AN ECOFRIENDLY ANTIMICROBIAL FINISH BASED ON NATURAL BIOACTIVE COMPOUNDS

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ABSTRACT

In the textile and garment world, finishing plays a critical role for quality and value. Antimicrobial textile products continue to increase in popularity as demand for fresh smelling, skin friendly, and high performance fabrics are increasing day by day. The synthetic antimicrobial agents are very effective against a range of microbes and give a durable effect on textiles. But these synthetics agents are associated with some side effects like action on non-target microorganism and water pollution. Hence, there is a great demand for antimicrobial finishes based on non-toxic and eco-friendly bioactive compounds. Due to the relatively lower incidence of adverse reactions of natural agents in comparison with synthetic agents, they can be exploited as an attractive eco-friendly alternative for textile applications. Nature is an immense source of such bioactive compounds in the form of medicinal plants with active ingredients. Some natural plants such as *Aloe vera*, Eucalyptus oil, *Tulsi* leaf, curcumin, prickly chaff leaves and *Neem* can also be used for antimicrobial activity in textiles. Natural bioactive compounds have been widely reported as antimicrobial agents for textiles in a finishing setting. However, commercial applications were not reported yet, except for the case of chitosan. Typically, chitosan and plant extracts are the most explored. Yet, there are several major challenges regarding extraction, isolation, application and durability of the bioactive compounds. Nevertheless, due to their eco-friendly nature and non-toxic properties they are still promising candidates as antimicrobial agents for textiles. An antimicrobial textile with improved functionality finds a variety of applications such as health and hygiene products.

Introduction

In the textile and garment world, finishing plays a critical role for quality and value. Antimicrobial textile products continue to increase in popularity as demand for fresh smelling, skin friendly, and high performance fabrics are increasing day by day. An antimicrobial finish is also applied to the textile material in order to protect the skin of the wearer and the textile substrate itself. Textile associations and industries around the world have started to work on the materials and system for the protection and well being of the human society. Textile industry continuously searches for new technologies in order to accomplish the consumers´ demands. Consumers' attitude towards hygiene and active lifestyle has created a rapidly increasing market for a wide range of textile products finished with antimicrobial properties, which in turn has stimulated intensive research and development (16).

As a result, the number of bio-functional textiles with an antimicrobial activity has increased considerably over the last few years (5, 20). An antimicrobial textile with improved functionality finds a variety of applications such as health and hygiene products (5, 26); and because they are able to absorb substances from the skin and can release therapeutic compounds to the skin, they find applications for prevention, as surgical lab coats, or therapy, as wound dressings (2, 26). Hence, biomedical products will perhaps be the largest application of antimicrobial textiles (2, 26).

Microorganisms and textiles

Textiles are an excellent substrate for bacterial growth and microbial explosion under appropriate moisture, nutrients and temperature conditions (2, 16). In the medical surroundings, they can be an important source of bacteria that may contaminate the patients and clinician personnel (2). Bacteria and fungus, whether they are pathogenic or not, are normally found on human skin, nasal cavities, and other areas, such as in the genital area.

Microbial peeling from our body contributes to microorganism spreading into our cloths directly or indirectly. Recent studies strongly support that contamination of textiles in clinical settings may contribute to the dispersal of pathogens to the air which then settle down and infect the immediate and non-immediate environment. It is one of the most probably causes of hospital infections (2). Typically, pathogenic microorganisms like *Klebsiella pnuemoniae*, *Pseudomonas aeuroginosa*, *Staphylococcus epidermidis*, *Staphylococcus aureus* and *Candida albicans* have been found on textiles.

In addition, microorganism proliferation can cause malodours, stains and damage of mechanical properties of the component fibres that could cause a product to be less effective in its anticipated use. Additionally, may promote skin contamination, inflammation and in sensitive people, atopic dermatitis (9). Fortunately, the use of antimicrobial textiles may significantly reduce the risk of infections especially when they are used in close contact with the patients or in the immediate and non-immediate surroundings.

Antimicrobial agents for textile applications

Numerous major classes of synthetic antimicrobial agents are used in the textile industry and recent research is focused on natural compounds. Antimicrobial agents should possess broad spectrum biocidal properties. In addition, they should not permit the development of resistant microorganisms to the active compound or cause skin sensitization (2, 16).

