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# Cosmetotextiles: State of Art

## Abstract

The main aim of this article is to collect the scattered knowledge of Cosmetotextiles and present it to the world scientific community for scrutiny. Various aspects of Cosmetotextiles are compiled systematically and oriented towards product development. The technology of Cosmetotextiles is at the neonatal stage. The joint efforts of textile technologists, biochemists, cosmetic experts and medicos can achieve challenging targets in the field of Cosmetotextiles. Various derivatives of metals, plants and animals are used in pure and derivative form to generate cosmetic functionality in textiles. Various routes for the incorporation of cosmetic potential in textiles are available, of which microencapsulation and the use of cyclodextrin as cage material are the most popular. The content of moisture on skin surface is a key parameter in maintaining skin elasticity and glowing potential. The characterization of Cosmetotextiles is a difficult task, but the Europeans have taken the lead by classifying and standardising the testing of the cosmetic effects of cosmetotextiles.

**Key words:** natural moisturising factor (NMF), wellness, cyclodextrin, microencapsulation, Squalane, micro-massaging.

## Introduction

Cosmetotextiles are fast emerging as today's most potential customer lifestyle. Both men and women on both side of the Atlantic are equally excited by the concept of well-being clothes, especially those worn close to the body and capable of having cosmetic effects. Textiles which provide cosmetic and biological functions, such as pleasant feeling, energising, slimming, refreshing, vitalising, skin glowing, anti-ageing, body care, fitness and health, are categorised as cosmetotextiles [1]. The wellness or health promoting aspects of textile finishes have become a delightful functional matter in the 21<sup>st</sup> century. Wellness can be defined as a pleasant state free from disease, a healthy balance between the human body and mind. Wellness has become a social determination which symbolises the wish for eternal youth against ageing. The extracts of natural products and selected essential oils are added to textiles, which not only have healing properties but also keep the wearer fresh and vigorous. In wound dressings, where a slow release of the drug is essential, drug complexes with natural compounds, such as chitosan, hyaluronic acid and alginates serve this purpose. The Natural Moisturizing Factor (NMF) is a scale to express the activeness of skin in terms of the moisture level in the horny layer of the skin surface. At a moisture level of 20%, the skin remains lustrous and elastic; at the moment it reduces to 10%, the skin becomes dry and rough. The merger of two apparently different sectors - cosmetics and textiles clears the way to climb the heights of cosmetotextiles.

Cosmetotextiles are capable of imparting skincare benefits, combating ageing

and promoting a feeling of wellness or well-being. Cosmetotextile is a consequence of the fusion of cosmetics and the textile industry through various techniques, such as micro-encapsulation. In other words, a cosmetotextile is a textile consumer article containing a durable cosmetic substrate which is released over time [2]. Legally, cosmetotextiles are not accepted as cosmetic products. The European Cosmetic Directive has defined cosmetic products as "any textile article containing a substance or preparation that is released over time on different superficial parts of the human body, notably on human skin, and containing special functionalities such as cleansing, perfuming, changing appearance, protection, keeping in good condition or the correction of body odours is called a cosmetotextile" [3]. Cosmetotextiles can be considered as cosmetic textiles when the cosmetic ingredients grafted onto the textiles have to be transferred to the wearer's skin, and the amounts transferred have to be enough to ensure that cosmetic benefits are possible.

## Characterisation of cosmetotextiles

European Standardisation concerning the testing of multifunctional textiles felt the strong need to form test standards for cosmetotextiles.

The European Union formed a working group - WG-25 to form test standards for cosmetotextiles. The WG-25 has identified some areas where standardisation is required immediately and formed five subgroups to work on different aspects of cosmetotextiles. Both subjective and objective evaluations of cosmetotextiles are possible to test various cosmetic effects.

## Chemical properties

The chemical properties of cosmetotextiles are tested according to existing legal directives and regulations for cosmetics. Presently, thirteen relevant directives are identified and listed dealing with both textiles and cosmetics. The European Cosmetic Directive is working for the development of standards for cosmetotextiles.

## Toxicity/innocuousness

This subgroup came to the conclusion that cosmetotextiles cannot be considered as medicine. The cosmetics have to be first applied on textiles, then the textiles have to be used close to skin. Cosmetotextiles should successfully pass EN ISEO 10993, OE CD test methods (OECD 405, 406, 407 & 471). OEKO TEX may also be another option. All members of this group agreed to process their activities in two steps.

- Step I: Test individual ingredients based on current testing standards in the cosmetic industry.
- Step II: Test the whole product with a general biological test similar to an antimicrobial test.

These test methods should be find a balance between cost & safety.

