conditions, including hair loss, wrinkles, photoaging, skin dryness, dark spots, uneven skin tone, hyperpigmentation, and others, cosmetic goods have been shown to have demonstrable therapeutic efficacy on the skin [36].Many contemporary cosmetic goods, such as moisturizers, hair care products, and makeup, contain nano-sized components. Since 1986, Christian Dior and Loreal have introduced liposome-based anti-aging topical formulations (such as creams, lotions, gels, and hydrogels) to the cosmetics market under the trade names CaptureTM and niosomes, respectively [37].

Nanoparticles are present in many cosmetic products. These products nanoscale components offer improved clarity, coverage, cleaning, or absorption. For instance, the titanium dioxide and zinc oxide nanoparticles used in sunscreen offer dependable, comprehensive protection from damaging UV rays.For a longer period of time, these nanomaterials provide superior light reflection. The applications of nano systems in cosmetics are discussed in light of their function in the various formulations on offer. These nanostructures can be found in a variety of cosmetic products, helping anti-aging or skin-whitening ACIs penetrate the skin, extending the wear time of makeup, serving as carriers for ACIs that fight bacteria in deodorants, and even being present in UV protection products [38]. Numerous nanoparticles found in cosmetic products that claim to promote skin absorption may actually be unstable when applied to the skin and unable to transfer chemicals below the skin's surface layer. However, they might increase the diffusion of cosmetics from the cosmetic vehicle into the epidermal layer, making the skin more responsive to them. Only insoluble, stable nanoparticles, like polymers, nanogold, nanosilver, and titanium dioxide, are formally recognized as having the ability to enter the body and pose a direct threat to health [39].

Utilizing Nano-Drug Delivery Systems in Cosmetics

Nanotechnology has recently offered fresh solutions to a number of issues in the pharmaceutical and medical industries. The same idea has been used to create unique formulations in the field of cosmetics known as nanocosmeceuticals, which offer specialized treatments for cosmeceutical issues. Smaller sizes have the possibility to gain new features such improved solubility, transparency, chemical reactivity, and stability, which may account for the novel benefits. The cosmetics business uses a variety of nanomaterials, including cubosomes, ethosomes, solid lipid nanoparticles, nanocapsules, dendrimers, nanocrystals, and nanoemulsions. Nanoscience-based cosmetic compositions are being widely commercialized. The next sections(Figure 2), provide an overview of numerous unique submicron-sized drug delivery systems utilized in the cosmetics industry to deliver active ingredients.

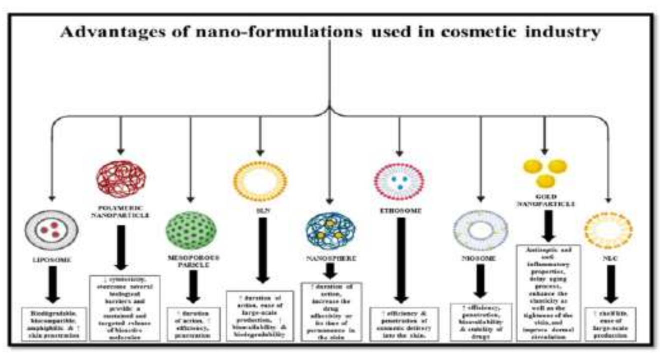

Figure 2: In the cosmetics sector, there are several different nanoformulations.

Micellar Nanoparticles

These have been utilized extensively in the beauty sector and are acknowledged as one of the most effective nanotechnology-based particles.They provide a strong and flexible framework for incorporating a variety of lipophilic active agents with different physicochemical properties in cosmetic compositions. The main characteristics of these particles that make them more effective than other nanocarriers include smaller particle size, greater encapsulation efficiency, and affordable manufacturing cost [40,41]. They are typically utilized as an alternative to traditional cleansers in skin washing products for the efficient removal of oil and dirt from the skin without impairing barrier integrity [42,43].

A revolution in transdermal drug delivery (TDD) has been brought about by these nanoparticles. For systemic drug administration via topical application, micellar nanoparticle-based emulsions are appealing possibilities. The method enables a high concentration of the medicine to penetrate the skin, resulting in a drug formulation that achieves the same advantages as TDD and is hence more tolerable. Different cosmetic companies assert that the most efficient solutions for washing the face are those that use micellar nanotechnology. In one of their studies, created a micellar shampoo and found that it was more viscous and had a greater capacity to emulsify fatty deposits than conventional shampoos [43].

