



Cosmetotextiles: A New Functionality of Garments for Well-Being

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Abstract

Consumers' rising awareness towards functional garments have led to the growing of a revolutionary type of cosmetic textiles. Cosmetotextiles are textile products containing various cosmetic active ingredients for skincare and well-being. Encapsulation, grafting, coating, doping and layer by layer deposition techniques have provided these cosmetic ingredients with effective stabilization, sustained dermal delivery and prolonged dermocosmetic efficiency. Various agents used in cosmetotextiles are slimming agents, aromas and perfumes, anti-cellulite agents, moisturizing agents, sunlight absorption agents and antioxidants agents. There are various natural and synthetic materials which are used in cosmetotextiles like essential oils, fruit extract, flower extracts, plant extracts and animal extracts as natural sources along with some synthetic substances including iron oxide, zinc oxide, titanium dioxide, ethane diol and zinc nanoparticles etc. It is anticipated that the development of cosmetotextiles will continue to grow and explore completely new possibilities for providing various body care functions to the wearer in the near future. This article provides an overview of the applications of cosmetotextiles and available commercial cosmetotextiles products.

Keywords: Cosmetotextiles; Skincare; Microencapsulation; Cosmetic ingredients; Garments; Wellness

Introduction

With the growing trend in enhancing beauty through healthy means, customers request for apparels and home textiles having basic characteristics, as well as some extra functions, including environmental protection, anti-pollution and most importantly, health and beauty care, in an attempt for a more natural and healthier life. On contact with human body and skin, cosmetic textiles are designed to transfer an active substance for cosmetic purposes. In view of the increasing demand in the relevant fields, researchers and textile manufacturers have invested extensively in cosmetic textiles for research and product development [1]. The wellness or health promoting aspects of textile finishes have become a delightful functional matter in the 21st century. Textiles which provide cosmetic and biological functions, such as pleasant

feeling, energizing, slimming, refreshing, vitalizing, skin glowing, anti-ageing, body care, fitness, and health, are categorized as cosmetotextiles [2].

Owing to the rapid development of novel sciences and technologies, textile materials have also found applications in the cosmetics field in recent years. A new sector of cosmetic textiles is launched, and the textile industry is very optimistic that these products will open new target groups and sustainable markets [3]. Textiles cover a large part of the body for most of the day which provides a unique opportunity for the convenient transfer of cosmetics to large parts of the body and continuous release of small doses of cosmetics may be more effective than single applications of large amount of cosmetic agent [4]. Traditional cosmetics leave

feeling of stickiness all over the body whereas cosmetotextiles can just put on and go about the daily lives while having this skin care function that fulfils the soaring demand of high function and sensitive skin products [5].

Important Cosmetic Ingredients

Generally, major cosmetic ingredients originate from inorganic and synthetic chemicals, animal derivatives and plant derivatives [1]. Natural materials used for impregnation of textile are plant derivatives such as aloe vera, padina povonica, flowers, fruits, essential oils, animal derivatives such as chitosan, squalene, and sericin, and synthetic materials such as iron oxide, ethane-diol, zinc oxide, and zinc nanoparticles [6]. Chitosan based cosmetic microcapsules can be embedded onto the fabric for products of different efficacy, including moisturizing, cooling, energizing, relaxing, anti-heavy legs, and mosquito repellent benefits [1]. Squalene along with ascorbyl phosphate, vitamin E, and hyaluronic acid help to protect the skin against photo aging and the formation of brown age spots [7]. Aloe Vera is used to obtain antibacterial, antiviral, antimitotic, wound healing, and anti-inflammatory effects [8,9]. Ginseng extract can be used by way of the microencapsulation technique to protect the skin from cancer and inflammation. Padina Pavonica is believed to improve the firmness and elasticity of the skin [10]. Hinakitiol is effective in giving a relaxation effect due to its aromatic nature [11]. Hyaluronic acid grafted pullulan polymers were prepared by one step esterification and demonstrated high swelling ratio and a relatively quick hemostasis ability, making it a promising wound healing dressing [12].

Gallic acid has recently been recommended as an active component to produce cosmetic textiles [13]. When gallic acid in the form of a microsphere is applied to the skin via cosmetic textiles, it improves the skin's photo-protection ability [14]. Peptides have many functions as cosmetic ingredients including skin moisturizing, firming and elasticity-promotion and anti-wrinkle. The high-water content and large pore size of most peptide hydrogels may result in relatively rapid release of drug [15]. Impregnated cotton and synthetic fabrics with copper oxide show powerful biocidal effects and can be used to produce socks to prevent fungal infection [16,17].