## Presence of vitamin E

The testing of Vitamin E content on textile surfaces can be performed quantitatively through a colour reaction by utilising the reduction properties of Vitamin E, as follows:

- FeCl<sub>3</sub>- solution is dripped onto the finished textiles. In the presence of Vitamin E, Fe<sup>3+</sup> ion is reduced to Fe<sup>2+</sup>.
- Dipyrindyl solution is dripped, which forms a red celate complex in the presence of Fe<sup>2+</sup> ions.

## Efficacy

The efficacy of cosmetotextiles should be tested using the same testing tool & testing conditions as for cosmetics. WG-25 agreed to set some guidelines to solve the complexity of this problem. The ISO/DIS 11930 test may be successful in testing the efficacy of cosmetotextiles, although this test is designed for cosmetics.

## Perfume performance analysis

This analysis is required to test the performance of various perfumed textiles. Headspace gas chromatography/mass spectrometry (Headspace GC/MS) is a specific technique used to analyse volatile compounds. A specimen is placed in an airtight closed sampling vessel and then subjected to a temperature with a known temperature profile. The vapours in the vessels are sampled to analyse the odour issues, for identification of polymer additives and for residual solvent analysis according to various ASTM standards like ASTM - D3362, D3452, D4128 etc [4].

## Durability

WG25 formed a separate subgroup to emphasise the durability aspect of cosmetotextiles. For wash fastness, a lot of testing methodologies are recommended by this subgroup. The efficiency of a binder to bind microcapsules on a textile surface depends on the compatibility of the different interfaces of the products involved in the finishing process. The choice of binder adapted to fix the microcapsules can be finalised by making a comparison of the surface energy components induced by various components in terms of the contact angle. Generally, the adhesion of microcapsules is closely dependent on the chemical nature and structure of the textile substrates [5].

## Labeling

In last meeting of the WG-25 group concerning the feasibility of introducing a standard for labeling in the packaging of cosmetotextiles, the following recommendations were presented in two parts: part one regarded the level sewn into cosmetotextiles, and the second part concerned a note written on packaging. The WG-25 group is still actively involved in finalising labeling standards for cosmetotextiles.

## Classification of cosmetotextiles

A classification of cosmetotextiles is not available in literature. The authors made

an effort to classify cosmetotextiles on the basis of various concepts.

### Classification of cosmetotextiles on the basis of their influence on the human body

In terms of their influence on the human body, cosmetotextiles can be classified as follows.

- cosmetotextiles for slimming
- cosmetotextiles for moisturising
- cosmetotextiles for energising
- cosmetotextiles for perfuming
- cosmetotextiles for refreshing and relaxing
- cosmetotextiles for vitalising
- cosmetotextiles for UV protection
- cosmetotextiles for improving the firmness and elasticity of skin.

#### *Cosmetotextiles for slimming*

A slim body structure is desired by both men and women around the world. The textile structures that work to offer a slimming effect by means of yarn properties, fabric structure and finishes are called cosmetotextiles for slimming. Surgery and exhaustive exercise are two major ways to reduce cellulites. The use of compressional garments has offered a third option for slimming, as well as a reduction in muscle damage and a maintaining muscle function. Functional muscles give a better appearance and a good-looking effect by accelerating blood flow in veins. Cosmetotextiles for slimming provide rehabilitation to the wearers [6, 7]. Skintex slimming has better efficacy in a pair of elastic and tight jeans, which provide intimate contact between the fabric and targeted body part. Skintex has adopted the concept of progressive compression in a typical product - 'Skintex Anti-heavy-legs'.

#### *Cosmetotextiles for moisturising*

The group of textiles that works to provide a moisturising effect on human skin is called cosmetotextiles for moisturising. Squalane, a stable form of squalene and a major component of lipids, can be extracted from various essential oils like olive oil and shark liver. Squalane is able to add a layer of oil on the human skin to suppress water loss from the skin in order to keep it soft and supple. A squalane substance with several hydrophilic groups has an affinity to form hydrogen bonds with water molecules on human skin. Squalane is able to reduce the presence of wrinkles and fine lines due to its humectant potential. Human skin easily absorbs and spreads squalane with zero oily and greasy marks. Textiles which are able to deliver squalene in a controlled

manner can be used as cosmetotextiles for moisturising [8].

Nanotechnology can lead to the development of hydrophilic textile surfaces. The integration of TiO<sub>2</sub> increases the possibility of moisture absorbance on textile surfaces through the photocatalytic process.

In the case of polyethylene fibres, a thin film of TiO<sub>2</sub> can be deposited using the layer-by-layer deposition method [9]. This approach can be used to develop quick-dry textiles for sports or outdoor clothing. Cosmetotextiles for slimming require a large amount of ingredients on human skin. In the case of typical pantyhose, 4% of a skin moisturising ingredient is required for a single daily dose.

