

"Nano Present" and "Nano Future": The Growing Role of Shrinking Technology in Dermatology, Part 1

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This is the first of a 2-part series. In this part, Dr. Nasir introduces nanotechnology and its role in skin care products.

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 is devoted to cosmetic products for the face. A smaller portion touches on some of the uses of nanotechnology for specific body parts or for treatment of specific conditions.

anotechnology is a rapidly growing field with enormous implications for consumers, patients, and society.¹⁻³ Matter made at the nanoscale possesses unique properties allowing for the creation of substances with advantages over macroscopic precursors. These advantages include specificity, adaptability, and targeted activeingredient delivery. Furthermore, skin care products employing nanotechnology can be engineered to eliminate

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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. undesirable qualities. Products incorporating nanotechnology are being discovered and manufactured at a growing rate. A substantial proportion of the patents issued for nanotechnology-based discoveries are in the realm of cosmetics and consumer skin care products. The interest in nanotechnology and skin care is expected to burgeon.

The cosmetic industry leads in the number of patents for nanoparticles, which can be found in sunscreens, hair conditioners, shampoos, lipsticks, eye shadows, aftershave products, moisturizers, deodorants, and perfumes.⁴ Antiaging products are a major source of excitement for nanomaterials. Properly engineered, nanomaterials may be able to topically deliver retinoids, antioxidants, and drugs such as botulinum toxin or growth factors for collagen and elastin into the skin. A recent survey found that among the 270 or so nanotechnology products available, the majority are cosmetics.⁵ Furthermore, because of recent safety concerns, additional products that contain nanomaterials may not advertise their use.

DEFINITION OF NANOTECHNOLOGY

Nanotechnology capitalizes on the special properties of matter in the size range of 1 to 100 nm.⁶ The size of

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nanoparticles is difficult to grasp. Cells, cellular organelles, and bacteria are enormous on the nanoscale. The adenovirus, which is dwarfed by any eukaryotic cell, is a whopping 150 nm. If the adenovirus were cubic and not icosahedral, it could carry more than 3 million 1-nm particles. It is also important to remember that most atoms are 0.1 to 0.5 nm in diameter.⁷ Given the extraordinarily tiny dimensions of nanoparticles as compared with 1000 nm hair shafts, it is easy to envision nanoparticles penetrating skin. It is even easier to envision nanoparticles penetrating skin with compromised barrier integrity.

At this size range, matter behaves differently.8,9 For example, the chemical reactivity of substances can increase.¹⁰ As a particle shrinks in size, its surface area relative to volume grows exponentially. This makes available a large number of surface moities for interaction with the environment or with other nanoparticles. The surface moieties can be hydrophobic, hydrophilic, or electrically charged. The interactions can allow, for example, for the assembly of a nanoliposome, which could be manufactured to contain an active ingredient, such as a retinoid, for delivery into the epidermis, or an antioxidant, such as ascorbic acid, could be stabilized in a topical nanoliposome formulation for similar delivery. The optical qualities of matter can also be manipulated at the nanoscale. For example, zinc oxide, a component of sunscreens, is opaque at the microscales and macroscales. The wavelength of visible light is 400 to 700 nm. Nanoparticles of zinc can be made so small that it all but vanishes when applied to the skin. Physical properties of matter also change at the nanoscale. Microsized and macrosized zinc can be dissolved only in an oily vehicle. Nanoparticles of zinc are more readily dispersed in aqueous vehicles and can be incorporated in cosmetically elegant preparations. The 3 properties of matter, chemical, optical, and physical, can be manipulated and exploited in precise ways by using nanotechnology. The ability to achieve this on an industrial scale at a relatively low cost has manufacturers and consumers interested.

DEFINITION OF NANOCOSMETICS

Nanocosmetics are products that maintain or enhance the appearance of the skin, hair, and nails and capitalize on nanotechnology as their principal advantage. A broader definition would include products that help the appearance of the teeth and eyes, as well as products that contain any nanomaterials on their ingredient list, rather than the active or key ingredient.

