

“Nano Present” and “Nano Future”: The Growing Role of Shrinking Technology in Dermatology, Part 2

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This is part 2 of a 2-part series. In this part, Dr. Nasir examines the use of nanoparticles in products for special sites including the hair and nails, as well as products for the 5 senses.

The use of nanotechnology in medicine and dermatology is too broad to be covered in its entirety. This review is by no means comprehensive and covers only a small subset of applications of nanotechnology in cosmetic dermatology. It is hoped that readers will get a sense of the promises and challenges of nanotechnology, as well as future applications and safety concerns. The bulk of this review was devoted to cosmetic products for the face, which was featured in part 1 of this series. This smaller portion touches on some of the uses of nanotechnology for specific body parts and for the 5 senses.

PRODUCTS FOR SPECIAL SITES

Hair

Goals for manufacturers are providing shape, moisture, shine, texture, and thickness to the hair. Pureology Hair Care manufactures several products, including NanoWorks Shampoo and NanoWorks Conditioner. These products contain antifrizz agents that give the hair polish and

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Disclaimer: In this article, trade names are used, and much of the information mentioned on each product comes directly from manufacturers' publicly available sources (eg, package inserts and corporate advertising in print and electronic media). Redacted comments are in quotation marks and block quotes, and manufacturers declined to provide the author with proprietary, corroborative, or contradictory information. Some products have been discontinued but may still be available.

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color protection. The color protector is DryShine, a patented set of reflective nanomica, which is shiny but not greasy or stiff in texture. The NanoWax is a nanoparticulate polymer resin made from orange peel wax to allow structure, pliability, and shaping of the hair. Minoxidil is being tested in nanodelivery vehicles designed to enhance penetration. Zotos International, Inc, manufactures the Bain de Terre Recovery Complex Anti-Frizz Silky Shine Serum, which contains nanospheres that deliver multifunctional active ingredients to the hair. The nanospheres are positively charged and adhere best to the damaged areas of the hair. The goal is to reduce the appearance of frizz and fragility.

Nails

Ideal products attempt to increase nail health, strength, length, and improve surface texture and color. Kara Vita makes Cuticle Tender, which exfoliates, moisturizes, and protects the periungual skin. The manufacturer claims proprietary enzymes remove dry, dead skin, and nanospheres containing emollients hydrate for the entire day.

Eyes

Enhancing the eyes' appearance can involve cosmetics that provide highlights or camouflage imperfections, topical muscle relaxers that reduce fine lines, and mascara or topical treatments that thicken and lengthen eyelashes. AMOREPACIFIC Corporation manufactures Time Response Eye Renewal Creme with nanodelivery technology, which purports to treat the eye area. The manufacturer reports that "skin appears perfected, firm, evenly toned, and immersed in moisture."¹ The key ingredient is epigallocatechin gallate, a polyphenol found in green tea, and an antioxidant that reduces oxidative degradation of collagen and elastin. Lancôme Rénergie Microlift Eye R.A.R.E. uses the same polymer networks of silica nanoparticles and proteins to lift and tighten the periorbital skin as in the rest of its Rénergie line. The manufacturer claims that its Firming Complex adapts microlift technology specifically for the eyes to reinforce the firming benefits, as well as reduce puffiness and dark circles.¹

Lips

At one point, DERMAdoctor manufactured POUTlandish Hyper Moisturizing Lip Paint & Treatment, which contained zinc oxide to provide sun protection. Manufacturer literature claimed²

Poutlandish is the next big thing – by offering something much, much smaller. It exploits "nanofine" zinc oxide particles to provide SPF protection that is invisibly transparent. One nanoparticle equals about 1 - 80,000th of the diameter of a human hair. Zinc Oxide particles in Poutlandish measure only 25nm!

The manufacturer added that lips retain full definition and diminution of vertical lines. In addition, the manufacturer claimed moisturizers in the products keep the lips looking moist, and added antioxidants prevent free radical damage. Lancôme also manufactured Primordiale Optimum Lip, which¹

Delivers 100% Botanically Pure Vitamin E—via Nanocapsule® technology—and Gatuline, a gentle alpha-hydroxy-acid alternative, to reduce lipstick bleeding and feathering due to fine lines and wrinkles.

Kara Vita makes Lip Tender, which the manufacturer claims is³

More than a lip plumper, this 4-in-1 fast-acting formula provides lasting moisture, nourishing age correction and protection from daily stress while nanosphere-delivered peptides stimulate collagen production for plumper, healthier lips.