#### *Cosmetotextiles for energising*

Some of the textile articles able to lift the energy level of a human being are called cosmetotextiles for energizing. CoQ10 is a shorter for coenzyme Q10. Human body cells use this coenzyme to enhance movement and energy level. Moreover, it is a natural antioxidant [10]. Although scientific proofs are not available, the authors believe that it can be a useful substance to develop textiles for energising.

#### *Cosmetotextiles for perfuming*

A textile article that absorbs foul odours and offers pleasing perfumes is called a cosmetotextile for perfuming. The growing awareness to protect the human being from foul body odours by providing a pleasant smell is the driving force behind the development of a good deodorant textile. A variety of synthetic and natural products are used to add the functionality of deodorancy to textiles. Chitin, chitosan, acetyl-glucosamine, D-glucosamine and various essential oils like clove, jasmine, lavender, hyssop, sandalwood, rose and frankincense etc. are used to achieve a perfuming effect. The incorporation of deodorant into a textile substrate is conducted during polymerisation or during dope formation/ or at the finishing stage. Toyobo Co., Japan, treated a fabric made of 90:10 acrylonitrile-methylacrylate copolymer fibres with 30% hydrazine solution for 3 hr at 98 °C to give an absorbing capacity of NH<sub>3</sub> and H<sub>2</sub>S [11, 56].

#### *Cosmetotextiles for refreshing and relaxing*

A textile structure that enables to provide a refreshing and relaxing effect comes under the class of cosmetotextiles for refreshing and relaxing. In the summer, a cool feeling gives a refreshing and relaxing sensation that 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. Skintex Supercool is a typical commercially available cosmetotextile that works on the principle of increasing the area of body contact with a seamless microdenier polyamide/elastane structure. Skintex 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 [12].

#### **Cosmetotextiles for vitalising**

A textile structure that is able to release revitalising aromas synthesised by plants and fruit based ingredients like ginger, menthol, orange or rosemary at a slow rate comes under the category of vitalising textiles. These ingredients are added to textiles using the microencapsulation technique. The durability of this function remains even after a number of launderings. Vitalising cosmetotextiles are suitable for bathrobes and other similar purposes [13]. The Whirlpool Personal Valet clothes vitalising system smoothes wrinkles and eliminates odours from clothing within 30 minutes in perfect conditions.

#### **Cosmetotextiles for UV protection**

Prolonged exposures to ultraviolet radiation can result in skin damage, such as sunburn, premature skin aging, allergies, and even skin cancer, which results in an inferiority complex in the human being. Textiles which can provide effective protection against such damage are called cosmetotextiles for UV protection. 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, stretchability, 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 [14 - 19].

#### **Cosmetotextiles for improving the firmness and elasticity of skin**

A specialised group of textiles dedicated to improving the firmness and elasticity of human skin is classified as cosmetotextiles for the firmness and elasticity of skin. These textiles are capable of releasing some natural products that soothe the skin, thereby improving the firmness and elasticity of skin in a controlled manner [20]. Padina Pavonica is believed to

improve the firmness and elasticity of human skin. It is extracted from the protective coating of a brown algae found in the Mediterranean Sea. After a successful collaboration between Cosmetil and Variance, cosmetically inspired fluid lingerie called Hydrabra was launched on the market, providing moisturising and firming effects [21]. Hydrabra has a specially designed lower cup made of ultra-thin cloth impregnated with a lotion formulated with extracts of Padina Pavonica to enhance firmness and elasticity.

#### **Classification of cosmetotextiles on the basis of the method of grafting**

Various wellness ingredients are added to textiles by different techniques at different stage of manufacturing to achieve a cosmetic effect. The selection of techniques depends on the nature of the cosmetic ingredient and textiles, as well as on the amount of cosmetic ingredient to be added. On the basis of the method of incorporation of the wellness substrate into the textile, a classification can be made as follows.

#### **Cosmetotextiles created by the insertion of dope additives into the fibre**

Active agents are added to the fibre forming material at the time of dope preparation before fibre extrusion. For example, the manufacturing of inherently conductive, UV absorbing, and de-lusturing fibres can be possible by using carbon nanotube, Zn nanoparticles and TiO<sub>2</sub>, respectively, as dope additive. Inherently functionalised fibres can be used to manufacture textile materials for various purposes [22].

