

Review Article

A review of some significant breakthroughs in developments of chemically treated textile materials for skin care

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Abstract

The article reviews some of the recent researches in development of chemically treated textile materials for effective skin care. When nano particles are applied on textile materials they impart a number of functional properties of which ultra violet radiation protection is one such and concerns the skin. Since ultraviolet radiation is harmful to skin and causing many types skin diseases that have created global concern. The harmful impact of ultra violet radiation on human skin, UPF measurement method and UV protective finishing on textile material using nano ZnO and nano TiO₂ particle have been explored. In order to address the issues relating to skin health caused by progressive public use of antimicrobial clothes, a placebo-controlled side-to-side study has been carried out with antimicrobial clothes versus fabrics of similar structure but minus the antimicrobial activity, to evaluate possible adverse effects on the healthy skin microflora. An innovative effort has been taken to develop medicinal herb extracts treated garments using alternate medical concepts to cure selected diseases of which allergic dermatitis is one such.

Introduction

Textiles are one of the most heavily traded commodities in the world. The industry is very diverse and its products are used by virtually everybody from private households to large businesses. The textile industry is already an important user of nanotechnologies and there are a significant number of “nanotextiles” in the market, including many consumer goods, with the incorporation of nanoparticles. These include many textiles used in direct contact with the skin, such as underwear, shirts and socks but also interior textiles like cushions, blankets or mattress covers.

Sunlight is considered as crucial to all forms of living beings and is one of the renewable sources of energy. Sunlight has three rays based on their variation of wave length. These are ultraviolet (UV) rays, visible light and infrared rays. Of these rays the shortest wavelength is found in UV rays and the longest in infrared. Both the rays are not visually perceptible. In the case of the visible light the wavelength spans between 400 - 700 nm and comprises of all basic primary, secondary and tertiary colours. UV rays can be split into 3 types: UV-A, B and C in which each of the rays comprises of the wavelength 315 - 400 nm, 280 - 315 nm and 100 - 280 nm, respectively [1]. The incident sunlight on earth surface consists of 50% of visible light, which is the major percentage, 45% of infra red radiation and only 5% is UV radiation [2].

In order to protect textile materials from rotting antimicrobial substances have originally been applied on them, particularly under tropical climate conditions. Presently, there is a fast increasing demand for antimicrobial consumer goods which is caused by attitude of consumers towards hygiene and active lifestyle. Thus, the application of antimicrobial agents has spread to outdoor clothes, health care sector, sport, and leisure. The majority of fabrics use silver ions as the active antimicrobial agent [3].

The infestation of microbes can cause threat to living as well as non living organisms. Harmful microbes can cause unpleasant odour

that arise from inner garments, spread of diseases, staining in textile materials. Despite antimicrobial substances having been known for years, only during recent years they have been applied for textile finishes. There is an increasing public awareness of the hygienic life style and many textile finished products are expected to have antimicrobial properties.

Effect of nano treated textiles on skin

Nanotechnology has during recent times witnessed a drastic growth into many consumer products. This has resulted in concerns about the potential risk for human health following consumer exposure. Also, a concern has developed regarding occupational safety and health, related to the exposure of workers involved in production, processing and handling of consumer goods consisting of nano materials. The safety of nano materials is gaining more concern. Several health effects such as pulmonary inflammation, geno toxicity, carcinogenicity and circulatory effects arise from exposure to engineered nano materials [4]. There is a knowledge gap between the technological progress in nanotechnology and nano safety research which is estimated to be 20 years, and it is likely to expand. The European Agency for Safety and Health at Work has established as priority for research related to the safety and health in Europe during the period 2013-2020 the increase of knowledge on nano materials in occupational settings, including new generation nano materials and understand their characteristics in