Various fruit oils are used to provide aroma to the wearer for refreshment and relaxation. There are various encapsulated essential oils which have found their place in aroma therapy, providing skin glowing, moisturizing, refreshing and other wellness effects [18,19]. These oils have positive effects on mood and mental status like fatigue, insomnia, anxiety, agitation, stress, mental exhaustion, pains of various origin including bones and joints, memory and concentrations, panic attack. Also, essential oils have healthier effects on skin, like anti-bacterial, anti-fungal, anti-inflammatory, strengthening vascular walls, delaying ageing, removal of metabolic waste, improvement of lymph circulation, anti-cellulite actions [17,20,21]. The grafting vitamin E microcap-

sules into fabrics has been reported to significantly increase skin moisture and elasticity as well as reduce skin wrinkle and roughness [22]. Coating cotton fabrics with protein-based nanoparticles containing vitamin E by a low-cost pad-cure method has shown an effective approach to impart them with antioxidant properties. It is helpful in guarding against various skin diseases [17,23,24]. Due to its antioxidant properties, it can protect against lipid peroxidation and has the ability to slow skin ageing [25,26]. Vitamin E contributes to the healing of wounds, and the treatment of dermatological conditions and in the prevention of skin cancer [27].

Preparation of Cosmetotextiles

Depending on the type of cosmetic product, the desired effect, and the method of transfer to the skin, there are different ways of final finishing and binding the cosmetic agent to textiles. Synthetic and inorganic substances, such as copper oxide, may be attached to the textile material by impregnation from a solution, as well as adding to the molten mass of the synthetic polymer [16,17]. The best way of incorporation of cosmetic ingredient is in the form microcapsules. Microcapsules can be applied to textiles by padding, coating, spraying or immersion methods. For all these methods, a binder is required to fix the capsules on to the fabric [28,29]. Applications of microcapsules by exhaust method is suitable for knits and woven garments [30]. This technique's vast use can be witnessed in functional finish fabrics, medical and healthcare textiles, aromatherapy, cosmetic textiles, and many more functional textiles [31].

Active agents are also added to the fiber forming material at the time of dope preparation before fiber extrusion. For example, the manufacturing of inherently conductive, UV absorbing, and de-lustering fibers can be possible by using carbon nanotube, Zinc nanoparticles and TiO₂, respectively, as dope additive. Various cosmetic ingredients are grafted onto fiber, yarn, and fabric surfaces to achieve cosmetic effects [32,33]. Bed linen can be made more comfortable and healthier using fibers coated by microcapsules with essential oils or antibacterial or anti-dust agents as well as anti-mite chemicals [34].

Different Applications of Cosmetotextiles

Cosmetotextiles for slimming

The textiles that offer a slimming effect by means of yarn properties, fabric structure and finishes are called cosmetotextiles for slimming. The use of compressional garments has offered the best option for slimming, as well as a reduction in muscle damage and maintaining muscle function. Retinol and caffeine extracts are normally applied to these textiles to fight cellulite [35]. Cosmetotextiles for slimming provide rehabilitation to the wearers [36,37]. Recently, anti-cellulite underwear development was reported by REUTERS. Skintex® Slimming, as one of the anti-cellulite fabrics, contains a combination of recognized ingredients, such as caffeine, retinol, Vitamin E, and algae extract, which may reduce the

outer appearance of cellulite. It has been reported that the slimming effect persists even after the garment has been washed several times, and it can be simply and easily renewed at home [4,38].

Underwear that helps women slim or men feel cool and fresh, purveyors of cosmetotextiles were out in force at Paris's annual lingerie trade fair. U.S., based Invista, part of privately held Koch Industries, launched its brand of cosmetotextiles under the Lycra Body Care trademark. Philippe Andrieu began his company Onixxa in 2003 with just one product, a pair of tights with a slimming agent in them [39].

Cosmetotextiles for moisturizing

On contact with this type of cosmetotextiles, moisturizing ingredients can be transferred from the fibers to hydrate the stratum corneum of skin. Commonly used moisturizing ingredients include vitamin E [24], vitamin C [40], chitosan [41] and aloe vera [42]. Encapsulation of these natural ingredients can be readily achieved by spray-drying, sonication and complex coacervation [43]. Cognis, a spin-off from Henkel, launched the first commercial moisturizing textile by a product line called Skintex®, which is made up of microcapsules loaded with vitamin E, squalene, and aloe vera [44].