In the \$200-billion global cosmetic industry, the current global market for nanotechnology is estimated to be \$62 million and, barring curtailment through

regulation, is expected to grow annually at a 16% rate and reach more than \$150 million by 2012.¹¹ Sunscreens are expected to account for the bulk of the growth, but other cosmetics, if they prove superior to current competitors, are likely to follow. The growth of antiaging products may continue during a recession, especially as their cost is competitive when compared to procedures.

REPORTING OF NANOTECHNOLOGY

Most of the advances of nanotechnology are patented and proprietary. Manufacturers must balance the advantages and drawbacks to divulging nanomaterial content of their products. It is disadvantageous for manufacturers to divulge trade secrets to competitors. Some consumers may find a new technology or a label with the term *nanotechnology* appealing, whereas others, including consumer protection groups and regulatory agencies, may scrutinize the products more because of safety concerns. In fact, regulatory hurdles and consumer backlash have caused some manufacturers to remove any voluntary reference to nanomaterials on advertising materials or lists of ingredients.

TYPES OF NANOMATERIALS IN SKIN CARE Nanoparticles

Nanoparticles act individually or in combination to carry out a specific task. Some are made to disperse, some to aggregate, and some to polymerize under the right conditions. They can be solid or hollow and act as transport agents or composite.

Picoparticles

Picoparticles are approximately 2 to 3 orders of magnitude smaller than that of nanoparticles and appear to be on an atomic or small-molecule scale. An example of a picoparticle would be water or an atom of zinc or titanium. One manufacturer, BIONOVA, Inc, for Barneys New York has⁵

developed several proprietary nanotechnologies, which can be used as a technological platform for creation of multiple products oriented toward enhancement of selfhealing processes. This technological platform is based on development of nanotechnology of bioactive complex modeling, which has the ability to manipulate not only with nano, but also with pico size particles.

Nanoemulsions

Nanoemulsions are nanosized packages of oil and water emulsions that allow for the stabilization, deeper penetration, and targeted delivery of a variety of substances into the skin (eg, antioxidants, vitamins, hyaluronic acid). Examples of some personal care products and manufacturers that use nanoemulsions or nanospheres include L'Oréal Revitalift, Freeze 24-7, la prairie Skin Caviar Intensive Ampoule Treatment, Olay, PureOlogy, Colorescience, and Caudalíe Teint Divin Suncare Regimen. A subcategory of this is nanoscale coatings and thin films.

Fullerenes

Fullerenes are nanosized polyhedral molecular cages shaped like geodesic spheres that can be manufactured to transport material into the skin. They can be designed to trap metals, ions, and small molecules and can be modified on the outside with an enormous array of moieties to allow functionality or targeted delivery.

Nanotools and Nanodevices

The tiny robots and computers of science fiction have not yet been used in dermatology. However, nanosized molecular machines and computational devices have been synthesized by using very clever techniques and may be available in the future for diagnostic or therapeutic purposes.^{1,5,8,9}

PRODUCTS FOR THE FACE

Moisturizers

Emollients are substances that soften and soothe the skin and are used to correct dryness and scaling of the skin. Effective emollients occlude the skin and contain humectants and lubricants. One example of a moisturizer touting nanotechnology is Everyday Skin Penetrating Cream by Kara Vita, which uses nanospheres to deliver emollients to dry skin, along with bioactive occlusive agents to strengthen the skin's barrier. The manufacturer's goal is to have a potent, single-application moisturizer that lasts all day. The composition of the nanosphere and of the bioactive occlusant is proprietary. Another example is Arouge Deep NanoMoisture Care Set. The manufacturer's contents are proprietary. However, the company advertises the ability of its extremely small active ingredients to penetrate the skin deeply.¹²

Arouge uses advanced technology to create extremely small moisture molecules. Because they are so small, they rapidly penetrate the deep layers of [the] skin. Arouge uses nanotechnology to make the molecules so small. Arouge has trademarked this solution, calling it NanoMoisture. What this really means for [the] skin is that the moisture penetrates deeper, bringing the moisturizing and rejuvenating effects deeper into [the] skin than other [skin care] products. The company goes on to say, "Many people tell us that they are comfortable with their current facial care products, but they would like to extend their cleansing and moisturizing with the deeper and longer-lasting benefits of Arouge's NanoMoisture."¹²