Teeth

Efforts regarding dental care target enamel strength and enamel appearance, including color, surface texture, and preventing and treating disease, pitting, plaque, and gingivitis. Song-Sing Nano Technology Co, Ltd, makes the Nano Toothbrush, which uses nanosilver as its active ingredient. NanoGold Toothpaste is a cutting-edge toothpaste with innovative nanotechnology. It contains pure nanoparticles of gold that are highly effective in disinfecting the bacteria in the mouth. It also contains acid-tocopherol, hydrated silica, fluorine, phosphoric acid, and sodium, among others. Nano Gold Toothpaste is more effective in cleaning, whitening, and improving the aesthetic appearance and health of teeth. Using nanoparticles, Japan's Sangi Company, Ltd, has sold more than 50 million tubes of toothpaste and continues to expand its line of products containing nanoparticles. The company has learned to synthesize hydroxylapatite, a key component of tooth enamel, as nanocrystals. When nanohydroxylapatite is used in toothpaste, it forms a protective film on tooth enamel, and even restores the surface in damaged areas. Similar products that claim to actually repair cavities will be available soon.

Body

The manufacturers of Eczemel Nano-Cream, dermaviduals, capitalized on the affinity of nanoparticles to the stratum corneum. The particles are nanoliposomes made of monolayers of phosphatidylcholine and contain and transport active ingredients into the epidermis. These include coenzyme Q10, vitamins A and E, and γ -linoleic acid (from primrose oil). The purpose of this combination was to enhance barrier function, reduce transepidermal water loss, increase skin hydration, and support epithelialization. Eczemel Nano-Cream was marketed to treat eczema and has been discontinued.

PRODUCTS FOR THE SENSES

Sight

Mentioned previously, nanoparticles can be made more visible, less visible, or chameleonlike and can alter the appearance of the skin's color and texture. By directing light, they can even change the shape and volume of the face. It should be possible to create cosmetics that are reflective in order to make the face more visible at night. Furthermore, it should be possible to create cosmetics that register physiology, such as body temperature. If these are coupled with neutralizing dyes, such cosmetics could minimize flushing from rosacea or embarrassment. In the distant future, cosmetics that utilize nanotechnology may be incorporated into

circuitry that emits light in pixels or patterns tailored to individual preferences. Tattoos created with nanotechnology could be biodegradable and more easily reversible. They may also be available in a wider variety of hues.

Sound

No one has yet created a cosmetic capable of manipulating sound, but this is not unthinkable. The sound properties of nanotubes are currently being studied. It may be possible to create products with the ability to augment or dampen environmental sounds, or tune us into sounds we normally do not hear.

Touch

The term *cosmetically elegant* is used in dermatology to refer to the patient's perception of the product. Nanoparticles can be used to elicit a wide variety of tactile features, including feedback, grip, and smoothness. It may be possible to create a topical agent that changes the skin's texture depending on the location, such as reducing friction in the skin's folds and enhancing friction in the palms and fingertips.

Taste

The sensation of taste can be uplifting and can transport us to another time and place as readily and as powerfully as the sensation of smell. Some lipsticks are already flavored, and the range or durability of cosmetic flavors may be easier to manipulate with nanotechnology. It should be possible to package taste in nanomaterials that do not dull with time, change during the course of the day, or change in response to environmental or personal circumstances.

Smell

Fragrances can evoke vivid memories and emotions. Fragrances made with volatile organics may lose their scent or be associated with an allergy. This could potentially be obviated with nanotechnology to create new scents or mask fragrances. At one point, Chanel manufactured Calming Emulsion and Coco Mademoiselle Fresh Moisture Mist both of which are fragrances that used ultralight nanoemulsion particles that hydrate and prolong fragrance. Future cosmetics in time-released packages may emit fragrances in a cyclic or pulsatile fashion. Furthermore, fragrances packaged in particles coated with receptors for certain odors could be released in the presence of odors. This could either mask undesirable odors or be used as a signal. For example, if 2 people wore matching fragrances, they could sense each other's presence before seeing or hearing them.

PRODUCTS THAT PROVIDE FEEDBACK

Features of makeup could be manipulated to be responsive to stimuli, such as body temperature or electrical or magnetic fields. For example, temperature sensing, self-correcting makeup could activate a camouflage tint during the flushing of rosacea. It may also be a better heat sink and make patients feel less warm during flushes. Absorbent particles could wick moisture via a self-assembled capillary network from axillary skin to the arms to reduce the effects of hyperhidrosis. Moisture sensitive nanofragrances could be released only during axillary sweating. Fragrance release could be pulsatile to avoid olfactory adaptation in the subject and in bystanders. The possibilities are staggering, and this is the reason for excitement about nanotechnology. In forensics, masking fragrances could be released upon interaction with strong odors. In the military, nanodetectors in facial paint could elute certain fragrances based on nearby biological or chemical hazards.