Squalene is able to reduce the presence of wrinkles and fine lines due to its humectant properties. Human skin easily absorbs and spreads squalene with zero oily and greasy marks [45]. The integration of TiO₂ increases the possibility of moisture absorbance on textile surfaces through the photocatalytic process. In the case of polyethylene fibers, a thin film of TiO₂ can be deposited using the layer-by-layer deposition method to develop quick-dry textiles for sports or outdoor clothing [46].

Cosmetotextiles for energizing

Some of the textile articles able to lift the energy level of a human being are called cosmetotextiles for energizing. Human body cells use this coenzyme to enhance movement and energy level. Moreover, it is a natural antioxidant [33].

Cosmetotextiles for perfuming

A textile article that absorbs foul odors and offers pleasing perfumes is called cosmetotextiles for perfuming. A variety of synthetic and natural products are used to add the functionality of dendromancy to textiles. Chitin, chitosan, acetyl-glucosamine, D-glycosamide and various essential oils like clove, jasmine, lavender, hyssop, sandalwood, rose and frankincense, etc. are used to achieve a perfuming effect [33]. Matsui Shikiso Chemical Co., Japan, have encapsulated a variety of essential oils from musk, civet, ambergris, pine and citrus and grafted the microcapsules onto the fabric fiber by interfacial or in situ polymerization techniques [47]. Encapsulation of fragrance is also a promising approach to protect the volatile components from evaporation, oxidation, and contamination [48]. In addition to sustainability, the resistance to washing and handling can be improved by incorporating fra-

grance in suitable textile binders and softeners [49].

Cosmetotextiles for refreshing and relaxing

In the summer, a cool feeling can be achieved either by using phase change materials in the form of microcapsules or by increasing the area of contact between high moisture-transmitting fibrous surfaces and the human body [33]. Skintex-Supercool is a typical commercially available cosmetotextiles produced by encapsulation method works on the principle of increasing the area of body contact with a seamless micro-denier polyamide/elastane structure. Spintex supercool can also be produced by encapsulation of menthol along with emollients and highly durable synthetic coolants. The highest cooling is required in the armpits, back, chest and shoulders because these areas are most prone to sweating [50].

Cosmetotextiles for vitalizing

Vitalizing textiles can release revitalizing aromas synthesized by plants and fruit-based ingredients like ginger, menthol, orange or rosemary at a slow rate. These ingredients are added to textiles using the microencapsulation technique. The durability of this function remains even after a number of launderings. Vitalizing cosmetotextiles are suitable for bathrobes and other similar purposes [33].

Cosmetotextiles for UV protection

Prolonged exposure to ultraviolet radiation can result in skin damage, such as sunburn, premature skin aging, allergies, and even skin cancer. The fabric cover factor directly decides the protection against UV radiation but indirectly depends on the type of weave, depth of shade, fabric areal density, stretch-ability, wetness and washing cycle of the fabric. 1,2-ethanediol, Zn nanoparticles, iron oxide, zinc oxide, titanium oxide, carbon black, bi-reactive oxalic acid, dianitide derivatives and various other chemicals are used to improve the UV protection factor (UPF) of textiles [51-57]. Lignin, a cellulose material, has exhibited dramatic synergistic effect with chemical sunscreens in developing UV-protective textiles [58]. In another study, lignin/PVA nanocomposite fibers were developed by electrospinning, an environmental-friendly technique, with not only UV protective but also antimicrobial efficiencies [59].

Cosmetotextiles for antimicrobial

Textiles treated with non-harmful and eco-friendly antimicrobial microcapsules provides a long-term-controlled release for preventing or combating the growth of harmful bacteria [60]. Bed linen can be made more comfortable and healthier using fibers coated by microcapsules with essential oils with antimicrobial properties as well as anti-mite chemicals. Lee et al. investigated β-cyclodextrin as a carrier for encapsulating antibacterial chemicals, benzoic acid and vanillin, and embedded them onto cellulose fibers by using N-methylol-acrylamide, and found the anti-bacterial activity was resistant to 10 laundering cycles [61,62].