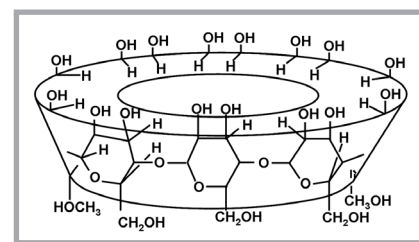
#### **Cosmetotextiles created by the use of grafting layers**

Various cosmetic ingredients are grafted onto fibre, yarn and fabric surfaces to achieve cosmetic effects. Cyclodextrins (CDs) are cyclic structure oligomers of glucose, consisting of 6 to 8 glucose units, produced by the starch digests of the bacteria *Bacillus macerans*. The chemical structure of cyclodextrin is shown in **Figure 1**. The individual glucose units are connected by 1,4 bonds. The polar OH groups of the individual glucose units are on the outside of the cylinder due to their steric arrangement. The outside is hydrophilic, whereas the inside of the cylinder is non polar and thus hydrophobic. The cavities of the host CD can take in all those molecules which can fit into the cavity and are non polar enough to interact with the lipophilic cavity surface and then release them again.  $\alpha$ -cyclodextrin,  $\beta$ -cyclodextrin, and  $\gamma$ -cyclodextrins have 6, 7 and 8 glucose units in which  $\gamma$ -cy-

clodextrin has proven a suitable wellness substance. A research group has permanently grafted  $\beta$ -CD molecules onto a Tencel (cellulosic fibre) fabric surface [23]. After the successful grafting, benzoic acid, vanillin, iodine etc. were either sprayed on the CD grafted fabric or a previously prepared inclusion compound was grafted on Tencel. The fabric treated was found to be satisfactory after various aroma & antimicrobial finishing tests without any significant modification of the original fabric surface [24].

#### **Direct coating on textile products**

Some active agents are coated on fibre, yarn or a fabric surface according to the suitability of the existing facility and the use of the end product. Bed linen can be made more comfortable and healthier using fibres coated by microcapsules with essential oils or antibacterial or anti-dust agents as well as anti-mite chemicals. Fuji Spinning Co. Japan disclosed in a European patent that fibre treated with an emulsion of alpha-tocopherol acetate gets a reduced antioxidant function. Host-guest molecule technology is required to prolong the antioxidant function on the textile surface [25]. As the CD



**Figure 1.** Chemical structure of cyclodextrin.

vitamin E complex does not show any substantivity with textile surfaces, padding, spraying, coating or printing are the other alternative application techniques. For permanent fixation of the complex, reactive polyurethanes have proven to be advantageous. The fixation of CD vitamin E complex can provide the following effects.

- Free from formaldehyde
- Soft handle
- Good fastness on textile surfaces
- Applicable on all types of fibres.

The fixation of the complex is physical, particularly for cellulose and wool fibre (reaction with -OH, -NH<sub>2</sub>-groups). The fixation of the charged cyclodextrin with reactant crosslinking agents is also possible, but then only for application on cellulose fibres.



### **Using the microencapsulation technique**

Various cosmetic ingredients are susceptible to heat or prone to oxidation, whereas deodorants are volatile. These are the major driving forces to adopt microencapsulation as the major technique to develop cosmetotextiles. Microencapsulation can prolong the shelf life of various volatile and nonvolatile cosmetic ingredients by delaying oxidation and evaporation, respectively. The suitability of microcapsules for cosmetotextile applications depends on the range of the diameter, mechanical robustness and content release profile of microcapsules to offer appropriate potential for specific functionality. Microcapsules can be integrated with the textile substrate by two major methods: firstly, by covalent grafting using a selected skin-friendly binder, the amount and type of which used depends on the textile substrate, and it must be capable of binding the microcapsules firmly to offer adequate wash fastness; secondly, by the exhaust method, requiring very precise control of temperature and pH. This method is suitable to treat knits and woven garments [26].

### **Classification of cosmetotextiles on the basis of fabric engineering**

Fabric engineering aspects are able to generate various cosmetic and wellness functions in textiles. For example, knitted compression garments are able to apply specific pressure on a localised area of the human body [6]. On the basis of fabric engineering, cosmetotextiles can be classified into the following three groups.

- Woven fabric based cosmetotextiles
- Knitted fabric based cosmetotextiles
- Nonwoven fabric based cosmetotextiles

### **■ Cosmetic ingredients**

Generally, major cosmetic ingredients originate from inorganic and synthetic chemicals, animal derivatives and plant derivatives. People consciously avoid the use of inorganic, synthetic chemicals and animal derivatives for cosmetic applications because they are biased towards plant derivatives. Various scientific and medical researches have proved that plant derivatives are safer than chemicals and animal derivatives as cosmetics.

#### **Synthetic and inorganic compounds**

Various inorganic and synthetic compounds are used to provide cosmetic benefits to the wearers. 1,2-ethanediol, Zn nanoparticles, iron oxide, zinc oxide,

titanium oxide, carbon black, bi-reactive oxalic acid and dianitride derivatives are used to provide protection against UV radiation. Acetyl-glucosamine and D-glucosamide are used to provide a deodorant effect in textiles [11, 14 - 19]. Copper oxide is used to promote healing and antimicrobial functionality in textiles.