Nanoliposomes

These are commonly employed as controlled release systems and are a nanometric variant of liposomes that can be defined as vesicles with concentric bilayers, where the fluid volume is enclosed by bilayers of phospholipids [44]. Because conventional liposomes are huge and contain another liposome inside of them, they have a limited ability to penetrate the skin or small blood arteries, whereas nanoliposomes do. They function as an incredibly adaptable nanomaterial in the cosmetics industry due to their biodegradability and biocompatibility [45]. Liposomal cosmetic compositions are more stable on the skin since they are difficult to wash off. Because they closely mirror the biological makeup of the skin, these are excellent transporters of cells and biomembranes and can be successfully applied to the skin. Additionally, they can be used to fix and transfer nutrients and to give body wash, lipstick, and deodorants pleasing fragrances [38,45].Due to the tiny size of the particles, nanoliposomes used in cosmetics improve the hydration of the skin, making it smooth and elastic. In cosmeceutical applications, they can serve as a TDDS by delivering active molecules to the deeper skin layers and even the systemic circulation. Their commercial applicability in beauty care products have been limited, however, because to difficulties with low medication stacking, low repeatability, and physicochemical fragility [46-48]. They are mostly used for moisturizing and anti-aging effects in the cosmetics industry.

Recently study showed how an innovative method, utilizing elastic nanoliposomes, can enhance the absorption profile of collagen peptides produced from Asteriaspectinifera. In addition to preventing light-induced aging by reducing the expression of MMP-1 (which is created when exposed to UV radiation), this combination of ingredients produced a formulation that showed promise [49,50]. It may also be employed as an environmentally acceptable source of materials for anti-aging cosmetics. Study also conducted on experiment to examine the moisturizing properties of commercial creams with nanoliposome creams containing skimmed donkey milk. They came to the conclusion that the cream with nanoliposome encapsulation has the ability to permeate deeper layers, producing a good amount of moisture with a quick rate of hydration, and may thus have anti-aging properties [51].

Ethosomes

The skin, which is the biggest organ in the human body, is known to prevent chemicals from entering the systemic circulation because it has a thick stratum corneum that serves as a vital physiological barrier. Soft, flexible vesicles called ethanolsomes are utilized to improve the transdermal administration of a range of cosmetic treatments because they contain a very high concentration of ethanol and lipids [52]. They can be tailored to include antioxidants, anti-aging ingredients, salicylic acid, and other cosmeceutical products that safely and effectively penetrate the skin. The skin may receive cosmetics applied topically significantly more effectively with these systems than with traditional liposomes [53].

The capacity of niacinamide and melatonin to permeate the skin more effectively has been demonstrated to be improved by the ethosomal formulation of these drugs [54]. According to another study, the active ingredient for phenylethyl resorcinol's skin-lightening effect was successfully transported into the skin via ethosomes integrating it [55,56]. According to one of the investigations done by Yücel et al., the liposomal formulation was less effective than transdermal application of ethosomes laden with rosmarinic acid, which has anti-aging characteristics. As compared to liposomes and the rosmarinic acid solution, the ethosomal formulation had a higher skin penetration profile and greater transdermal flux [57].According to results from both ex vivo permeability and hair growth experiments, Pravalika et al.'s investigation with ethosomal vesicles incorporating the baldness medication minoxidil revealed that the ethosomal gel had improved penetration when compared to other commercial formulations [58].

Nanostructured lipid carriers (NLCs) and solid lipid nanoparticles (SLNs)

These two cutting-edge delivery systems consist of a single layer of shells with a lipoidal center and are utilized to formulate both medicinal and cosmetic items [59,60]. These formulations are distinguished by a solid-state lipid matrix with a nanoscale dimension. The formulations tiny size allows for direct penetration of the corneum layer, which improves the penetration of active substances into the skin [61,62]. They exhibit enhanced safety and biocompatibility and work well as a transporter delivery mechanism in cosmeceutical applications [38]. To obtain positive results, SLNs have been incorporated into a number of dermal cosmetic products since 2005 [63,64].SLNs are frequently utilized in sunscreen formulation, serving as active transporters for molecular sunscreen ingredients. Compared to commonly used formulations, they require less sunscreen ingredient while yet providing the same level of protection. Tocopherol acetate was used in the formulation of SLNs to prevent chemical deterioration and to increase UV-blocking capacity [65]. Another study that included chitin, tocopherol, and chemical UV absorbers in SLNs revealed improved UVB protective action [66].They are ideal for cosmeceuticals that are used to treat irritated and itchy skin, dermatitis, and film development, which aids in the reinforcement and restoration of the skin barrier. In contrast to NLCs, which have relatively superior encapsulation, the crystalline form of SLNs results in less effective drug encapsulation. In comparison to NLCs, SLNs also have a shorter shelf life and slower drug release rates [63].

