Antimicrobial Textiles


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Abstract

The inherent properties of the textile fibres provide room for the growth of micro-organisms. The staining and loss of the performance properties of textile substrates are the results of microbial attack. Thus there is a need to produce and develop new and cutting edge fabrics which are resistant to attack and can inhibit the proliferation of pathogenic species. The new developments would help reduce the ill effects and possibly could comply with the statutory requirements imposed by regulating agencies. This paper reviews ways and means of finishing textiles and assessing their antimicrobial properties.

Keywords: Pathogen, Microbe, Antimicrobial, Bacteria, Triclosan, Chitosan, Nanofibres

1. Introduction

Textiles are developing into interdisciplinary high tech products with interesting changes. It has become an integral part of everyone's life. These are used to envelope human body, thus protecting it from dust, sunlight, wind and other foreign matter present in the environment. In the past textiles were considered primarily for economical and functional point of view. But now the consumers are increasingly aware of the hygienic life style and there is a necessity and expectation for a wide range of textile products finished with utilitarian properties. Among health care professionals today, there is increasing concern over exposure to, and transference of, various microorganisms. Microbial infestation poses danger to both living and non living matters. Obnoxious smell from the garments, spread of diseases, staining and degradation of textiles are some of the detrimental effects of bad microbes.

Today, in addition to protecting the healthcare worker from patient micro-organisms carried by healthcare worker and patient-to-patient transference. The increase in the presence of resistant pathogens that can be transmitted is also of concern. These issues have led to the production and development of innovative new products in the textile industry. Textiles have the potential to be suitable barriers but they must prevent the transmission of pathogens found in the atmosphere. Bacterial and viral diseases are spread through both airborne and blood borne pathways.

2. History

During World War II, when cotton fabrics were used extensively for tentage, tarpaulins and truck covers, these fabrics needed to be protected from rotting caused by microbial attack. This was particularly a problem in regions where fighting took place in jungles. Military fabrics were treated with mixtures of chlorinated waxes, copper and antimony salts that stiffened the fabrics and gave them a peculiar odour. At this point of time, potential polluting effects of the application of, these materials and toxicity-related issue were not a major consideration. After World War II, and as late as the mid-to-late 1950's fungicides used on cotton fabrics were compounds such as 8-hydroxygiunoline salts, copper naphthenate, copper ammonium fluoride and chlorinated phenals. These treatments had limited industry acceptance because of relatively high cost and loss of fabric strength in processing. As the government and industrial firms became more aware of the environmental and workplace hazards these compounds caused. Alternative products were sought. Hence man-made fibres such as nylon, acrylics and polyester, which have inherent resistance to microbial decomposition, came into wider use to replace cotton in many industrial fabrics.

3. What Are Microbes?

Microbes are the tiniest creatures not seen by the naked eye. They include a variety of micro-organisms like Bacteria, Fungi, Algae and viruses.

Bacteria are unicellular organisms which grow very rapidly under warmth and moisture. Further, sub divisions in the bacteria family are Gram positive (Staphylococcus aureus), Gram negative (E-Coli), spore bearing or non spore bearing type. Some specific types of bacteria are pathogenic and cause cross infection.

Fungi, moulds or mildew are complex organisms with slow growth rate. They stain the fabric and deteriorate the performance properties of the fabrics. Fungi are active at a pH level of 6.5. Algae are typical micro organisms which are either fungal or bacterial. Algae require continuous sources of water and sun light to grow and develop darker stains on the fabrics. Algae are active in the PH range of 7.0-8.0 Some harmful species of the bacteria and fungi

are listed in Table 1.

Bacteria	Fungi
Gram positive bacteria	**Cloth damaging fungi**
Staphylococcus aurues orpyogens	Aspergillus niger
Staphylococcus epidermidis	Aspergillus fumigatus
Corynebacterium diphtheroids	Trichoderma viride
	Curvularia lunota
	Penicillium species
Gram negative bacteria	
Escherichia coli	
Klebsiella pneumoniae	
Proteus vulgaris	
Pseudomonas pyocynans	
Salmonella typhi	
Vibrio cholerae	

4. Necessity of Antimicrobial Finishes

Antimicrobial treatment for textile materials is necessary to fulfill the following objectives:

a) To avoid cross infection by pathogenic microorganisms;

b) To control the infestation by microbes;

c) To arrest metabolism in microbes in order to reduce the formation odour; and

d) To safeguard the textile products from staining,

c) Discolouration and quality deterioration.

5. Mechanism of Bacterial and Liquid Transmission Through Fabrics

Fabrics are three dimensional entities with void and non-void areas. The physical and chemical properties of the fabric, the shape and surface characteristics of the bacteria, and the characteristics of carriers contribute to control the movement of micro organisms through fabric structures. Bacteria are transported from one location to other by some other object such as dust, lint, skin particles and liquids. Bacterial transmission can occur with or without liquids, but the presence of liquids assists transmission.

Liquids and bacteria can be drawn through capillary action enhanced by wicking. Yarns and fibres used in fabric construction are usually cylindrical and surrounded with narrow spaces/interstices forming capillaries.