#### **Animal derivatives**

##### **Chitosan**

Chitosan is an animal derivative used for wound healing, as well as for antibacterial, blood clotting and deodorant effects. It is a natural product derived from chitin - a polysaccharide found in the exoskeleton of shellfish like shrimps or crabs. Chitosan improves skin texture, nourishes & stabilizes moisture level, stimulates cell regeneration and forms a high molecular film for skin protection [27].

##### **Squalene**

Squalene is a fatty compound that is found in a number of vegetable oils, including palm oil, olive oil, but it usually extracted from shark liver, where it is found in high concentrations. Squalene is a natural antioxidant. Squalene is the saturated form of squalene, providing additional permeability, nutrients and a water retention capability. Squalene chemically resembles the natural skin lipid called sebum. Squalene is well absorbed into the skin to support the skin's ability to regenerate and maintain hydration naturally. Its ability to penetrate into the skin also helps carry other ingredients into deeper skin levels. 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. Along with the other ingredients, it helps soften the skin to reduce fine lines and wrinkles [28].

#### **Plant derivatives**

Plant-based cosmetic ingredients secured directly from nature are valuable essential oils and extracts. These ingredients are carefully derived from the cold press peel of herb plants and fruit by distillation from blossom and leaves.

##### **Aloe Vera**

Aloe Vera is a semi tropical plant of the lily family. Over 250 different species are available, but only four have nutritional value, of which the Aloe Vera *Barbadensis* Miller group is prominent. The Aloe Vera leaf contains over 75 nutrients and 200 active components including 20 minerals, 18 amino acids and 12 vitamins. Aloe Vera products can lose much of their original beneficial components through over processing, which results in

10 - 15% of aloe-vera at best. Aloe vera should be processed with extra care to minimise the loss of essential vitamins, minerals and other active constituents. An Aloe product should be certified by the International Aloe Science Council. Scientific research on Aloe vera has proved that textiles treated with it are very pleasant to wear, having a significant effect on energy levels, which offers a feeling of well-being. Aloe vera is used to obtain antibacterial, antiviral, antimycotic, wound healing and anti-inflammatory effects [29].

##### **Ginseng**

Ginseng is promoted as an adaptogen, and root of the ginseng plant is the most valued form [30]. Ginseng extract can be used by way of the microencapsulation technique to protect the skin from cancer and inflammation. Ginseng extract is able to block carcinogens 12-O-Tetradecanoylphorbol-13-acetate (TPA), the cancer-causing enzyme ornithine decarboxylase, and the expression of cyclooxygenase-2 (COX-2). Ginseng expression led a reduction in the production of prostaglandin E-2.

##### **Fruits**

Various fruit oils are used to provide aroma to the wearer for refreshment and relaxation. Various chemicals are extracted and applied on fabric surfaces as a source of aroma by different techniques like citral (lemon scent), allyl caproate (rose scent), anillin (apple scent), cinnamaldehyde (Pineapple), prenyl Acetate (banana) and heliotropin (Cherry) [31].

##### **Essential oils**

There are various essential oils which have found their place in aroma therapy, providing skin glowing, moisturizing, refreshing and other wellness effects. These oils are microencapsulated by covering them with a polymeric coating and then applying them on cotton, polypropylene, polyacrylonitrile and polyamide fibre surfaces. The prominent essential oils are lavender oil, thyme oil, sage oil, peppermint oil, eucalyptus oil, camomile oil etc.

##### **Flowers**

Some flowers find their way into wellness through the extraction of specific chemicals like innone (violet), cedar oil (Lilac), Hydroxycitronellol (Lily), Alpha-hexylcinnamaldehyde/benyl alcohol (Jasmine) using various extraction techniques. Finally these well-being extracts can be added to textiles by the microencapsulation technique to achieve various cosmetic aims [31].

### ***Padina pavonica***

Padina Pavonica is extracted from the protective coating of a brown algae found in the Mediterranean Sea. Padina Pavonica is believed to improve the firmness and elasticity of the skin [32]. Cosmetil in collaboration with Variance developed cosmetically inspired fluid lingerie called Hydrabra to provide moisturising and firming effects. The bra has a specially designed lower cup with ultra-thin cloth impregnated with a lotion formulated with extracts of Padina Pavonica.