Cosmetotextiles for improving the firmness and elasticity of skin

Cosmetotextiles are capable of releasing some natural products that soothe the skin, thereby improving the firmness and elasticity of skin in a controlled manner. *Padina Pavonica* extract obtained from brown algae found in the Mediterranean Sea is believed to improve the firmness and elasticity of human skin. After a successful collaboration between Cosmetil and Variance, cosmetically inspired fluid lingerie called Hydrabra was launched in the market, providing moisturizing and firming effects [33]. Hydrabra can release active agents extracted from seaweeds that can soothe the skin and promote skin firmness and elasticity [4].

Cosmetotextiles for anti-ageing

Light, pollution, inflammation, and other oxidative-associated stress can increase the level of oxygen free radicals in the human body, which will accelerate the senescence of skin. Therefore, cosmetic ingredients with strong free radical scavenging effect can be employed for the development of anti-ageing textiles, including vitamin E (α -tocopherol), hyaluronic acid [63] and plant extracts from coffee, cocoa, or cinnamon [64] and animal derivatives such as collagen and chitosan. EVO Care Vital, a commercial product with a finish containing a formulation of vitamin E, Aloe Vera and Jojoba oil, is devoted to improving the firmness and resilience of skin.

Cosmetotextiles for wound-healing

Wound-healing textiles of gauzes, bandages and wound dressings are mainly used for hygienic and medical purposes. In wound dressings, a slow release of the drug is essential. Many active ingredients and antimicrobial ingredients have been employed, including chitosan, methylene blue, epidermal growth factor, HA and silver nanoparticles. On the technical side, electro-spinning has attracted a lot of attention in the wound healing area due to the many promising properties (e.g. ultrafine fiber and large surface area) of the produced fabric. Miguel et al. developed a skin-like layered structure patch composed of an asymmetric electro-spun membrane that displayed porosity, wettability, and mechanical properties similar to native skin. Chitosan and aloe vera were also incorporated to provide antibacterial effect [15,65]. Chitosan is an animal derivative used for wound healing, as well as for antibacterial, blood clotting and deodorant effects [4].

Miscellaneous Commercially Available Cosmetic Textile Products

Specialty Textile Product, a UK-based chemical company uses microencapsulation technology to develop Bio Cap having vitamins A, D, E and aloe vera as active agents for the benefits for skin care and sense of well-being [1]. This cosmetic textile treatment can be applied to the wide range of fabrics for bedding, underwear, T-shirts, stockings, and socks [3,4]. The company is also offering anti-cellulite treated microencapsulated textiles for cooling effect

[66]. Cognis-Skintex, German company used chitosan microcapsules for cosmetic textiles to natural and synthetic fibers. Chitosan is encapsulated to prevent heating, drying and cold and helps to protect the skin from dehydration and maintains its flexibility with soft touch [42]. The variety of products are offered to impart properties like moisturizing, cooling, and mosquito repellent finishes. The company also provides reloading of the microcapsules after several washes to prolong the functional properties of these textiles [66]. Cognis also developed Skintex Supercool, a technology for treating fabrics with high-tech microcapsules that provide a cooling sensation. These contain natural source ingredients like menthol and myrtilol, emollients and synthetic coolants [50].

Woolcelluliteopment International Limited (WDI) makes use of sensory perception technology to encapsulate the active ingredients to impart aroma, moisturizers, anti-bacterial and anti-fungal properties, and cellulites. Microcapsules are used in a variety of products like apparel, hosiery, interior textiles, home textiles [4,50]. Lanxess, the German chemical multinational Bayer, offering cosmetic textile products such as Bayscent® Aromatherapy and Bayscent® Neutralizer. Lytess, a French company, is marketing particular kind of collant that can drain and slim legs and also other textile products, like jeans, pants, and t-shirts that are able to release other cosmetic substances [42].

Lenzing introduced Tencel® C, comprising fiber with chitosan. This cosmetotextiles is said to relieve itching, regulate cells and protect the skin, in addition to having an antibacterial effect. Stockings made with these fibers were shown to protect the skin, allow it to retain more moisture, improve skin elasticity and stimulate skin cell regeneration [42]. Cosmetotextiles, Quiospheres®, a product of Clariant and Lipotec is said to generate wellness and well-being to the consumer through state-of-the-art cosmetic microencapsulation that can be applied to any fabric [42]. Quiospheres® microcapsules are based on high technology actives or peptides and actually work with the layers of the skin [67].