Antimicrobial agents are natural or synthetic compounds that inhibit the growth (bacteriostatic or fungistatic) because they can be protein, lipid synthesis or enzyme inhibitors, all of which are essential for cell survival; or kill (biocidal) the microorganisms by damage in the cell wall. Almost all antimicrobial synthetic agents in use on textiles are biocides.

The major classes of synthetic antimicrobial agents for textiles include triclosan, metal and their salts, organometallics, phenols, quaternary ammonium compounds and organosilicons, etc. (11). Several synthetic antimicrobial agents have been tested in textiles: Quaternary ammonium compounds, silver, polyhexamethylene biguanides (PHMB) and triclosan even in an industrial scale. They have powerful bactericidal activity, as indicated by the MIC value, and also different application methods, effectiveness on fibres depending on chemical composition, and side-effects. However, they may cause skin irritation, eco-toxicity and bacteria resistance. Furthermore, the biocide can gradually lose activity during the use and launderings of the textile. The synthetic antimicrobial agents are very effective against a range of microbes and give a durable effect on textiles. But these synthetics agents are associated with some side effects like action on non-target microorganism and water pollution. Hence, there is a great demand for antimicrobial finishes based on non-toxic and eco-friendly bioactive compounds.

Eco-friendly bioactive compounds

To diminish the side effects and risks associated with the application of synthetics antimicrobial agents, there is a great demand for antimicrobial textiles based on non-toxic and eco-friendly bioactive compounds (11). Due to the relatively lower frequency of adverse reactions of bioactive compounds in comparison with synthetic agents, they can be exploited as an attractive eco-friendly alternative for textile applications (20). Although there are many bioactive compounds, the study on their use in textiles is very limited and not well documented, except for the case of chitosan, natural dyes and natural plant extracts which has been widely reported (1, 11). Natural bioactive compounds have been widely reported as antimicrobial agents for textiles in a finishing setting (11). However, commercial applications were not reported yet, except for the case of chitosan. Typically, chitosan and plant extracts are the most explored. Yet, there are several major challenges regarding extraction, isolation of the bioactive compounds, application and durability. Nevertheless, due to their eco-friendly nature and non-toxic properties they are still promising candidates as antimicrobial agents for textiles.

Chitosan a biopolymer derived from a component found in crustacean shells called chitin, has long been known to possess antimicrobial attributes. Antimicrobial textiles using chitosan is also extensively reported in the literature (8, 17 and 24). Antimicrobial fibers obtained from chitosan are readily available in the market for potential use (14, 15). The antimicrobial activity of chitosan is influenced by several factors such as the type of chitosan, the degree of deacetylation, molecular weight and other physical and chemical factors such as pH, ionic strength and addition of non-aqueous solvents. Chitosan can be considered an antimicrobial agent for textile finishing.

However, its application in textile materials is effective against a wide range of microorganisms only at high concentrations, which causes a decrease of the air permeability on fabrics and turns the fabric very inflexible. Another disadvantage is the low durability after application (11).

Aloe vera plants are well known for their medicinal and healing properties from centuries. *A. vera* called the ‘miracles plant’ or the ‘natural healer’. *Aloe vera* (*Aloe barbadensis*) belongs to the family *Liliaceae* and is known as "Lily of the Desert". *A. vera* is a plant of many surprises. The healing properties of the succulent plant *A. vera* have been known for thousands of years. Belonging to the lily family and related to the onion, garlic and asparagus, evidence supporting the early use of *Aloe* was discovered on a Mesopotamian clay tablet dating from 2100 BC (6). In Cairo in 1862, George Ebers, a German Egyptologist, bought a papyrus, which had been found in a sarcophagus excavated near Thebes a few years earlier.

An eco-friendly natural herbal finish from *A. vera* extracts for various textile applications has been developed by researchers. Some selective species of *A. vera* plants were identified and screened for their activity and the extracts were applied to cotton fabrics. Research has shown that Aloe leaf contains a large number and variety of nutrients and active compounds. *Aloe vera* also has antibacterial and antifungal properties that can be exploited in applications for medical textiles such as bandages, sutures, bioactive textiles, etc. (11)

Sericin is a natural macromolecular protein derived from silkworm *Bombyx mori* which constitutes 25-30% of the silk protein. It is a bio-molecule of great value since it has antibacterial properties, UV resistance, resists oxidation and has hydrating properties. It has several applications, such as moisturizing agent in shampoos and creams, and is also an important biomaterial for various applications including textiles. Although the application of sericin as an antibacterial agent for textiles has not been reported yet, it has been found evidence of such a potential application (11, 3). Functional properties of some synthetic fibers can be improved by coating sericin protein. Sericin modified polyester has been reported by Yamada & Matsunaga and Wakabayasi & Sugioka (23, 25).