Lancôme makes Hydra Zen Creams, which contain the proprietary ingredients Acticalm 2, Biolactone, and nanoencapsulated triceramides. These are designed for long-lasting hydration, which, according to the manufacturer, protects the skin and keeps it fully hydrated and smooth all day long.⁵

Lancôme also promotes nanotechnology with their Primordiale line, which "melts into skin thanks to its ultra fine moisturizing texture (nanotechnology) combined with high tolerance sugar esters to bring intense hydration."⁵ Furthermore, the Primordiale line contains a Duplex System that "combines two vegetal extracts with Vitamin E to ultra-smooth, refine [the] skin and improve its elasticity."⁵

Cleansers

Cleansers debride, exfoliate, and decontaminate the skin. Some cleansers incorporate nanoparticles of silver as a disinfectant and skin decontaminant. Manufacturers tout the importance of gently decreasing bacterial load on the skin. One example is Cosil Nano Beauty Soap manufactured by Natural Korea Company, Ltd. Another company, Nano-Infinity Nanotech Co, Ltd, incorporates zinc oxide and nanomicelles to remove makeup and exfoliate the skin, creating a clean, smooth sensation after washing.

Sunscreens

Sunscreens employing nanomaterials rely on the unique properties of metallic zinc and titanium at the nanoscale. Macrosized zinc and titanium require oily vehicles for solubility. Their nanosized counterparts are easily dispersed in water-based topical preparations. Hence, they are more cosmetically elegant when applied and less likely to be comedogenic. Furthermore, nanoparticles of zinc and titanium are much smaller than the wavelength of visible light (400-700 nm) and vanish on the skin without leaving a whitish film. Also, because of their small size and ready solubility, sunscreens with nanoparticles are more easily dispersed on the skin and can provide more effective overall coverage of the skin. Finally, because they are physical blockers, they are more likely to block UVA and UVB light. Sunscreens containing these particles are widely available. Recently, manufacturers have shied away from mentioning them on their product lists, but independent laboratories working for Consumers Union have demonstrated nanoparticle content in several brands that specifically market themselves as free of nanoparticles.

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The advertising of one product, sunVex, reads as follows:5

sunVex lotions are multifunctional skin care products. Formulations are based on ingredients that are naturally derived, and contain broad-spectrum UVA/UVB protection. Nanotechnology provides a new type of sunscreen protection such that sunVex products do not contain or rely on harsh chemical sunblocks common in many of today's sunscreens. In addition to the great soothing feel, sunVex products do not leave that chalky residue on your skin. Your skin will feel soothed and refreshed.

One product that targets the male audience, D-Fense Antioxidant Moisturizer with SPF 17 manufactured by MOXIE for men, contains the active ingredient nanofine zinc oxide.

Photoactivated nanoparticles of gold are used for medical diagnosis and therapy. The benefits of nanoparticles of gold in the cosmetic realm are unclear, except perhaps as an anti-inflammatory and antioxidant. Neiman Marcus manufactures Chantecaille Nano Gold Energizing Cream, which contains 24-karat gold particles that are bound to silk microfibers. The cream is moisturizing and contains antioxidant and anti-inflammatory properties.¹³

Enhancing Appearance

The skin's texture can be divided into 2 categories, which are patient perception and observer perception, and the skin's texture has 2 qualities, appearance and feel. For patient satisfaction, texture enhancers must improve how the patient's skin looks as well as how it feels to the touch. Roughness, scaliness, and surface irregularities are undesirable. A tight, drawn, or cracking sensation during skin movement is undesirable. Skin rebound, turgor, and elasticity are desirable, whereas sagging and flaccidity are undesirable. Even, smooth, uninterrupted skin color and tone are desirable, whereas skin surfaces broken by shadows, pigment, blood vessels, fine lines, or skin lesions are undesirable. Cosmetic products employing nanotechnology address each of these aspects in single-use or combination-use products.