PRODUCTS IN SALONS

Cosmetologists and salons will soon be exposed to nanotechnology, either through products available in treatment salons, spas, and medical spas, or through devices and instruments used to reduce the spread of infection. For example, Nano Care Technology, Ltd, produces antibacterial makeup instruments. These are manufactured with nanoparticles of silver coating that can be applied to metal products such as water taps, door locks, knives, forks, scissors, or trays. The company notes that in salons,¹

people merely notice that the hairdressing tools and appliances are polluted with bacteria and microbial and people might get infections by tiny injuries. After people cutting finger nails with scissors, the bacteria or microbial always stay on the surface and chinks of the scissors. Bacteria and microbial transferred when the next people use them...Our technology uses an easily applied coating means make the appliances antibacterial and durable and the hairdressing appliance producers don't have to go back to the design board to change the shape of their products. The appliance processed by this means can effectively protect people from the hairdressing-related infections such as trachoma, conjunctivitis, virosis hepatitis, dermatitis and AIDS.

SAFETY

No discussion about nanotechnology is complete without mentioning safety. Naturally, as the proliferation of nanomaterials in skin care products, the environment, and the workplace accelerates, legitimate concerns take center stage.⁴⁻⁶ The potential for nanoparticles to generate

reactive oxygen species, which can damage nucleic acids, proteins, and membrane lipids has been amply demonstrated, even for inert materials such as titanium dioxide. The potential for nanomaterials to penetrate intact skin in animal models and human ex vivo models has been amply demonstrated.^{1,2,7-21} The penetration can be enhanced with certain vehicles, with flexion of the skin, and in damaged skin (eg, UV burned). It is also likely to be greater through intertriginous skin, skin with impaired barrier function (eg, in atopic dermatitis, contact dermatitis, seborrheic dermatitis, and psoriasis), or skin which has been cosmetically enhanced (eg, through laser resurfacing, chemical peels, or dermabrasion). In addition, systemic entry of nanomaterials through the eyes, nose, mouth, and other orifices is not difficult to conceive. Toxicities from these exposures have been shown.²²⁻³⁸ The potential for exposure of infants and children already exists, as does the potential for exposure to fetuses in pregnant women.

As a result of these concerns and consumer group feedback, nanotechnology, once touted as a buzzword, may be going underground. Since writing this review, several products based on nanotechnology are no longer available from the manufacturers. In one survey, 67 companies were asked if they had nanomaterials in their products; however, only 8 replied. In a 2007 study, *Consumer Reports* determined that all 8 of its tested sunscreens containing zinc oxide or titanium dioxide contained nanoparticles. Only one manufacturer disclosed this fact. The others did not mention the presence or absence of nanoparticles. In October 2008, *Consumer Reports* reported that among the companies that stated their sunscreens did not contain nanomaterials, only 1 of 5 companies was accurate in their claims. In the *Consumer Reports* study, Aubrey Organics Natural Sun SPF 25 Green Tea Protective Sunscreen, Badger SPF 30 Sunscreen, Kiss My Face SPF 30 Sun Screen with oat protein complex, and Mexitan SPF 30 Sunscreen contained nanoparticles despite claims to the contrary; only one product, Zinka Colored Nosecoat, was free of nanoparticles.³⁹

There is no requirement to label nanomaterial content in personal care products. A nanotechnology task force commissioned in 2007 by the US Food and Drug Administration did not call for labeling requirements. This is not likely to continue for long. Several factors are likely to increase regulation of skin care products containing nanomaterials: (1) some nanomaterials have shown toxicity in vitro; (2) some animal models and human skin studies have shown that nanomaterials can penetrate intact and altered skin (by sunburn, tape stripping) skin; (3) there is a proliferation of groups (eg, Citizens' Coalition on Nanotechnology, Friends of the Earth,

Consumers Union) which is calling for further regulation³⁹⁻⁴²; (4) even the *FDA Nanotechnology Task Force Report* concedes that there may be safety concerns and has solicited public comment on sunscreen nanoparticle toxicity; (5) the new administration is more favorably disposed to consumers' concerns vis-à-vis industry, particularly in the realm of protecting public safety.

The United Kingdom and the European Union are further along in nanomaterial regulation. The Institute of Occupational Medicine in Edinburgh, United Kingdom, has asked its government to restrict use of carbon nanotubes in car panels, tennis rackets, and bike frames. Carbon nanotubes have a long, slender shape. It is the long, slender form of asbestos that has been linked to mesothelioma. By analogy, there is a concern that nanomaterials, which mimic these known carcinogens, can pose a similar risk.²⁷ Dermatologists need to play an active role in understanding the benefits and hazards of nanotechnology in order to educate patients, consumers, and policymakers on the safe and fruitful advancement of products in this field.

SUMMARY

Nanotechnology is moving at a rapid clip in dermatology. A large array of products has already been developed for the health and beauty of the skin, eyes, nails, hair, and teeth. The delivery mechanisms of nanotechnology also allow for the topical application of drugs that must currently be ingested or injected. It is likely that progress will be made in nanotechnology and skin care in the future, and that future advances will take place under the watchful eye of regulators with input from dermatologists, consumers, and scientists.

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