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relation to toxicity in biological systems [5,6]. The risk for the workers and for the consumers is linked to the characteristic properties of certain nano materials that make them different from their macro scale counterparts and will be determined by the chemical composition of the nanomaterial, its physicochemical properties, the interactions with the textile materials and the potential exposure levels. Ingestion exposure via the gut, airborne exposure via the lungs and dermal exposure are the most important exposure routes to be considered in a risk analysis. In addition, the increasing use of nano materials, including for industrial purposes, raises specific concerns regarding their disposal at the end of their life cycle with the unavoidable release to the environment that may lead to indirect human exposure. At present, some EU Regulations already include a specific mention to nano materials. This is the case of food (including additives and packaging), biocides and cosmetic products. But this is still not the case of textiles. The growing concern about the possible negative effects of nano materials on humans and on the environment can lead to restrictions to "nano textiles". In fact, for instance, the 2014 version of the ecological label GOTS (Global Organic Textile Standard) fully bans the presence of nano finishes in textiles. Also in the recent discussion of the new version of the EU ecolabel for textiles, there were several voices to exclude nano materials. In the present paper, after making an overview of the use of nanotechnology in textiles, with special emphasis on textiles for major consumer applications, the safety and health concerns related to nano textiles are presented. The paper includes then a case study concerning the development of a test method to evaluate the skin exposure to nanoparticles, mainly directed to the transfer of the nanoparticles from the textile to the skin. This paper does not deal with the penetration of the nanoparticles into the skin. There are many studies about this topic, related for instance to sunscreens and cosmetics, which are often based on nanomaterials. In fact, only the smaller nanoparticles seem to be able to penetrate in the undamaged skin, although in the skin is injured, larger nanoparticles can penetrate [7]. In a recent study, Larese Filon, *et al.* [8] made a literature survey involving 129 relevant publications and concluded that the smaller nanoparticles, with dimensions smaller than 4 nm, can easily penetrate the skin, while those with dimensions from 4 nm to 20 nm, can potentially penetrate intact skin. Nanoparticles with size between 21 and 45 nm can also penetrate and permeate in damaged skin.

Nano materials have the potential to improve the quality of life and to contribute to industrial competitiveness in Europe. However, the new materials may also pose risks to the environment and raise health and safety concerns. The Scientific Committee on Emerging and Newly Identified Health Risks has concluded that, even though nano materials are not per se dangerous, there is still scientific uncertainty about the safety of nano materials in many aspects and therefore the safety assessment of the substances must be done on a case-by-case basis. In the case of textiles, there are still very few studies on the possible health risks involved with "nano textiles" [9]. The release of nanoparticles from textiles is particularly relevant when the incorporation is made by fabric finishing. It can occur by different mechanisms. In this paper, the release resulting from skin contact, involving abrasion and sweat, has been analysed more in detail, involving a possible standard test method. The studies made up to now involve silver and titanium dioxide nanoparticles, which are present in the most common nano textiles in the consumer market. Nevertheless, there are still a lot of discussions on if these nanoparticles can really penetrate into the different skin layers and on the negative effects on human health. In the case of titanium dioxide, it is very commonly used in sunscreens, the nanoparticles being deliberately spread over a large surface of the skin. Comparatively,

the dermal exposure coming from textiles is much lower, so the relative relevance of skin exposure coming from textiles can be questioned. Also in the case of nano silver, it is used in deodorants, deliberately put on the skin, food packaging or even in toothpastes. Again the relevance of the silver nanoparticles from the textiles to the human body can also be questioned.

Nano treated fabrics for protection of skin for UV radiation

The intensity of ultra violet radiation depends on geographical location of the place, sun's altitude, season, time of the day as well as closely connected to the incident angle [10,11]. Though only small amount of ultra violet radiation falls on the earth, it has adverse effect on human skin. UVR can cause cellular damage and photoaging of the skin and skin cancer by occurring DNA damage (formation of cyclobutane pyrimidine dimers), gene mutations, immunosuppression, oxidative stress and inflammatory responses [12]. The radiation of UVA easily passes through the atmosphere and falls on the earth as the stratospheric ozone layer cannot filter those rays which in long-term exposure causes aging of the skin and induces immediate and persistent pigmentation (tanning). Around 1% - 10% ultraviolet B radiation (UVB) comes on earth surface as the stratospheric ozone layer filter the major proportion of this rays. It is responsible causing sunburns, tanning, photo aging and skin cancer and has been found that UVB radiation is thousand times more effective in causing sunburn than UVA [13]. It is a matter of luck that no UVC radiation comes on the earth as the whole proportion is filtered out by ozone layer which is more dangerous for skin damaging than that of UVA and UVC. The effectiveness of ozone layer is now under threat as the use of a particular gas called CFCs (Chloro-fluoro-Carbons) is increasing day by day which is likely to damage the ozone layer. Realizing the facts it is necessary to protect skin from over exposure of ultra violet radiation. To keep oneself save from ultra violet radiation it is required to avoid the UVR source but it is not the wise decision as our every day's work related to combine integration of various outdoor activities. It is recommended that to wear a sunscreen, avoid going out in sunbath or cover up with clothing coated in ultraviolet protective agent [14,15]. There are some demerits associated with sun screen since it only absorbs UVB rays (280 - 315 nm) but not UVA rays (315 - 400 nm) and it requires to be attached to skin frequently. Recently, researches relating to textile materials have turned focus on developing nano metal particle for coating on the fabric that not only absorbs the ultra violet radiation but also impart significant enhancement in physico chemical properties of fabric.

