Application of Nanotechnology in Antimicrobial finishes for Textiles: A review

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Abstract

Pathogens may spread illness via contact with infested fabrics, which generate odor when close to the skin. Microbial degradation causes fabrics to become discolored, tinted and lose their ability to perform their intended purpose. For medicinal and hygiene applications, non-toxic and environmentally friendly antimicrobial agents are in high demand. Polyhexamethylenebiguanide (PHMB), quaternary ammonium compounds (QACs), metals (including metal oxides and salts), triclosan, and n-halamines were among the synthetic biocides whose effects were intensively studied. Aside from the natural biocides, such as essential oils and plant-based chitosan, plant-based extracts (AMPs) were the most often used plant-based biocides. A review of recent research on antimicrobial finishing, types of finish agents, and various current developments in antimicrobial finishing will be briefly covered to minimize the risks associated with the application of organic and inorganic antimicrobial finishes and plant-based antimicrobial finishes.

Keywords: Antimicrobial finishes, nanotechnology, Textiles

1. Introduction

The medical and pharmaceutical industries were the primary users of antibiotics. Nevertheless, other applications may be developed in the future. Antimicrobial reagents are being used more often to treat textile fibers[1]. Medical, surgical, and sanitary items, as well as food packaging, are further examples. Biocidal treatments in textiles (sportswear, undergarment, bed linen) and water filtration are becoming more popular as people's standards of living rise. Medical, surgical, and healthcare operations have grown more dependent on final antibacterial treatment owing to the possible dangerous microorganisms present in the hospital environment, which may cause cross-infection disorders[2]. In addition to viruses, bacteria, unicellular plants and animals, some algae and fungus, there are many more microorganisms. Gram-positive, gram-negative, spore-bearing, and non-spore-bearing bacteria all fall within this category. Pathogenic microorganisms have been found in several of the samples[3]. It is common for a microorganism (e.g., bacterium or fungus) to have an exterior cell wall made of polysaccharides. Under the cell wall, a semi-permeable membrane houses internal organelles, enzymes, and other cellular constituents, ensuring the integrity of these components and protecting the cell from the external environment.

DNA, RNA, and other types of nucleic acids. Enzymes in the cell wall are responsible for the chemical processes inside the cell wall. The genetic code of all creatures is stored in nucleic acids. Therefore, substrate creation and chemical processes may favor microbe development; a damp and warm climate further exaggerates the issue[1]. Microbes are frequently prevalent in the environment. Peptidoglycan and teichoic acid are found in gram-positive bacteria. Peptidoglycan makes up 90% of the cell wall and is composed of amino acids and sugars. Staphylococcus aureus, a gram-positive bacterium, is an example of a pair, short-chain, or graphic cluster. It may develop to a diameter of 0.5 to 1.0 mm at a temperature of 35 to 40 °C. Cross-infection in the hospital setting is caused by Staphylococcus aureus, accounting for 19 percent of all surgical infections. Boils and scaling skin infections are also caused by it. Staphylococcus epidermidis, Streptococcus pneumonia, Streptococcus pyogenes, and Streptococcus viridian's are all examples of gram-positive bacteria. Lipoproteins attached to peptidoglycan by the outer membrane of gram-negative bacteria differ from the outer membrane of gram-positive bacteria in that they are utilized to transport molecules with too low a molecular weight. In contrast to gram-positive bacteria, gram-negative bacteria are more difficult to eradicate since they have more cell walls. As an example of gram-negative bacteria, E. coli (also known as E.coli) may be found in the human digestive tract. The bacteria Escherichia coli can grow in the body when raw food is consumed and/used. E. coli symptoms include severe diarrhea (particularly in children) and renal damage. Others in this family include Klebsiella pneumonia, Pseudomonas aeruginosa, Salmonella Typhi, Salmonella enteritidis, and Haaminiphilusinfluenzae, to name just a few[4]. Fabrics that come into close touch with the human body might get infested by a microorganism, causing cross-infection by diseases and an unpleasant odor. Furthermore, microbial degradation causes fabrics to become discolored, tinted and lose their functional properties [5]. Fungi moths or mildews are organisms with a reduced rate of development; they discolor the substrate and impair the fabric's functional properties. This kind of microorganism, which may be either fungus or bacteria, causes black stains to appear on the material's surface. Dust mites may be found in various household fabrics and bed linens, although they are most prevalent in mattresses and carpets. Allergies are caused by the healing waste products of dust mites, which feed on human skin.

2. Methodology

2.1Methods of Antimicrobial Finishing

Some germs may be inhibited (static) or killed (cidal) due to antimicrobial finishing on textile substrates. Because enzymes produce microorganisms' sustenance, an antimicrobial finish must prevent protein synthesis in germs and hinder enzyme production from killing them. Silver, quaternary ammonium compounds (QAC), N-Halamines, triclosan, and polyhexamethylenebiguanide (PHMB) are examples of well-established antibacterial agents that are almost biocides[6].

