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Preparation and characterization of cotton fabrics with antimicrobial properties through the application of chitosan/silver-zeolite film

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Abstract

The development of antimicrobial cotton fabrics using chitosan/silver-zeolite film has been investigated in the present work. The film was applied to 100% cotton fabric using a common pad-dry-cure technique and citric acid was used as crosslinking agent. The resulting fabrics were characterized through infrared spectroscopy (FTIR), contact angle and scanning electron microscopy with X-ray microanalysis (SEM/EDS). The antimicrobial activity of the fabrics was assessed through the viable-cell counting method and the materials showed activity against *S. aureus* and *T. rubrum.* The textile performance of the fabrics was analysed regarding their characteristics of hydrophilicity and breathability. The finishing did not change the hydrophilic behaviour of the material. Although the permeability to air has reduced 20%, the permeability to water vapour remained practically unchanged. Therefore, the results suggested that the process approach of applying chitosan/silver-zeolite film is recommended to produce textiles with antibacterial properties.

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Keywords: Cotton finishing, antifungal; antibacterial, chitosam/silver-zeolites film

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1. Introduction

Textile materials, especially those of natural origin, have long been recognized as being environments susceptible to microbial proliferation. They enable the development of fungi and bacteria as they act, for these microorganisms, as sources of energy or of nutrient retention due to their molecular structure. Besides, they provide hot and humid environments, which are ideal for their proliferation. Synthetic fibres are more resistant to the microbial attack because they are hydrophobic. However, regardless of their origin, most fibrous materials allow the propagation of microorganisms [1–3].

The problem of microbial proliferation also directly affects users of textile products, since microorganisms can cause bad odours, skin irritations and even, in some cases, infections. Given the need to protect textile materials from undesirable aesthetic changes and to prevent problems related to the hygiene and health of the user, the production of textile materials with antimicrobial finishes has increased over the last years [2,4,5]. Antimicrobial textiles are used in the production of the most diverse types of products, from simple decorative articles to technical textiles, from sportswear and protective clothing to articles for medical application [6,7].

The metal salts and the particles with metals have been applied in the industry to give the materials antimicrobial properties. The evaluation of the antimicrobial performance of these compounds has been widely studied since they exhibit activity even at very low concentrations [8]. In industrial applications, the emphasis is on those compounds in the form of nanoparticles since they possess a high specific surface area, which allows an increase in the concentration of retained metal atoms, intensifying the antimicrobial activity [9].

Among the materials that release silver ions are included silver zirconium phosphates and zeolites with silver [10]. In this case, the materials used as matrix have a morphology and size distribution that can be in the range of microns, and, in this case, cannot be defined as nanomaterials [11]. They act through the release of silver ions when in contact with the fluids, for example, found in a wound. They bind to the disulfide (-S-S-) and sulfhydryl (-SH) groups of the cell wall proteins, causing an interruption of the metabolic processes, inhibiting growth and causing the death of the cells.

The effects caused by the accumulation of silver, both in humans and in other living species, are known and worrying, therefore, significant efforts have been made by the industry in the search for new antimicrobial products that minimize the amount of silver used without impairing the intended effect [8,12].

Natural zeolites are porous crystalline materials of hydrated sodium aluminosilicate. They have a permanent negative charge that can be equilibrated by interchangeable cations, which justifies their use as adsorbent, cation exchanger and catalyst for multiple uses. These unique characteristics allow their application aiming to, simultaneously, increase the antimicrobial, anti-UV or flame retardant properties of the materials [13–15].

Zeolites have a strong affinity for Ag^+, binding to this ion electrostatically up to, approximately, 40% (w/w) within its framework. Therefore, silver-zeolites can provide finishes with antibacterial properties. The application of SZ, dispersed in a polycarboxylic acid solution, to cellulosic materials may be an interesting possibility to produce antimicrobial textile fabrics, for use in various health and well-being areas [15,16].

Among the natural polymers, chitosan has attracted much attention due to its unique combination of properties. Being biodegradable and biocompatible, its antimicrobial properties have been explored for a variety of applications in the most diverse areas. More recently, its ability to coordinate with metal ions, forming complexes, has been used to improve its bioactivity [17–21].

This work focused on the preparation and characterization of cotton finished with chitosan/silver zeolites film and on the evaluation of its antimicrobial activity.

2. "Material and methods"

The samples used were composed of bleached taffeta plain-weave fabrics, 100% cotton, 585 g/m^2, supplied by Têxtil Belém (Brazil). The Chitosan (Chitoclear® 42030) was purchased from Primex (Iceland), zeolites 4A (LTA) doped with silver ≈0.3% (w/w) were offered by the Department of Physics of the School of Engineering of the University of Minho, all other reagents were purchased from Sigma-Aldrich (Portugal).