The UV protective finish on textiles has impressed the buyers particularly among those that live in warmer parts of the globe. This is because there is no alternative option available to avoid ultra violet radiation that emits through sunlight [16]. Most of the investigations have been carried out in padding method to apply nano particles as better UPF value was obtained in almost all of the experiments on textile material. But exhaustion method in case of applying nano particle on textile substrate is still rare. Further research on this finishing process can bring out a significant change on applying method.

Studies on antimicrobial active clothes on healthy human skin

Beside silver, quaternary ammonium compounds, polyhexamethylene biguanides, triclosan, or chitosan are also used. Antimicrobial agents can be applied to the textile substrates as a finish by exhaust, pad-drycure, coating, spray, and foam techniques, or the substances can be applied by directly adding into the fibre spinning dope [17]. Manufacturers claim that the antimicrobial effect is restricted

more or less to the fibre surface, but mostly the amount of biocide released onto the skin from each product is unknown. In dermatology, antimicrobials are mainly used as liquids to eliminate pathogens in skin antisepsis and disinfection.

The application of therapy-enhancing antimicrobial fabrics in dermatology came up in 2006, when Gauger, *et al.* used form-fitting antimicrobial textiles, based on silvercoated yarns in the treatment of atopic dermatitis [18]. In this double-blind, placebo-controlled trial with 68 atopic dermatitis patients, they were able to show that antimicrobial fabrics, worn for 2 weeks tightly on the skin, may reduce the non physiological colonization of the patients skin with the microorganism *Staphylococcus aureus* [19,20]. Subsequently similar studies confirmed that antimicrobial cloth at least have influence on the pathological skin flora of atopic dermatitis skin and thus may support or reconstitute physiological functions [21–23]. Whether an influence on the physiological skin flora on skin of healthy subjects occurs has not been addressed so far. In contrast to therapy-enhancing textiles, which support physiological or healing functions, the public use of antimicrobial cloth as a consumer good should not pose any risk to the human health under normal or foreseeable use [24-27]. The question of such health risks is important for the increasing number of people using antimicrobial cloth especially in sport and leisure activities, who wish to feel clean and safe or to control malodour. The main concerns with the regular use of topical antimicrobial substances on skin comprise the development of irritant and allergic dermatitis [28] as well as disturbances in the ecological balance between the host (transient) and the normal (resident) microflora. Since most studies on the impact of antimicrobial agents on normal microflora have been carried out on the intestinal flora [29], less is known on the effects on the human skin microflora [30], although the skin microbiota provides an important barrier against the colonization of potentially pathogenic microorganisms and against overgrowth of already present opportunistic microorganisms. Proposed beneficial roles also include further processing of skin proteins, free fatty acids, and sebum [31]. Adverse effects of antimicrobial clothes, especially formfitting sport and leisure underwear, on the ecological balance of the human skin microflora, are poorly studied. We therefore investigated in this study, whether silver-finished and silver-loaded antimicrobial fabrics lead to changes in the physiological human skin microflora of healthy subjects under usual use. To address this question, a placebo controlled right/left-intra individual pre-/post-comparison trial with 60 volunteers was performed over a period of 6 weeks. Antimicrobial fabrics, provided with a strong antimicrobial activity according to ISO 20743, were used in this long-term wear trial and compared with the short-term application of an antibacterial silver-containing deodorant. Furthermore, we evaluated the effect of the antimicrobial fabrics on skin physiological parameters. In particular, transepidermal water loss (TEWL), stratum corneum hydration (corneometry) and skin surface pH (pHmetry) were objectively used to monitor the skin barrier functions, in order to look for the advent of irritations or secondary effects of a changing microbial composition of the skin microflora.

Studies have indicated that no significant adverse effects of antibacterial clothes have been observed on the physiological human skin microflora or the skin barrier of healthy people [32]. Worth of note is that the subject of evaluation was healthy skin that is already in good conditions at the start of the study.