### ***Hinokitiol***

Hinokitiol is natural wood oil extracted from domestic Hinoki trees. It is effective in the prevention of bacteria, mould and insects. It gives an antibacterial effect against various microorganisms like *Staphylococcus aureus*, *Staphylococcus epidermidis* (1, 7, 8, 13), and *Schistosoma mansoni*. It is effective in giving a relaxation effect due to its aromatic nature [33].

### ***Vitamin E***

Vitamin E belongs to the group of lipid-soluble vitamins and is available in nature in many vegetable oils. The chemical term for vitamin E is „ $\alpha$ -Tocopherol”, as shown in **Figure 2**. Vitamin E is used as an antioxidant and active substance due to its moisture binding ability in emulsions, creams, lotions, body and face oils and aliphatic cosmetics for dry skin care, as well as in decorative cosmetics like lipsticks. It is helpful in guarding against various skin diseases. Vitamin E is also a powerful antioxidant. The term “antioxidant” describes the capability of molecules to neutralise radicals and act as scavengers. Free radicals emerge as side products through normal cell breathing and try to snatch away an electron from other structures to complete their outer shell [34]. As a consequence of this, the cell membrane gets damaged. Antioxidants and thus also vitamin E “deactivate” free radicals by giving off an electron, thereby protecting the cells from “oxidative stress”.

### ■ **Mechanism of skin care finish**

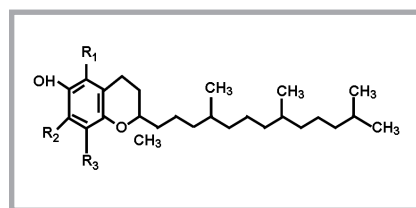
The human skin or dermis is made up of cells, blood vessels and nerves in an extra-cellular matrix composed of fibrillated protein formations, collagen, elastin, etc., which provide resilience to stretching, and a colloidal gel substance which fills up the spaces between all the different dermal components. This gel substance is chiefly composed of water, mineral salts and glycosaminoglycans

[23]. Free radicals are generated on human skin by photosynthesis. The antioxidants are capable of neutralising the free radicals. These free radicals are atoms or molecules which possess an unpaired electron in their outer shell. These free radicals emerge as byproducts while cell breathing tries to snatch an electron from other structures, which causes damage to the cell membrane. The antioxidant (like vitamin E) protects the cell membrane by giving an electron to free radicals.

### Recent and future trends in product developments

Specific engineering aspects can generate wellness abilities in typical textiles. Invista International, Switzerland [35], suggested that the use of graduated compression in garments for the legs offers many physiological benefits for the wearer, such as reduced fatigue and leg swelling, as well as enhanced athletic performance. Invista developed new lycra leg care stockings which are a combination of function and fashion, with the potential to significantly reduce post-exercise muscle soreness.

Institute für Textil- und Verfahrenstechnik (ITV Denckendorf), Germany [23], described the potential of atmofil polyester yarns to produce wellness effects. Atmofil is a differential shrinkage elongation (DSE) yarn in which a functional partially oriented yarn (POY) component is combined with the core component



**Figure 2.** Structure of vitamin E.

through air intermingling. After the realisation of Atmofil yarns into woven or knitted fabric, the respective elongation and shrinkage components are released during fabric finishing. The finished fabric offers a viscose-like handle and appearance.

Tejin Co. Ltd, Japan, was the first to manufacture and sell two million of its trade marked ‘Amino Jeans’ within 24 hours. They are treated with arginine and blown, being new potential in the wellness innovation market. Arginine is an amino acid said to maintain skin youthness [36]. The field of cosmetotextiles is full of poten-

tial for those that always work with a positive and optimistic mind-frame. This field feels a strong requirement for the clubbing together of different types of industries like the textile, cosmetic, herbal pharmaceutical, etc. In a typical research finding, Phaneuf et al. [37] considered polyester fabric as a control material, exposing it to ethylenediamine (C-EDA) to achieve wellness effects.

Skintex technology incorporates active ingredients by micro-encapsulation. The active ingredients are encapsulated inside the microcapsule and firmly anchored on the fibre within the fabric of a textile without affecting the feel and visual appearance of the textile. In a typical application, chitosan is encapsulated to prevent warmth, drying out and cold. At the same time, chitosan helps to protect the skin from dehydration and keeps a supple and velvety soft touch. The ingredients are released either by friction during wearing or the chitosan layer is slowly reduced over time through the wearer’s enzymes. Each textile structure has a limit to load the extra ingredients. A highly active ingredient in each microcapsule with maximum utilisation of the capsule interior is required for attaining a long lasting well-being effect. Skintex wellbeing ingredients are highly concentrated, and hence, even with a very small release, their effect can be seen and felt. Moreover, they are dermatologically tested according to the Ecotex 100 standard. In terms of traces of vitamin E, this technology is effective even after 100 washings if clothes are washed according to Skintex recommendations [38].