Making skin beautiful can require correction of color, gloss, or the shape of the face. Most skin is translucent and reflects approximately 5% of incident light. The remainder is scattered and absorbed, either by melanin or hemoglobin. Melanin absorbs UV and visible light, and hemoglobin absorbs green and yellow light. Red and infrared light exit the skin and give it its optical characteristics. Powders with nanoparticles can manipulate skin color. For example, platelike mica powder coated with nanometer-thick titanium dioxide can be adapted to generate light interference patterns based on size. If

the film is 130 nm, the mica generates blue light. At 150 nm, green light is generated. At 100 nm, red and blue light are generated. Interference patterns can generate color correction. Titanium-coated mica is high gloss, but this can be corrected by the addition of barium chloride and sodium sulfate. The latter gives the skin a matte finish. If the shape of the particles is altered, the reflection characteristics can be changed. If particles are more reflective in shaded areas of the skin, such as wrinkles, and if they are more reflective on convex surfaces, the face can look more 3-dimensional. Thus, it can be possible to engineer a nanoparticulate makeup that corrects color, gloss, and face shape. Furthermore, if the particles are designed to have a refractive index that is higher than air, internal reflection can generate the illusion of added evanescent light.

One age-defying manufacturer using nanochemistry is Beyond Skin Science. The company's products include a hydrating face mist, a night cream, a skin-purifying cleanser, and a day treatment. The manufacturer uses nanostructured systems to optimize the delivery of active ingredients into the skin that are hydrating and antiwrinkle and protect the skin from moisture loss and environmental attacks. The manufacturer appeals to the consumer with the fast absorption and lightness of its day treatment product, which allows the application of makeup immediately afterward.⁵ There is a time-release feature to the day treatment product that allows healthy cell renewal and the production of collagen. Components are not known, but the patented technology is called NanoChem.

Platinum is used as a catalyst for many chemical reactions. Platinum Silver Nanocolloid Cream, manufactured by DHC, is a moisturizer combining platinum, silver, botanicals, and coenzyme Q10 for the treatment of wrinkles and age spots.

Some manufacturers attempt to deliver active ingredients into the skin to enhance its appearance. These include retinoids, hydroquinones, hyaluronic acid, and collagen. Others attempt to deliver drugs to the skin for cosmetic purposes. This includes γ -aminobutyric acid to reduce skin muscle tone and eliminate frown lines. Medicis Phamaceutical Corporation and Revance Therapeutics, Inc, are working on a topical form of botulinum toxin designed to enter the skin and treat rhytides and hyperhidrosis.

RCP Therapeutics manufactures a product called Bimene. This company employs nanoparticles to carry type III collagen to the skin along with other cutting edge ingredients, including hyaluronic acid, pentapeptides, and a penetrating form of vitamin C in their mission to support, protect, and renew living skin.⁵ According to the manufacturer, the nanoparticles are able to penetrate the skin and reduce fine lines.

AmerElite Solutions manufactures the CollagenFusion Skin Care System, which is based on nanotechnology that works with the body's natural process in order to reduce the appearance of fine lines and wrinkles, along with moisturizing and hydrating the skin.⁵ The active ingredient is a trade secret called Collamin-G. The manufacturer states that its components are approximately 200 to 500 times smaller than a pore of the skin; therefore, approximately 200 to 500 elements penetrate the skin through a single pore at one time.⁵ The product is used to reduce fine lines.

Colorescience makes Dual Finish Pressed Compacts, which use nanotechnology and vitamins incorporated in mica that deliver antioxidants to the skin.

It is difficult to produce a stable and easily penetrable formulation of vitamin C. Several manufacturers have capitalized on nanotechnology to help them prevail in this challenge. For example, JamieO Skincare manufactures Crystal Radiance Microdermabrasion System and Rewind Time Daily Vitamin C Serum. Crystal Radiance Microdermabrasion System is a twice-weekly regimen that cleanses the skin. The manufacturer notes, "Crystal Radiance gently buffs, exfoliates, and stimulates skin cells to provide an in-home microdermabrasion experience. Used twice a week, Crystal Radiance smooths dry, patchy skin and stimulates cell turnover to produce a visible glow."5 Rewind Time is a vitamin C serum that "stimulates collagen and elastin production in the fibroblasts, reducing the appearance of wrinkles. It also reduces discoloration associated with sun damage and prevents free-radical damage, slowing the aging process."5 The manufacturer notes that active ingredients include a proprietary peptide, a nonirritating form of vitamin C and a "nanotechnology delivery system to ensure the active ingredients penetrate the skin's surface and travel deep into the lower level of skin called the dermis."5

The nanoemulsion formulation of La Prairie Skin Caviar Ampoules, available at Bergdorf Goodman, permits maximum penetration of the exclusive, patented Cellular Complex. It is available as 2 separate ampoules: a powder containing pure vitamin *C*, which is mixed with the nanoemulsion. The complex is reported to brighten the skin and eliminate fine lines.