Neem (*Azadirachta indica*) is an evergreen tree of India, which belongs to the plant family *Meliaceae*. *Neem* is a medicinal tree whose bark, stem, leaf, root and fruit can be used for antibacterial and anti fungal action. *Neem* contains a very important constituent namely “NIMBUS” ($C_{30}H_{36}O_9$). This compound has the property to act against bacteria. *Neem* leaves, seeds and bark possess a wide spectrum of antibacterial action against Gram-negative and Gram-positive microorganisms, including *M. tuberculosis* and streptomycin resistant strains (4). Antimicrobial effects of *Neem* extract have been demonstrated against *Streptococcus mutans* and *S. faecalis* . The extract of *Neem* has been widely used in pesticide formulations that due to their pest repellent properties have the potential to inhibit the growth of Gram-positive and Gram-negative bacteria. When the seeds or leaf of *Neem* is crushed either as raw or as dried material and then an extract is made in aqueous solution, all the soluble products from a ticotion, which is filtered and the filtrate is used for all the studies.

Recent literature reference has been cited to use products derived from *Neem* for fixing on textile. At present, little has been reported of its use in textiles as an antimicrobial agent. Few studies concerning application of *Neem* extracts to cotton and cotton/polyester blends have been reported (11, 12 and 22).

***Tulsi* (Ocimum Sanctum)** it is well that *Tulsi* (Ocimum Sanctum) an Ayuredic herb has several curative properties. One of the important medical values of *Tulsi* is its antibacterial activity. *Tulsi* is a small herb which is widely distributed in India. It grows in all climatic conditions. *Tulsi* is recognized by its pleasant odour. Its anti bacterial property may be due to some of organic compounds like camphor, camphere, cineole, limolene, pine (α,β) present in it. *Tulsi* is used in cosmetics, soaps and hair oils. *Tulsi* leaf has the property of antifungal, antibacterial and antiseptic. Thilagavathi et al. observed that *Tulsi* leaves having antimicrobial activity are suitable for textile application (21). The bacteria- resist property of *Tulsi* oil has also been studied by Sarkar et al. (18).

Natural dyes structures and protective properties of natural dyes have been recognized only in the recent past. Many of the plants used for dye extraction are classified as medicinal, and some of these have recently been shown to possess remarkable antimicrobial activity. The antimicrobial activity of natural dyes (11, 7) on textiles has been discussed in literature. Punica granatum , henna and many other common natural dyes are reported as powerful antimicrobial agents owing to the presence of a large amount of tannins (10). Several other sources of plant dyes rich in naphthoquinones such as lawsone from henna. Several commercially available natural dye powders, namely Acacia catechu, Kerria lacca, Quercus infectoria, Rubia cordifolia and Rumex maritimus, have been found very effective against some common microbes (20). Gupta et al. have studied antimicrobial properties of eleven natural dyes against gram positive and gram negative bacteria. The textile material impregnated with these natural dyes shows less antimicrobial activity (7).

Curcumin, a common natural dye used for fabric and food colorations, was used as an antimicrobial finish due to its bactericidal properties on dyed textiles. A common dyeing process, either batch or continuous, could provide textiles with colour as well as antimicrobial properties (19). Turmeric or cumin, a fluorescent yellow pigment extracted from the rhizomes of several species, has been used as a dye for dyeing wool, silk and cotton. Because of its bioactive activity saffron also transmits antibacterial properties to textiles. The antimicrobial activity of plant extracts such as peppermint, primrose and perilla oil, has been also explored for applications in the textile industry (11).

Clove oil (eugenol) is the main product of *Syzygium aromaticum*. The bioactivity of clove oil was explored in size paste as size preservative as well as finishing agent for textile to make it antimicrobial (11) but still, further investigation has to be done. In a study Sarkar et al. showed that clove oil was very effective against bacteria (18).

Prickly chaff flower (*Achysanthus aspera*) is one of the herbs most commonly found in India. It presents antimicrobial activity against both Gram-negative and Gram-positive, however with a low activity (11). It was tested in cotton fabrics but the results showed mild antibacterial activity against Gram-negative bacteria.

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