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Nanodermatology: A Blessing or Bane?

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Editorial

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Introduction

Nanoscience represents the study of particles on an atomic or molecular scale, whose size is measured in nanometers. A nanometer is equal to one billionth of a meter (i.e., 10^{-9} m). Nanotechnology, employing the concept of nanoscience, is an emerging branch of engineering pertaining to the use of particles on a nanoscale (1-100 nm). Applying this novel concept of nanotechnology in the field of dermatology for diagnostic, therapeutic and preventive applications is the Nanodermatology [1]. Nanotechnology has revolutionized the treatment of several skin diseases by its armamentarium of nano particles each with different physico-chemical properties. At the present scenario, an increasing demand is felt by scientists and pharmaceutical companies throughout the world for nanodermatology. One of attributing factors can be the huge number of registered patients with regard to dermatology, particularly cosmetology [2].

The word "Nano" is derived from a Greek word "Nanos" which means "dwarf" [3]. It was Richard Feynman who is considered as the father of nanotechnology, gave the concept that molecules and atoms can be manipulated to form smaller components which are not visible to the naked eye [4]. However, the term nanotechnology was coined by Professor Norio Taniguchi. According to him, "Nanotechnology is a process of separating, consolidating and deforming materials atom by atom or molecule by molecule" [3]. Nanoparticles possess novel physical and chemical properties in contrast to the same material but without nanosize features making it quite interesting for researchers, engineers and various manufacturing companies. It is an innovative branch in the sense that it can unleash the new use of an already existing material without nanoscale features [2].

Types of nanoparticles

Nanoparticles are extremely small particles whose size range from 1 nm to 100 nm and behave and react as a total unit. These can be categorized on the basis of shape, size, structure, physical and chemical properties. Nanoparticles can take the shape of a sphere with a phospholipid covering (liposomes) or a vesicle with a polymeric membrane (nanocapsules) [5]. Lipid particles dispersed in an aqueous base [solid lipid nanoparticle (SLN)] are good hydrating and photopotective agents [6]. Some nanoparticles have a branched tree like structure (dendrimers) while some are formulated in a cube like shape (cubosomes). Fullerenes are comprised of carbon atoms packed in the form of a hollow tube, sphere or ellipse [7]. Nanocrystals are crystalline structures consisting of 10-400 nm size particles employed for delivery of poorly soluble drugs while Microsponges are formed of several beads that release drugs in a controlled fashion in response to stimuli like temperature, rubbing, pH and moisture [8,9]. Niosomes are nonionic surfactant vesicles having a high penetration and stability and Virosomes are liposomes consisting of viral proteins devised for delivery through vaccines [10,11].

Applications of Nanodermatology

Nanoparticles have diverse uses in dermatology which can be of therapeutic, diagnostic and preventive potential. However, some of the important uses of nanodermatology have been summed up in the table 1.

Sunscreens [12]	Nanoparticles of compounds like titanium dioxide (TiO_2) and zinc oxide (ZnO) have capability to reflect, adsorb or disperse UV- radiation.
Wound healing [13]	Nanoparticles containing chitin nanofibrils promote healing of wounds
Moisturisers [1]	Nanoemulsions, liposomes and SLNs are used as excellent vehicles for delivering moisturizers.
Acne [14-16]	Adapalene polymerized with Poly-lactic acid [PLA] and Poly (lactic-co-glycolic acid) [PLGA], tretinoin loaded in SLN, benzoyl peroxide in a microsphere formulation
Antiseptic agents [17-19]	Chlorhexidine gluconate employed as nano-formulation; nanosilver, uncoated TiO_2 are employed as antiseptic agents.
Inflammatory skin disease [20-25]	Liposomal formulations of corticosteroids, cyclosporine, methotrexate, tacrolimus, dithranol, SLN and NLC psoralens, and SLN encapsulated podophylotoxin.
Light based therapies and Lasers [26,27]	Nanoparticles of iron and Nanogold used as chromophores; Gold nanospheres for photothermal therapy.
Vaccination [28]	Nanosized liposomes for delivery of vaccines via topical route.
Treatment of cancer [26,29]	Nanogold for melanoma; dendrimers for delivery of chemotherapeutic agents for treatment of neoplastic diseases; Anti-tumor antibodies can be coupled with Gold nanospheres.
Diagnostic applications [30-34]	Optical fabrics for nanodiagnosis; quantum dots for the diagnosis and monitoring of several skin diseases; Nanogold as excellent labels for sensors; Sentinel node identification in skin cancers by quantum dots.
Diseases of hair [35,36]	Minoxidil formulations like liposomal minoxidil and Polyethylene glycol coated minoxidil have shown better performance in hair disorders; liposomal finasteride as alternative to oral finasteride
Cosmeceuticals [1,13,37]	Antiageing creams employing chitin nanofibrils, nanosomal proretinol A in antiageing and skin lightening creams; Nail paints with nano silver formulation; Nanoparticle based lip gloss and lipsticks; Cationic cericin nanoparticles as hair cosmetics,
Transdermal drug delivery [1]	SLN and NLC for transdermal drug delivery; Polymeric nanoparticles of Insulin.

Table 1: Applications of Nanodermatology.

Toxicity and Safety Concern

With the increasing demand for the use of nanoparticles, there is also a growing threat of unknown risks these particles can pose to humans and environment mainly because of their small size which imparts them unique physico-chemical properties [3]. The need for prescribing doctor to be aware of the nature and safety of drugs containing nanoparticles cannot be underestimated, in view of the above.

Nanoparticles of titanium and zinc have been widely used in sunscreen formulations in order to make them aesthetically pleasing. Studies have now revealed that these do not pose a risk since they are unable to penetrate the intact skin barrier [38]. However, when these sunscreens are applied to burnt, diseased and damaged skin, a theoretical risk can't be ruled out [39]. Oxides of Titanium on exposure to ultraviolet radiation produce free radicals which can damage nucleic acids, cell organelles and induce mutations in chromosomes [40].

Cobalt and chromium nanoparticles can penetrate the intact skin barrier and damage human fibroblasts [10]. Silver nanoparticles have been shown to be toxic to keratinocytes and skin fibroblasts [41]. These get deposited in the skin and produce a blue black skin discoloration called as agyria [42]. The organ which is most affected by nanosilver and nanogold toxicity is the liver [43]. In rats, nanoparticles of silver have shown to cause blood brain barrier disruption, astrocyte swelling and neural degeneration [44]. Carbon nanotubes simulate asbestos fibers in their behavior due to their long fine nature and can produce inflammation and mesothelioma [45]. Recent studies have shown that fullerenes being prothrombogenic may be toxic to the cardiovascular system [46]. There are controversial reports regarding the genotoxic potential of fullerenes. The photoactivity of fullerenes is believed to be responsible for the above toxicity [47]. Nanoparticles with superparamagnetic properties have revealed neurotoxic potential due to the generation of reactive oxygen species, impairment of mitochondrial function and leakage of lactate dehydrogenase [48].

Conclusion

Though the use of nanotechnology is a relatively new concept, but it has gained a widespread popularity in different fields like chemistry, engineering, medicine, etc. In dermatology and cosmetology, it has introduced diagnostic, therapeutic and preventive indications. However, there is also a growing alarm that these nanoparticles are associated with considerable toxic effects on the humans and the environment alike. Main toxicities of nanoparticles include tissue inflammation, teratogenicity, cytotoxicity and carcinogenicity. Hence, a meticulous evaluation of these nanoparticles using standardized techniques to determine their full toxic potential, before prescribing them on a large scale of population is our moral and ethical duty.

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