Some manufacturers rely on a network or polymer to drape over the skin, coat it, and protect it, and to serve as a reservoir of long-lasting, time-released antiaging compounds. One example is DiorSkin Forever Extreme Wear Flawless Makeup SPF 25, manufactured by Dior. The company makes a nanostretch network, which is "an invisible, micro-airy nano-network for a perfect complexion."⁵ This is "an exclusive nano-stretch network inspired by nano-textile technology to ensure makeup will fit like a second skin." The product also contains a hydragel moisture-stabilizing system, "a new-generation moisturization regulator for optimal comfort, hour after hour."⁵

At one point, Lancôme advertised a similar mode of action with their Rénergie series. Products included Rénergie Microlift Flash Lifting, which performs "25,000 microlifts for results in a flash," and Rénergie Microlift Serum, which contains microlifters enhanced with a powerful tensing agent to immediately tighten skin for an instant lifting effect that lasts all day. The microlifters are made of nanoparticles of silica and proteins that presumably form a dermobonding network to immediately lift, tighten, and firm the skin. These products have since been discontinued for unknown reasons.

L'Oréal has a competitive Revitalift line. This employs the proprietary ingredient Pro-Tensium, which "works to immediately form a resistant and flexible network that instantly re-tightens skin."5 A compatible Anti-Wrinkle + Firming Day Cream packages retinol and vitamin E into nanosomes to allow penetration of the skin's surface. The Revitalift Anti-Wrinkle + Firming Facial Cloth Mask is a cloth mask that contains nanosomes of proprietary Pro-Retinol A and Par-Elastyl. These are designed to make skin firmer and fight against the signs of aging.¹² According to the manufacturer, the mask is "infused with 7X your daily dosage of anti-wrinkle moisturizer, so you get a weeks' worth of treatment in just 10 minutes."12 Powerful deep delivery of product and speed of action are benefits touted by many cosmetic manufacturers employing nanotechnology.

One combination of products to enhance the skin's appearance and protect the skin is DiorSnow Pure UV Base SPF 50, manufactured by Dior, which contains a makeup base and a brightener and delivers UVA and UVB protection.

Diorskin Forever Extreme Wear Flawless Makeup SPF 25 also uses polymer technology and a nanostretch network, which the manufacturer states is "an invisible, micro-airy nano-network for a perfect complexion."⁵ It also contains a hydragel system, "a new-generation moisturization regulator for optimal comfort, hour after hour."⁵ The network is "inspired by nano-textile technology to insure makeup will fit like a second skin and a unique hydra-gel moisture-stabilizing system, Dior takes smoothing, wear, and comfort to the ultimate extreme of beauty. No transfer and waterproof."⁵

JUVENA of Switzerland manufactures Juvedical DNA Skin Optimizer Cream SPF 20 and Juvedical DNA Skin

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Optimizer Fluid SPF 20. Although the active ingredients are not listed, the manufacturer notes⁵:

JUVENA of Switzerland selected the absolutely best size for cosmetic skin care – 40 nanometers. The nanotechnology was chosen because it makes it possible to place the sensitive ingredients in the form of tiny crystals directly into the cell nucleus. The crystals fulfill two tasks at the same time: they are the active substance and a means of transportation—all in one—traveling deep and directly into the skin where they provide a 'supply' depot. From here the skin can take what it needs, whenever it needs it. The availability and accessibility of the substances for the cells is thereby increased and the protective mechanism optimal.

The concept of a depot is attractive to manufacturers who want durability and time release. The potential for ingredient entry into the cell nucleus can raise safety concerns.