An experimental study that was recently conducted on an SLN formulation that included fucoxanthin (which protects against UVB light) found that the presence of the SLN carrier improved the bioavailability of fucoxanthin and can be a promising carrier for sunscreen cosmetics, showing greater stability and good sunscreen-boosting action [64,67]. Another study coupled the flavonoid's capacity as a natural antioxidant with NLCs to create an efficient approach for cell transport. Additionally, the developed NLCs were effectively integrated into the skin and did not significantly cause cytotoxicity, indicating that they may one day be utilized in moisturizing and anti-aging cosmetics [68].

Nanocrystals

These are molecular assemblies that range in size from 10 to 400 nm and are typically used to administer medications that are poorly soluble. They are composed of thousands of molecules arranged in a predefined pattern. Nanocrystals mostly contain bioactive substances and aid in accelerating their dissolving rate. The first commercially available product with rutin-containing nanocrystals was called "Juvedical" produced by Juvena in 2000 [69].According to a study, rutin nanocrystals have more bioactivity than the standard rutin glycoside [70]. The solubility and penetration profiles of the anti-pollution substance SymUrban were seen to noticeably enhance in its nanocrystal form in one of the most recent research conducted by Köpke et al. The weakly soluble active ingredient in SymUrban was made more dermally bioavailable by these nanocrystals, which also seemed to be an effective way to distribute the substance [71].

Nanoemulsions

Typically consist of colloidal solutions of water in oil (w/o) or oil in water (o/w) with a size between a few nanometers and 200 nm [72]. In contrast to conventional formulations, the droplets attractive visual, rheological, and enhanced drug delivery features are caused by their small size. Additionally, it is more well-liked because of its low viscosity, high solubilization capacity, and higher kinetic stability as a result of sedimentation and flocculation. These are often transparent and stable and used for cleaning, particularly in the beauty sector. In the cosmetics sector, these substances serve as potent carriers for the formulation of body lotions, skin creams, sunscreens, etc. Additionally, new medication delivery systems for fatty substances like fragrances, colors, essential oils, fatty acids, and emulsifiers are created using nanoemulsions. These delivery systems are ideal for delivering lipophilic substances because they increase their concentration in the skin. As a result, they are crucial in the development of cosmetic products. The rise in patent applications for nanoemulsions indicates the rising industrial interest in these substances [73]. A hydroglycolic extract of Opuntiaficus-indica Mill was used to create an O/W nanoemulsion, which has high strength and saturating capacity [74]. Additional research showed that nanoemulsions, specifically O/W nanoemulsions, could greatly improve the penetration profiles of polar components in comparison to standard emulsions that nanoemulsions might generally alter the distribution profiles of atoms[75,76].

Although they have many drawbacks, such as insolubility and instability, antioxidants are important in the cosmetic and pharmaceutical industries. Researchers have created antioxidant nanoemulsions with improved efficacy to solve these issues [77]. In one study, Zhang et al. created an oil-in-water nanoemulsion to solve the issues with ellagic acid's poor aqueous solubility. They came to the conclusion that the produced nanoformulation had improved skin permeability and water solubility, enhancing its whitening impact [78].

Nanocapsules

These are polymeric nanoparticles that contain an aqueous or lubricous phase. They are used in beauty care products to safeguard chemicals, cover offensive scents, and lessen compatibility problems between different formulation elements. Polymeric nanocapsule suspensions can be utilized as carriers or to apply directly to the skin after being fused into semisolid systems. Polymers and surfactants can be included in the formulation to control the degree of skin penetration [79].

In one work, durable poly-l-lactic acid nanocapsules with a size of about 115 nm were made via nanoprecipitation, and the successful establishment of the continuous release of fragrance was accomplished by encapsulating odorous atoms in a polymeric nano-transporter [80]. In order to increase the potency of antiperspirant formulations, this kind of encapsulation of atoms in biocompatible nanocapsules can play a significant role [46]. New stimuli-responsive nanocapsules were recently created by researchers to transport vitamins and extracts, and they were then put into semisolid formulations like lotions. When these formulations were applied to the skin, the nanocapsules were driven to release their active components at the specific site of the skin by factors brought on by injured skin, such as a pH shift and the presence of enzymes [81].Due to the inherent instability of perfluorocarbon emulsions, one study recently showed the successful inclusion of perfluorodecalin (an oxygen carrier) into a silica nanocapsule core as a new strategy for topical therapy of aged skin. Additionally, this combination outperformed emulsions in terms of delivery and stability [82]. Barbosa et al. created benzophenone-3-containing Pluronicnanocapsules made of poly(-caprolactone), carrot oil, and Pluronic for use in sunscreen formulations. These nanocapsules demonstrated synergistic SPF action with a non-irritant profile and enhanced the stability of the benzophenone in the topical formulation [83].