A clinically proven patented fabric design from Solidea, Italy, offers cellulite reducing shorts and hosiery range by the micro-massaging of body parts. The manufacturer claims that “MicroMassage Magic” garments are helpful for smoothing and reshaping the bottom and legs, improving the health and appearance of legs and thighs. This patented design of Solidea combines compression with massage through everyday movement. The Solidea range in Australia is going to include Magic Maman Anti-cellulite maternity shaping shorts that promote blood circulation and reduce water retention [39]. Typical MicroMassage Magic Shorts contain 80% polyamide, 18% Elastane and 2% cotton fibres.

Active textile based composite materials are used in wellness products by Swiss Federal Laboratories for Materials Testing and Research for the improvement of the physical performance of multiple

sclerosis (MS) patients [40]. Two polymer membranes are laminated along with a textile material to make personal light-weight cooling garments. This composite clothing provides moderate body cooling to patients who are suffering from an abnormal hardening or thickening of an artery or other body part, as well as an improved nerve conduction velocity. This garment was manufactured using 10 and 15µm thick polymer membranes from Sympatex, while the textile substrate was polyester fabric of 100 µm thickness. Wellness finishes with vitamin E have zero affinity with most textile fibres, hence they are first combined with cyclodextrin before application. Generally, a 3 - 7% wellness finish with an appropriate binder and softener is padded to obtain an 80 - 130% pick-up. The fabric treated is dried and cured at 140 - 160 °C for 2 - 4 min [41].

The USA based company Cupron Inc has launched a commercial range of pillows and pillowcases with the slogan “Beauty while You Sleep”, which helps to reduce wrinkles and liver spots [42]. Polyester filament was treated with wicking surfactant to maintain the sufficient breathability of pillows and pillow covers. Cupron used the copper oxide to offer an-

timicrobial and healing properties. This compound also promotes the healing of wounds because it has the ability to bind amino acids and create collagen. In the case of natural and solution spun fibres, Cupron used copper oxide as a melt additive in melt spun fibres coated on a fibre surface. The clinical trials of Cupron fibres showed that they improve skin tone and texture significantly. Cupron used 4×1 twill weave fabric with a copper impregnated weft and a Pima cotton warp.

Cognis, Germany, has introduced chemically and technically fine-tuned baby diapers, “Caremelts”, with maximum dermatological compatibility based on the application of phase change materials. Caremelts work close to room temperature. Caremelts utilise the combination of cosmetic waxes with fabrics which melt partially at body temperature. Caremelts are manufactured in a discontinuous way in order not to disturb the liquid acquisition functionality of the diapers or other hygiene potentials [43].

#### Skin Care Finishes

A range of wellness textile finishes have been launched by various cosmetotextile manufacturers, some of which are described as

■ **Skinsoft 415 New:** This finish was developed by Daiwa Chemical Inc., Japan, which is mainly composed of phospholipid containing 2-methacryloyloxyethyl phosphorylcholine (MPC) with phosphatidylcholine polar groups. Skinsoft 415 New, based on water soluble polymer, exhibits a superior moisture retaining effect. Sweet softener AN is also available for use with Skinsoft 415 New. This finish improves soil release, anti-browning and antistatic effects [44].

Ohara Paragium Chemicals Kyoto, Japan, have launched a broad spectrum of skin care and anti-ageing functional finishes for textiles, some of which are available on the market [45]:

■ **Parafine SC-1000:** This finish was developed by Ohara Paragium Chem. JP. and mainly consists of silk based amino acids. The amino acids are rich in moisture retaining properties which promote skin well-being by enhancing the amount of moisture on skin.

■ **Parafine SC-3000:** This finish imparts a fat-burning effect by the presence of capsaicin, as well as a moisture-retaining and skincare effect with raspberry and squalane, respectively.

