

Nanotechnology in Dermatology

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Abstract

Nanoscience is the branch of science dealing with study of minute particles on an atomic or molecular scale, whose size is measured in nanometers which is one billionth of a meter (i.e., 10⁻⁹ m). Nanotechnology is a branch of engineering which uses particles on a nanoscale. In dermatology and cosmeceuticals, the use of nanotechnology has been aggrandizing since its inception. The possible applications of nanotechnology in this field of science are diverse. Some of the significant indications comprises sunscreens, moisturizers, anti-aging formulations, phototherapy, anti-sepsis, vaccines, skin cancers, hair and nail care, antimicrobials, skin fillers, corticosteroids, visualization of tumors and sentinel lymph nodes, etc.

Keywords: Nanotechnology, Dermatology, Cosmeceuticals, Particles

INTRODUCTION

The application of this novel technology has revolutionized the treatment and diagnostic modalities of several skin diseases. An aggrandizing need is seen among scientists and pharmaceutical companies for nano dermatology which is dictated by the exponential number of registered patients with regard to dermatology, particularly cosmetology

(Fang, 2004). The term “Nano” in nanotechnology has been derived from a Greek word “Nanos” which means “dwarf”. The use of nanotechnology dates back to erstwhile, approx. 4000 years when prehistoric Egyptians, Romans and Greek researchers were applying the concept of nanotechnology in hair dye preparations (Farkas et al., 2011). Nanodivde is a very sensitive area in

nanotechnology (Sreeremya, 2017a). Among the nano technological advancement nanosuspension is the major technique implemented along with the link of pharmacology and nanotechnology (Sreeremya, 2017b).

HISTORY

Richard Feynman introduced the concept of manipulating atoms and molecules resulting in very minute components which are typically not visible to the naked eye. It was Professor Norio Taniguchi who described the term nanotechnology. According to him, "Nanotechnology is a process of separating, consolidating and deforming materials atom by atom or molecule by molecule". Nanotechnology is majorly concerned about how materials react or work at atomic, subatomic or molecular level (i.e., nano scale.). Nanotechnology involves the manipulation of matter in the size range of 1- 100 nanometers approximately while the atoms are about one third of a nanometer. Hence particles with such a size range are termed nanoparticles. These nanoparticles exhibit novel physicochemical properties in comparison to the same material without nanoscale characteristics which makes it an interesting field of research and technology. It is surprising to know that

nanotechnology can introduce a new use of an already existing material.

NANOPARTICLES IN DERMAL AND COSMETIC PREPARATIONS

Nanoparticles are very small substances with size ranging from 1 nm to 100 nm and behave and react as a total unit. They can be typed into various types according to their size, surface, shape and physicochemical Properties. The various types of nanoparticles majorly availed in dermatology and cosmetics have been described as under (Nasir, 2008).

Types of Nanoparticles

Nanoparticles can be classified on the basis of size, shape structure, physical and chemical properties. Nanoparticles can be spherical with a phospholipid covering, termed liposomes or vesicle with a polymeric membrane, called nanocapsules. Lipid particles in an aqueous base named solid lipid nanoparticle have hydrating photo protective properties. Drugs can be conjugated with lipids for aggrandizing drug loading and targeted release .Semipolymeric nanoparticles with a typically branched tree like structure are called dendrimers, while those packed in a cube like shape are cubosomes (Oberdoester et al., 2005). Fullerenes are carbon atoms arranged in the form of a

hollow tube, sphere or ellipse .Nanocrystal is the crystalline arrangement of 10-400 nm size particles used for delivering poorly soluble drugs (Nasir, 2010). Gold and silver nanoparticles are utilized for strong antiseptic properties (Morganti et al., 2008). Nonionic surfactant vesicles called niosomes have high penetration and stability .Microsponges are microporous beads that have regulated drug releasing property, particularly responding to rubbing, temperature, pH and moisture . Virosomes are viral proteins in liposomes and availed in vaccines (Muzzarelli et al., 1993).

Liposomes

Mezei and Gulasekharam, the two renowned researchers reported the efficacy of liposomes as a topical drug delivery system. The size of a Liposome usually differs from 20 nm to a few hundred micrometers (Morganti et al., 2004). These are basically spherical vesicles in which a part of the solvent is sequestered in a phospholipid bilayer (Muzzarelli et al., 2005). Their ability to protect the encapsulated drug from external environment makes them suitable for delivery of both hydrophobic as well as hydrophilic compounds (Stern et al., 2008).