2.2 Antimicrobial Finishing Mechanism

The antibacterial function of a given finish on a textile may be used to identify three different finishing techniques. Control-release, regeneration, and barrier-block are examples of these systems. There are issues with the first two mechanisms of ending.

An antimicrobial agent from fabric that comes into touch with the wearer's skin concerns the control release mechanism's longevity after laundry. These substances can irritate and cause allergies in people with healthy skin. After washing, the antibacterial characteristics of fabrics treated with a regenerate mechanism are no longer activated, leading to these issues. Chlorine bleach is not only bad for cotton, but it is also bad for your skin as well. In contrast to the other two ways, barrier-blocking does not have drawbacks. In order to destroy germs that come into touch with the fabric, these agents are attached to the fabric surface and do not leach[7]. Types of Antimicrobial Finish are :

- Organic antimicrobial agents
- Inorganic antimicrobial agents
- Eco-Friendly Antimicrobial Agents (Natural Plant and Fruit Extracts)
- f Nanotechnology in Antimicrobial Finishing

There were some interesting findings and some interesting discussions.

3. Results and discussions

Infectious diseases may be thwarted by nanotechnology. Several characteristics were used to regulate, modify, and assemble nanoscale components to produce materials, systems, or devices using nanotechnology. The antimicrobial properties of silver nanoparticles against bacteria were outstanding in studies. Polycaprolactone (PCL), an FDA-approved polymer, was combined with antibacterial metals such as zinc, copper, and silver to form filaments. Hot-melt extrusion was employed to make metal-homogeneously loaded filaments to extrude pellets made by vacuum-drying PCL and metal solution mixtures. Filaments with varied metal concentrations were used to create a variety of wound dressings. Silver and copper wound dressings were shown to be the most effective in killing germs when evaluated using a thermal activity monitor device[8].

In the modern-day, metal oxide nanoparticles (MeO-NPS) have emerged as a viable substitute for antibiotics that are both toxic and resistant to many antibiotics. Antibacterial and antifungal activity of ZnO nanostructured particles on cotton textile surfaces with different surfactants stabilized, homogenized, increased its resistance to leaching, and showed the highest antibacterial activity against different pathogenic bacteriological and fungal species with a high reduction of more than 90%. Using Znonano-particles and soluble starch as capping agents to study antimicrobial property demonstrated that the capping agents oversee antibacterial activity, resulting in reduced particle size of 3-5nm and increased antimicrobial rate[9]. Nanoparticles of copper in a glycerol-polyvinyl alcohol matrix in gel and moldable plastic form show that it is possible to develop and apply this technology.

At high temperatures, this is an easy puzzle to solve. Both Escherichia coli and Enterococcus fecal bacteria are inhibited in the presence of copper nanoparticles formed by the materials (. They have shown antibacterial efficacy against several different bacterial species with a minimum inhibitory concentration (MIC) against Staphylococcus aureus of 960 L/ml, making biocompatible nanogold (AuNPs) an attractive candidate for use in nanomedicine due to their unique size-dependent chemical, electronic, and optical properties[10].

Chitosan-neem nanocomposites were employed to solve the toxicity and washing-durability issues associated with plant-based extracts in the production of antimicrobial cotton. In contrast to chitosan, silver nanoparticles chelated with surfactant-aided chitosan gelation demonstrated perfect antibacterial activity at lower concentrations based on poly-(N-isopropyl acrylamide) chitosan micro-gel[11]. The biosynthesis of AgNP utilizing pre-hydrolysis fluid of Eucalyptus wood has been validated in another investigation as a beneficial antimicrobial agent for numerous biological purposes. Chitosan and acrylic acid bi-grafted polypropylene melt-blown nonwoven membrane immobilized with silver nanoparticles also shown good antibacterial and hydrophilic characteristics[12].

4. Conclusion

Antimicrobial finishing agents come in a wide range of intriguing varieties. On the other hand, limitations are possible to meet performance, environmental friendliness, and price criteria. Acceptable levels. While organic antimicrobial compounds have fewer side effects than their inorganic counterparts, they are less effective against a broader spectrum of bacteria and are not as durable in the wash. The usage of nano-particles has enhanced the efficacy of several antimicrobial agents, decreased environmental hazards connected with these chemicals (such as toxicity and washing durability), and demonstrated outstanding antibacterial properties vs. microorganisms. Despite their washing-durability problem, natural plants-based antimicrobial finishes are generally recognized antimicrobial agents for textile finishing because of their eco-friendly and non-toxic features. An increasing number of fields are turning to plant-based nanoparticle antimicrobial agents because of their superior characteristics and protection against pathogens compared to conventionally used biocides, and such value-added finishes could provide sustainable healthcare applications in textiles.

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