6. Factors Affecting the Capillary Absorption

6.1 Characteristics of the fluid – surface tension, viscosity, density.

Liquids have a wide range of surface tensions eg. Water 7.2×10^{-2} N/m , isopropyl alcohol 2.2×10^{-2} N/m, blood 4.2×10^{-2} N/m. Therefore fabrics to be used as barriers to bacterial transmission must be able to repel liquids of lower surface tension then those used where water repellency is of primary concern.

6.2 Nature of the surface surface energy and surface morphology.

If liquid adheres to the surface there is increased potential for adsorption and transmission to occur. In case the carrier is the dry particle, the fabric must act as a filter to prevent the movement of the microbial particle and its carrier.

6.3 Interaction of the fluid and the surface – interfacial tension and contact angle.

If the contact angle between the surface and liquid is greater than 90 degrees then the liquid will into a sphere and roll off the surface. However if the contact angle is less than 90 degrees, the liquid is likely to spread, leading to adsorption and absorption of the liquid into the fabric will be enhanced.

6.4 Pore characteristics – size, volume, geometry and orientation.

Pore size, geometry and volume are critical in establishing the fabric as a filter media. These characteristics also influence formation of capillaries in the fabric. Pores must be smaller than the particle for effective filtering.

7. Fabric Properties That Influence Barrier Properties

7.1 Repellency

Barrier effectiveness of the fabric increases as the repellency of the fabric increases. The fabric must be repellent not only to water, but also to lower surface liquids such as blood and alcohol. Barrier effectiveness of the fabric is reduced once a fabric is wet out by a lower surface tension liquid.

7.2 Pore size

The pore size of the fabric must be smaller than that of the bacteria or its carrier. The fabric must act as filter if the bacteria are carried by a liquid.

8. Antimicrobial Finishing Methodologies

The antimicrobial agents can be applied to the textile substrates by exhaust, pad-dry-cure, coating, spray and foam techniques. The substances can also be applied by directly adding into the fibre spinning dope. It is claimed that the commercial agents can be applied online during the dyeing and finishing operations. Various methods for improving the durability of the finish include:

8.1 Insolubilisation of the active substances in/on the fibre;

8.2 Treating the fibre with resin and cross linking agents;

8.3 Micro encapsulation of the antimicrobial agents with the fibre matrix;

8.4 Coating the fibre surface;

8.5 Chemical modification of the fibre by covalent bond formation; and

8.6 Use of graft polymers, homo polymers and/or copolymerization on to the fibre.

Nowadays, antimicrobial properties can be imparted to the fabric by application of antimicrobial dyes. Moreover, barrier properties

of the fabric are further enhanced due to decrease in pore size by incorporation of nanofibres in fabric construction. Antimicrobial agents used in the textile industry are known from the food stuff and cosmetics sector. These substances are incorporated with textile substrates comparatively at lower concentrations. these substances are not only permanently effective but also that they are compatible with skin and the environment. A wide range of antimicrobial compounds is now in use but differ in their mode of action. The following list demonstrates the effect of the various antimicrobial substances:

a. Oxidizing agents such as aldehydes, halogens and proxy compounds attack the cell membrane, get into the cytoplasm and affect the enzymes of the micro-organisms.

b. Coagulants, primarily alcohols irreversibly denature the protein structures.

c. Triclosan inhibits growth of microorganisms by using a electro chemical mode of action to penetrate and disrupt their cell walls.The Triclosan when incorporated within a polymer migrates to the surface, where it is bound. Because, it is not water-soluble, it does not leach out, and it continuously inhibits the growth of bacteria in contact with the surface using barrier or blocking action.

d. Complex forming metallic compounds based on metals like cadmium, silver, copper and mercury cause inhibition of the active enzyme centres (inhibition of metabolism). Amongst these, the silver compounds are very popular and already been used in the preparation of antimicrobial drinking water.

e. Chitosan is an effective natural antimicrobial agent derived from Chitin, a major component in crustacean shells. Coatings of Chitosan on conventional fibres appear to be the more realistic prospect since, they do not provoke an immunological response. Fibres made from Chitosan is also available in the market place.

f. Natural herbal products can be used for antimicrobial finishes since, there is a tremendous source of medicinal plants with antimicrobial composition to be the effective candidates in bringing out herbal textiles.

g. ZnO nano-particles embedded in polymer matrices like soluble starch are functional nano-structures with potential applications such as UV- protection ability in textiles and sunscreens, antibacterial finishes in medical textiles.

9. Conclusion

With 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. Taping new potential antimicrobial substances, such as, Chitosan from nature can considerably minimize the undesirable activities of the antimicrobial products. Scientists all over the globe are working in the area and few of them reported to have used antimicrobial finishes and fluoro chemicals to make the fabric having antimicrobial as well as blood repellant properties.

Chitosan and fluoro polymers reported to be most suitable finishing agents for medical wears with barriers against micro-organisms and blood. To carve a niche for textile materials, this kind of value adding finishes are the need of the hour.

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