Dendrimers

Extensively branched three-dimensional nanostructured macromolecules called dendrimers are responsible for their remarkable flexibility [83]. Typically, they are polymers, and their stability makes them useful for delivering active substances through the skin [62]. These compounds can be employed more effectively in the formulation of antiperspirants and shampoos. Dendrimersbranches and surface movement are caused by the hydrophobic characteristics of their outer areas mixed with the hydrophilic characteristics of their inner sections [84].Additionally, attributes including monodispersion, polyvalence, and reliability make them perfect transporters for the administration of drugs and cosmetics [4]. Resveratrol dendrimers, which have antioxidant and anti-aging properties, have been created and have helped to improve general solubility and skin infiltration [85]. This has subsequently promoted the scaling up and commercialization of this formulation based on a dendrimer structure [46].

Cubosomes

Cubosomes are nanoparticles, especially fluid crystalline ones, comprising a particular surfactant mixed with the right amount of water in a nanostructure. The most prevalent surfactant utilized in the production of cubosomes is mono-glyceride glycerol monoolein. These unique nanostructured particles are used in antiperspirant treatments as well as cosmeceuticals in cosmetics compositions. Numerous studies conducted in partnership with cosmetic companies aim to use cubosomes as a stabilizer for oil-in-water emulsions as well as a means of removing contaminants from cosmeceutical formulations [42,86,87].

A cubosome formulation containing erythromycin was reported by Khan et al., who came to the conclusion that the aforementioned non-invasive formulation functioned in a prolonged-release manner, had better activity, and was more effective at preventing and treating acne [88]. Additionally, one of El-Komy et al.'s clinical research suggested that the created cubosomal topical gel formulation containing alpha-lipoic acid is a secure and effective substitute for treating skin aging issues [89].

CONCLUSION

The astounding advancements of nanotechnology in various treatment made possible by the application of nanotechnology are explored in this review article.The application of nanotechnology to the treatment of cancer has fundamentally changed the area of medicine by offering innovative answers to the shortcomings of current treatments. Currently, the fields of pharmaceuticals, cosmetics, cosmeceuticals, dermatology, and biomedical applications, among others, are using and appreciating nanotechnology, which is seen as a promising and revolutionary sector. Cosmetics and cosmeceuticals are becoming more popular as a result of the introduction of more recent innovations and unique drug delivery mechanisms, which also enhance market share. These cosmetics are now an essential component of daily life, and the addition of nanotechnology has increased their appeal among consumers all over the world. However, due to its penetrability, it is also poisonous, which is a key problem that is frequently disregarded and can have negative health effects. Currently, innovative nanocarriers used in the formulation of various cosmetics and cosmeceuticals with improved results include liposomes, ethosomes, cubosomes, NLC, SLNs, nanoemulsions, and niosomes. These compositions are carried and delivered by nanosystems throughout the skin using a variety of methods, and they provide many benefits like wrinkle reduction, moisturization, and UV protection. Although the commercial value of these nanomaterial goods is increasing significantly, there is a great deal of controversy around their safety and toxicity in humans, necessitating further research. Therefore, the cosmetic regulation should include a precise list of references and the ingredients that have unexpected environmental impacts for all users of cosmetic products, including consumers and professional users, in order to guarantee the safety of using cosmetic products. Before these goods are put on the market, long-term toxicology or carcinogenicity studies on cosmetics, including nanocosmetics and nanocosmeceuticals (and its components), should be carried out. Aiming to improve consumer health, nanocosmeceuticals should be produced in this way. In addition, to ensure the safety of the formulations in people, thorough clinical trials of cosmeceuticals should be carried out, similar to those performed for pharmaceuticals. The production, storage, import, and marketing of cosmetics and nanoparticles should also be subject to strict laws.

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HOW TO CITE: Abhijit Bhosle*, Dr. Nayana Baste, Nanotechnology and its Therapeutic and Cosmetic Applications: A Review, Int. J. in Pharm. Sci., 2023, Vol 1, Issue 10, 85-101. https://doi.org/10.5281/zenodo.8428579