BellăPellé manufactured an EGF Complex Cocktail that topically delivers antioxidants to the skin in Fullersome packages. This product has been discontinued.

Arbonne manufactures an RE9 series, with products containing a combination of 9 active ingredients designed to work in concert to exfoliate, reduce fine lines and dyschromia, and protect the skin with antioxidants. It is not clear if all or some of these ingredients are delivered via nanospheres. The manufacturer notes⁵:

Bio-Hydria Complex: Proprietary blend of seven plant nutrients that soften and condition skin. Vitamin C, Magnesium Ascorbyl Phosphate: A biologically active form of vitamin C promotes collagen, elastin and ground substance (the strength and elasticity of the skin). Nanospheres: Infused with free radical fighting antioxidant vitamins, penetrate deep into the skin to protect, condition and adjust to skin's specific needs. Elhibin, a revolutionary, plant-derived skin protectant, contributes to skin's elasticity, softness and smoothness. Stimu-Tex, a unique, plant-derived skin moisturizer, helps to improve the appearance of the skin's epidermal lipid layer, minimizing water loss and helping skin. Alpha Lipoic Acid: A powerful antioxidant that penetrates skin quickly and absorbs into the skin's cells to increase cell metabolism. Kojic Acid: A highly effective, natural skin lightening agent that reduces the appearance of long-term sun and environmental damage. Copper: Visibly smoothes, softens and firms skin. Helps reduce the appearance of fine lines while promoting younger-looking skin. Alpha & Beta Hydroxy Acids: Activate healthy cells while diminishing the appearance of fine lines and wrinkles. Peptides: Improve skin roughness and lessen the appearance of wrinkle volume and wrinkle depth.

Kara Vita manufactures Enlighten Me! to correct skin discoloration and to even skin complexion. Nanospheres deliver active ingredients in a time-release formula to allow improvement of dyschromia in 2 to 8 weeks. The manufacturers recommend their Face Essential with SPF 15 moisturizer be used to prevent future discoloration. Also for dyschromia, KOSÉ Corporation manufactures Rutína Pure White to enhance the appearance of chronic lentigines, which appear with minimal UV exposure. The product is designed to reduce pigmentation. KOSÉ Corporation also manufactures a compatible Rutína Nano-Force Nourishing Milk, a moisturizer that delivers a hyaluronic acid derivative.

Fullerenes are employed by SIRCUIT Cosmeceuticals in SIRCUIT White Out, SIRCUIT O.M.G. serum, and SIRCUIT Sircuit Addict, and reportedly deliver a complex of skin nutrients designed for skin rejuvenation. The manufacturers note that fullerenes are more effective carriers of active ingredients than liposomes and nanosomes and are 10 million times smaller. The company's source is Shungite, which is an anthracite from the Shun'ga village in the Onega Lake area in the Karelia Republic of Russia, which has been reported to contain fullerenes.

Zelens makes a fullerene C-60 Day Cream, C-60 Eye Cream, C-60 Night Cream, and a DNA Protection Day Cream. The company touts the free radical scavenging properties of fullerenes and promotes the antioxidant properties of their products. One study has shown that α -alanine C-60 is comparable in its radical scavenging ability as thiourea and ascorbic acid.¹⁴

Freedom Plus Corporation makes Doctor Gunderson's Rāahj Nano Copper Facial Spray as a rejuvenating application. It has a companion product, Doctor Gunderson's Rāahj Synergized DHEA Facial Spray, whose active ingredient is dehydroepiandrosterone. Freedom Plus Corporation has certified test data from an independent laboratory to show its sprays contain nanoparticles.¹⁵ No safety data are available, but the potential of a spray to enter the skin, the eyes, and the airways is important to consider.

Less traditional uses of topical skin care products include those which act to decrease fat and to augment breast tissue. At one point, Osmotics Cosmeceuticals manufactured Lipoduction Body Perfecting Complex. It was designed to treat cellulite. The manufacturer claimed that most products designed to reduce cellulite are⁵

not effective because the beneficial ingredients never penetrate the skin's lipid barrier. As a result, these ingredients remain on the skin's surface. Lipoduction overcomes this problem by encapsulating the active ingredients into a patented permeation technology or nanotechnology that increases delivery up to 700% over traditional cellulite products. In addition, weak capillary action leads to a breakdown in the collagen matrix, which also contributes to the development of cellulite. Lipoduction contains high levels of pure grapeseed extract, an antioxidant proven to strengthen the capillary system and help prevent breakdown of the collagen matrix.