Legends & Heroes launched Denim Spa Therapy for Legs under the brand name Ript Skinz. Wrangler Mizuno Corporation and Ajinomoto Company have jointly introduced 'Amino Veil' [2]. Pulcra Chemicals introduced Cyclofresh Plus, which allows textile brands to treat textiles with long-lasting protection from unpleasant body odour and release of fragrances by a dual mechanism of two natural based ingredients, cyclodextrins and silver ions [50]. Italian company, Solidea has provided shorts and socks micro massage magic clothing in order to smooth and reshape the buttocks and legs, improving the health and appearance of the legs and thighs by reducing cellulite [2]. Lytess, a French company, is offering its customers not only a particular kind of collant that can drain and slim legs, but also many other textile products (e.g. jeans, pants and t-shirts) that are able to release other cosmetic substances [42].

Camangi Corporation, Taiwan introduced cosmetotextiles based on nylon and polyester under brand name UMORFIL con-

taining ocean collagen peptide amino acid for better skin comfort and flexibility [68]. Devan Chemicals, Belgium uses encapsulated essential oils and developed cosmetotextiles (brand name SceNTL) offering relaxation, wellbeing, and feel-good sensations for application in pillows, upholstery, curtains, carpets, masking scent [69]. Nilit Innergy, is the name of the project of the collaboration between the Israeli company Nilit and the Italian company Maglificio Ripa Spa who have launched the first technical clothing containing permanent natural minerals within the fabric that have several benefits like, muscle recovery, blood microcirculation and skin elasticity. NILIT Innergy is a polyamide (PA) 6.6 microfiber with integrated FIR (Far Infra-Red) properties [70,71].

Nurel patented NOVAREL technology which provides the skin with cosmetic benefits during garment use. These cosmetics are microencapsulated with aloe vera, vitamin E, rose hip oil, sweet almond oil and incorporated into the polyamide yarn during the spinning process. As per the type of ingredient, these products are useful in maintaining and enhance skin beauty, anti-ageing, skin hydration and antioxidant [72]. Galze GT, is an Italian company specialized in the production of medical stockings and performing compression seamless garments. The company launched Yaluronica a new line of firming underwear for women. Yaluronica products are made of an innovative and patented fiber, Meryl Hyaluronan fiber that contains gold and hyaluronic acid, which has not only slimming and restraining properties but also a significant firming, anti-aging and moisturizing effect on the skin [73].

The Covid-19 pandemic has led consumers to increasingly focus on beauty and health. This positively affected the market of the cosmetotextiles products and created an optimistic picture for the future of the industry. The cosmetotextiles market is expanding globally. Cosmetotextiles may be characterized by the chemical attributes or by the function they undertake. The joint efforts of cosmetic scientists, textile engineers, biochemists, dermatologists, and life scientists are allowing for standardization of testing and an expansion in products that can be taken through to market. Cosmetic functionality can be incorporated into textiles by modifying the fiber by introducing a functional moiety into the fiber's polymer chain, or by doping the polymer with additives before fiber extrusion, by functionalizing the yarns, or by coating the fabrics or garments for example by grafting or lamination [74,75]. Cosmetic market is very challenging, companies that focus solely on this area, establish dedicated production and R&D facilities in the field of cosmetotextiles products such as France based Lytess and Skin 'Up, who achieved great commercial success [76].

Conclusions

Cosmetic textiles are increasingly popular and expanding considerably in the textile industry. The application of cosmetic textiles can also be expanded to the bio-medical field. As a whole, it is anticipated that the development of cosmetic textiles will continue to grow and explore completely new possibilities for providing beauty and personal care to the wearer in near future. It

is really a challenging and exciting time for both the textile and medical industries. Numerous cosmetic active ingredients can be successfully applied by techniques like, grafting, encapsulation, plasma, sol-gel, doping, exhaustion, spraying and layer by layer deposition. With the rising demands and expectations of consumers, more sustainable and cost-effective cosmetotextiles of various health benefits are being developed worldwide leading to a new era of 'dermocosmetic fashion art'. Adidas, Nike and L'Oreal also have strong interest in cosmetotextiles, indicating the customer's requirement of cosmetotextiles. A variety of garments categories of cosmetic functionality like, garments with slimming, skin care, energising, cooling, fragrances, pain relief, insect repellent, anti-odour properties and ultraviolet protections are available. Customers worldwide have turned towards well-being through natural resources in an eco-friendly health promoting environment. It currently represents a niche market, but the development of new applications will provide new market opportunities for textile and apparel firms.

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