**Table 1.** Selected Cosmetotextiles with manufacturer's product name, basic cosmetic ingredients and product features.

S. No & Ref.	Manufacturer & brand name	Basic cosmetic ingredients	Product's features
1 [49]	Ajinomoto with Mizuno Corp USA with brand name "Amino Veil"	"arginine" amino acid	Tennis and golf clothes. Amino acid dissolves into the wearer's perspiration, enhancing the material's ability to absorb moisture, keeping the skin's pH level balanced and regenerating the skin
2 [50]	Yonex: Sports cloth manufacturer	Xylitol	Tennis and badminton clothes: These fabrics mainly consist of xylitol, which absorbs heat when it comes into contact with water and offers a cool feel (when the wearer start sweating)
3 [51]	Fuji Spinning, Japan with Brand Name V-Up	Pro-vitamin C soluble in sebum	Cosmeto-clothing: Pro-vitamin C converts into vitamin C in the presence of sebum and is applied on blouses, and men and women's shirts.
4 [35]	Invista (previously DuPont Textiles & Interiors) with International Flavors & Fragrances (IFF)	Aloe Vera, and Chitosan with other PCMs	Leg wear and intimate clothing for both men, women and Yoga Lines: Delivering cosmetic and well-being benefits like freshness, moisturising and massage for leg wear and intimate apparel. Stretch and recovery function through the use of Lycra
5 [52]	Richa (BE) Collection, 2007	phase-change materials (PCM)	Close-fitting women's motorbike pants: having a thin lining of Schoeller's phase change material, which can be removed in warmer weather and reattached at lower temperatures
6 [53]	Cognis Oleochemicals Corp. with brand name "Skintex"	distilled oils of plants, fruits and leaves	This fabric has the ability to provide gentle care to tired feet and legs with the special effects of invigorating aromas. This functionality lasts up to several launderings.
7 [54]	Dogi International Fabrics	aloe vera	Smart Fabrics with aloe vera nanoparticles which provide moisturising, calming, anti-oxidant and anti-ageing benefits
8 [55]	LYOSILK® Hefel Textil GmbH, Austria	Tencel and silk fibre	Lyosilk® consists of microfine Tencel fibres and pure silk. 300-1000 meter long individual delicate threads are twisted together to form open and soft silk yarn to use as weft. The actively breathable, fluffy Tencel® fibres become shinier, smoother and even more refined by the incorporation of pure silk.
9 [55]	SEACELL®ACTIVE Hefel Textil GmbH, Austria	Lyocell fibre sea algae and silver ions.	HEFEL has begun using t SeaCell® Active fibre in its bedding. The fibre is made from 100% cellulose and algae and is enriched with pure silver, which has strong anti-bacterial and fungicidal properties. According to Friedrich Schiller university in Jena, patients with chronic skin diseases can directly benefit from the new SeaCell® Active textiles. Functionality is not reduced even after 20 washes at 60 °C.
10 [39]	Solidea, Italy MicroMassage Magic	80% polyamide; 18% elastin; 2% cotton	The MicroMassage collection provides elegant shaping as well as the toning and smoothing of skin. The key is in the special patented three-dimensional wave-like knitting process of the fabric, which lightly massages skin by working with natural body movement to promote circulation in skin and fat tissue and stimulate the drainage of fluids causing orange peel
11	Cosmetil and Variance, Hydrabra,	ultra-thin cloth with extracts of Padina Pavonica	The cosmetically inspired fluid lingerie "Hydrabra" provides moisturising and firming effects



- **Parafine SC-5000:** This finish contains extracts from rice germ oil (ferulic acid and  $\gamma$ -oryzanol) and vitamin E. This combination offers anti-oxidation properties which contribute to skin anti-ageing. This finish promotes anti-oxidation, bio-membrane stabilisation and blood circulation in human skin.
- **EVOTM Care Vital:** This finish, developed by Dystar Auxiliaries GmbH, Frankfurt, Germany, contains a combination of vitamin E, Aloe Vera and Jojoba oil that offers an anti-ageing function in textiles [46]. These natural substances are embedded in silicone matrix to enhance the washfastness of the finished fabric. Evo Care Vital is applied as the last step in the conventional pad and exhaust finishing process. DyStar has also introduced Evo Care BeeWell with beeswax, Evo Care AVP and Evo Care AVS with Aloe Vera and Evo Care SJO with Jojoba oil [47]. Evo Care Vital fulfills current cosmetic requirements with its anti-ageing effect and the fact that it is applicable over a broad range of textiles that come directly into contact with the skin. West and Zhu [48] experienced a consistent improvement in skin integrity by exposing factory workers to dry coated aloe vera gloves.

5 selected cosmetotextiles with their manufacturers and brief characterisation are presented in **Table 1**.

## Conclusions

In the future, wellness finishes will play a key role in developing value added products to compete in the barrier-free market, where customer's expectations are reaching new heights everyday. The optimisation of the quantity of cosmetic ingredients and enhancing the durability of cosmetic effects are the two real challenges in this field. Cosmetotextiles is a fast growing industry in which different types of industries are working together. Customers worldwide have turned towards well-being through natural resources in an eco-friendly health promoting environment. The development and optimisation of cosmetotextiles is at the neonatal stage and requires proper attention and adequate funding. Various explored and unexplored natural products are available to feed the cosmetotextile industry, which have enough potential to offer wellness effects. Cosmetotextiles have to be designed in such a fashion so that the composition and construction of

textiles, garment design and cosmetic finish must all work together to exhibit optimum cosmetic effects.

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