APPLICATIONS

Nanoparticle Skin Penetration

Fueled by the expanding commercialization of products that includes engineered nanoparticles such as carbon nanotubes that strengthen everyday products including bicycle frames, tennis, and badminton rackets , and principally by the use of TiO₂ and ZnO nanoparticles in cosmetics and sunscreens for UVR protection(Muzzarelli et al.,1999), researchers in the nano toxicology field have typically sought to determine the conditions under which nanoparticles may penetrate the stratum and how the nanoparticle physiochemical features may influence penetration, systemic translocation, and toxicity(Endo et al.,2004). Most work in this area has focused on engineered nanoparticles; however, a connection to skin aging from exposure to soot and fine dust nanoparticles allied with traffic-related air pollution has recently been reported in this journal (Elder et al., 2009). The question of nanoparticle skin penetration from unintended exposure is clearly significant from an environmental and occupational health and safety standpoint (Elliott, 2010). Conversely, to be useful in therapeutic applications, nanoparticles must be able to penetrate the skin barrier, deliver their payload, and clear from the

body without adverse side effects (Dubina et al., 2009).

Nanoparticle penetration through a chronically defective skin barrier (i.e., open wounds) is not contested; however, despite nearly 15 years of active analysis, a debate still lingers on whether nanoparticles can penetrate healthy or a mildly defected skin barrier (Dhar et al., 2011). This lack of consensus stems, in part, from the wide diversity of in vivo and ex vivo skin models and nanoparticle types available, as well as limitations in analytical tools and instrument sensitivity to detect isolated nanoparticles (Diepgen et al., 1999).

Epidermal thickness and hair follicle density differs widely among species and anatomical locations, and these differences will affect nanoparticle skin penetration, making it difficult to draw conclusions from the decades literature base (De Jong et al., 2008). Nevertheless, trends are beginning to emerge. For example, (1) qualitative studies suggest that healthy human skin constitutes a formidable barrier to nanoparticle penetration, (2) hair follicles comprise (Debbage, 2009).

NANOMEDICINE AND NANOSURGERY

Skin Penetration by Topical Formulations

The skin is one of the largest organs of the body and garners ample opportunities for nanoparticles to act (Davis et al., 2010). Any topical delivery system intended for systemic effects has to traverse the barrier formed by surface lipids, stratum corneum and other epidermal layers to reach the dermis where blood vessels are situated. Substances use one of the three possible ways to traverse the epithelial barrier (Dussert et al., 1997). Trans cellular permeation, where substances need to pass through cells of stratum corneum and intercellular lipids; trans-append ageal permeation, where solute passes through hair follicles and sweat ducts ; and the intercellular permeation where solutes pass tortuously via the extracellular lipids between stratum corneum cells (Cross et al., 2007).

Particles of size greater than 500 Daltons cannot pass through intact skin. Hair follicles can be represented as micro-channels and are used as a conduit for the entry of such larger particles. It has been observed that particles of size as large as 10 micrometers can penetrate the hair follicle orifice. Nanotechnology helps

mainly in drug permeation by releasing active substances at specific sites, increasing stability, ensuring adequate contact, enhancing stability and reducing the need of chemical enhancers (BiaginiBiagini et al., 2008).

CONCLUSION

Nanoparticles are emerging field of science. There are many researches carried out throughout the world. Out of the research carried out globally 3% of nanotechnology research is carried out in India. This paper caters the different types of nanotechnology and how nanoparticles effect the skin.