Medicinal herb treated garments for dermatitis

In an era of environmental awareness, the new quality needs not only stress on intrinsic functionality and durability in service of the product

but on also on an eco friendly production process. Hence, there is an increasing global focus related to research on eco friendly antimicrobial agents based on textile products for textile application. In the case of natural product extracts various categories of active ingredients are found. There are many applications of antimicrobial textiles with improved functionality like health and hygiene products, particularly the garments worn near the skin, and many medical applications, like infection control and barrier material. Herbal products can substitute synthetic antimicrobial agents for textile applications owing to their comparatively lower occurrence of adverse reactions than modern synthetic pharmaceuticals, combined with economy, and can be utilized as an eco-friendly option [33,34]. Since years natural dyes are known for dyeing and medicinal properties they can prove very useful in offering antifungal and antimicrobial finish for textile materials. However, only very recently their structure and protective properties have been recognized [35]. In order to live comfortably and work with increased efficiency the fundamental necessity of human beings comprise of health and hygiene. Antimicrobial finish is considered important in order to protect human beings from pathogens and avoid cross infection [36,37]. With the advent of new technologies the growing needs of the consumer in the wake of health and hygiene can be fulfilled without compromising the issues related to safety, human health and environment. Tapping new potential antimicrobial substances, such as, chitosan from nature can considerably minimise the undesirable activities of the antimicrobial products. With the increasing demand for fresh and hygienic textile the consumption of antimicrobials is increasing day by day. Research and development activity is trying to keep pace by developing more and more effective and safe solutions [38]. Surveys indicate that 80% of the global population currently utilize herbal medicine in certain aspect of primary healthcare. In the case of traditional medicine herbal medicine constitutes a major component and in the case of other medical systems such as naturopathic, homeopathic, ayurvedic, traditional, oriental, and native American indian medicine it constitutes as a common element. Among many plant derived pharmaceutical medicines majority are used in modern medicine in such a manner which correlate directly with their traditional uses as plant medicines by native cultures. In the treatment of ailments such as heart disease, high blood pressure, pain, asthma, and other problems, the plant derived substances form the basis of a huge proportion of the commercial medications presently used. Efforts have been taken to impart medicinal property to cotton fabrics by using the combined theories and concepts of alternate medical concepts such as siddha, Ayurveda, colour therapy, pranic healing, naturotherapy, etc. The curative garments have been developed to cure allergic dermatitis, psoriasis, asthma, liver disorders, headache, joint pain and sinus trouble or common cold [39,40].

Conclusion

Skin care is an important aspect of human health and there have been interesting research developments in textile materials during recent years for dealing with dermatological problems. The influences of nano materials in health and safety have witnessed increasing concern on health and safety. Nanoparticles can be released from the textile materials due to different effects (abrasion and other mechanical stresses, sweat, irradiation, washing, temperature changes, etc.). It is then expectable that “nanotextiles” may release individual nanoparticles, agglomerates of nanoparticles or small particles of textile with or without nanoparticles, depending on the type of integration of the nanoparticles in textiles. The most important exposure route of the human body to nanoparticles in case of textiles is skin contact. Several standards are being developed under the auspices of the European

Committee for Standardization. A test method has been developed and applied to evaluate the skin exposure to nanoparticles, to evaluate the transfer of the nanoparticles from the textile to the skin by the effect of abrasion and sweat. The advancement of nano technology provides a number of techniques to introduce UV protected fabric by applying certain semi conductor metal oxide. So many researches have been carried out to coat the fabric using certain nano particles namely ZnO and TiO₂ to improve the UV absorption capacity of material as well as increasing UPF value to protect the human skin which have been playing a significant role to provide UV protected clothing. The harmful impact of ultra violet radiation on human skin, UPF measurement method and UV protective finishing on textile material using nano ZnO and nano TiO₂ particle have been considered. The progressive public use of antimicrobial clothes has raised issues concerning skin health. The microflora of the scapular skin was analyzed weekly for opportunistic and pathogenic micro organisms over six weeks. The antibacterial halves did not disturb the micro flora in number or composition, whereas a silver-containing deodorant displayed a short-term disturbance. Furthermore, parameters of skin morphology and function (TEWL, pH, moisture) did not show any significant shifts. In summary, antimicrobial clothes did not show adverse effects on the ecological balance of the healthy skin microflora. Medicinal herbs like neem, turmeric, holy basil, sandal wood, and so on have been chosen for curing various ailments of which dermatitis is one such. 100% cotton woven/knitted fabrics have been treated with the chosen medicinal herbal extracts and a given number of curative garments have been developed. The developed fabrics have been tested for its antimicrobial activity using standard test methods. The antimicrobial assessments of the medicinal herb extracts treated fabrics and clinical trials have confirmed the correlation between the curative performance and its antimicrobial activity. This offers an alternative method of drug delivery.

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