Stherb Cosmetics International Co, Ltd, makes Nano Breast Cream, which is a "combination of Nanotechnology and the timeless Thai herb, Pueraria Mirifica. Nanosomes are oxidation stable compound which expands the cellular substructure and promotes development of the lobules and alveoli of the breasts."⁵ The company reports that subjects "can instantly experience Natural Breast Enlargement & Firmness. Nanosomes are protected from Surface & bulk erosion also, this feature provides added advantage -Toning of Breast Skin, visible cleavage, radiant texture of breast skin & protection from free radicals."⁵ Whether or not the product is effective, the claim of penetration into breast tissue leaves open safety concerns.

Treating Acne

Acnel makes a nanolotion for dry acne skin. Kara Vita makes Clearly It! Complexion Mist, Clearly It! Spot Treatment, and Clearly It! Acne Treatment Lotion, which have nanospheres containing sulfur, tea tree oil, and salicylic acid. According to the company, the combination "dissolves dead skin cells, unclogs pores, stimulates collagen production and accelerates cell replacement. Plus, our nanosphere-delivered moisturizers and antioxidants nourish and repair for stronger, more resilient skin."⁵

Ag NanoTech, Inc, makes Bye Bye Acne, a proprietary nanosilver delivery system. Bye Bye Acne is compliant with the US Food & Drug Administration monograph on acne over-the-counter drugs, sustainable ingredients, eco-friendly packaging, and manufacturing in the United States. In Part 2 of this 2-part series, we will examine the use of nanoparticles in products for special sites, including the hair and nails, as well as products for the 5 senses.

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REFERENCES

- 1. Hall JS. Nanofuture: What's Next For Nanotechnology. Amherst, NY: Prometheus Books; 2005.
- Nasir A. Dermatologic toxicity of nanoengineered materials. Arch Dermatol. 2008;144:253-254.
- 3. Castanedo-Tardan MP, Nasir A, Jacob SE. Better understanding the chemicals that surround us. *Skin and Aging*. 2007;15:15-21.
- Morgan SE, Havelka KO, Lochhead RY. Nanotechnology and applications in cosmetics. In: *Cosmetic Nanotechnology: Polymers* and Colloids in Personal Care (ACS Symposium Series). Washington, DC: American Chemical Society; 2007:193-200.
- 5. The Project on Emerging Nanotechnologies. http: //www.nanotechprojec.org. Accessed January 6, 2009.
- 6. Bhushan B, ed. Springer Handbook of Nanotechnology. 2nd ed. New York, NY: Springer; 2006.
- Atkins P, de Paula J. Physical Chemistry. 7th ed. New York, NY: W.H. Freeman; 2001.
- 8. Drexler KE. Machine-phase nanotechnology. Sci Am. 2001;285:74-75.
- Drexler KE. Nanosystems: Molecular Machinery, Manufacturing, and Computation. New York, NY: John Wiley & Sons; 1992.
- Nel A, Xia T, Mädler L, et al. Toxic potential of materials at the nanolevel. *Science*. 2006;311:622-627.
- 11. Vo-Dinh T. Nanotechnology in Biology and Medicine: Methods, Devices, and Applications. Boca Raton, FL: CRC Press; 2007.
- 12. The International Nanotechnology Business Directory. http://www.nanovip.com. Accessed January 6, 2009.
- Derfus AM, Chan WCW, Bhatia SN. Probing the cytotoxicity of semiconductor quantum dots. *Nano Lett.* 2004;4:11-18.
- Sun T, Xu Z. Radical scavenging activities of alpha-alanine C60 adduct. *Bioorg Med Chem Lett.* 2006;16:3731-3734.
- ProductDescriptions.info. DHEA facial spray. http: //www.productdescriptions.info/DHEA.aspx. Accessed January 28, 2009.

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