REFERNCES

- I. BiaginiG, Zizzi A, Giantomassi F. Cutaneous absorption of nanostructured chitin associated with natural synergistic molecules (lutein). *J Appl Cosmetol.* 2008;26:69–80.
- II. Cross SE, Innes B, Roberts MS, Tsuzuki T, Robertson TA, McCormick P. Human skin penetration of sunscreen nanoparticles: In vitro assessment of a novel micronized zinc oxide formulation. *Skin Pharmacol Physiol.* 2007;20:148–154.
- III. Dussert AS, Gooris E. Characterization of the mineral content of a physical sunscreen emulsion and its distribution onto human stratum corneum. *Int J Cosmet Sci.* 1997;19:119–129.
- IV. Davis ME, Zuckerman JE, Choi CHJ . (2010) Evidence of RNAi in humans from systemically administered siRNA via targeted nanoparticles. *Nature* 464:1067–70
- V. Debbage P (2009) Targeted drugs and nanomedicine: present and future. *Curr Pharm Des* 15:153–72
- VI. De Jong WH, Borm PJA (2008) Drug delivery and nanoparticles: applications and hazards. *Int J Nanomed* 3:133–49.
- VII. Dhar S, Kolishetti N, Lippard SJ . (2011) Targeted delivery of a cisplatin prodrug for safer and more effective prostate cancer therapy in vivo. *Proc Natl Acad Sci USA* 108:1850–5

- VIII.** Diepgen TL, Coenraads PJ (1999) The epidemiology of occupational contact dermatitis. *Int Arch Occup Environ Health* 72:496–506
- IX.** Dowling A, Cliff R, Grobert N . (2004) Nanoscience and Nanotechnologies: Opportunities and Uncertainties. London: The Royal Society & The Royal Academy of Engineering. Report 44, 7–10
- X.** Dubina M, Goldenberg G (2009) Viral-associated nonmelanoma skin cancers: a review. *Am J Dermatopathol* 31:561–73
- XI.** Elder A, Vidyasagar S, DeLouise L (2009) Physicochemical factors that affect metal and metal oxide nanoparticle passage across epithelial barriers. *Wiley Interdiscip Rev Nanomed Nanobiotechnol* 1:434–50
- XII.** Elliott C (2010) The effects of silver dressings on chronic and burns wound healing. *Br J Nurs* 19:S32–6
- XIII.** Endo M, Hayashi T, Kim YA. (2004) Applications of carbon nanotubes in the twenty-first century. *Phil Trans R Soc Lond A* 362:2223–38
- XIV.** Fang FC (2004) Antimicrobial reactive oxygen and nitrogen species: concepts and controversies. *Nat Rev Micro* 2:820–32
- XV.** Farkas J, Peter H, Christian P . (2011) Characterization of the effluent from a nanosilver producing washing machine. *Environ Int* 37:1057–62.
- XVI.** Nasir A. The Future of Nanotechnology in Dermatology. *US Dermatology*. 2008;3:9-13.
- XVII.** Nasir A. Nanotechnology and dermatology: part I-potential of nanotechnology. *Clin Dermatol*. 2010;28:458-66.
- XVIII.** Oberdoester G, Oberdoester E, Oberdoester J. Nanotoxicology: an emerging discipline evolving from studies of ultrafine particles. *Environ Health Perspect*. 2005;113(7):823–839.

- XIX.** Morganti P, Morganti G. Chitin nanofibrils for advanced cosmeceutical. *Clin Dermatol.* 2008;26:334–340.
- XX.** Muzzarelli RAA, Chitin and its derivatives: new trends off applied research. *Carbohydr Polym.* 1993;3:53–75.
- XXI.** Muzzarelli RAA, Mattioli-Belmonte M, Pugnali A. Biochemistry, histology and clinical uses of chitins and chitosans in wound healing. In: Jollés P, Muzzarelli RAA, editors. *Chitin and Chitinases*. Basel, Switzerland: Birkhäuser Verlag; 1999:251–264.
- XXII.** Muzzarelli RAA, Muzzarelli C. Chitin nanofibrils. In: Dutta PK, editor. *Chitin and Chitosan: Research Opportunities and Challenges*. Contai, India: SSM International Publication; 2005:129–146.
- XXIII.** Morganti P, Fabrizi G, Bruno C. Protective effects of oral antioxidants on skin and eye function. *Skinmed.* 2004;3(6):310–316.
- XXIV.** Stern ST, McNeil SE. Nanotechnology safety concerns revisited. *Review Toxicol Sci.* 2008;101:4–21.
- XXV.** Sreeremya S., Biosynthesis of Nanoparticles: Review, (2017a) *International Journal of Nanomaterials and Nanostructures*, Vol. 3: Issue 1, pp:28-35.
- XXVI.** Sreeremya S., Nanodivide: Review, (2017b), *International Journal of Computational Biology and Bioinformatics*, Vol. 3: Issue 2, 24-25.