Covalent and non-covalent strategies for surface modification of different textile materials with antimicrobial properties

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New advances have been released in textile industry. Contributions at the level of textile fiber chains engineering has allowed modification of their structure, production of smart polymers responding to changes in environment, and attachment or entrapment of cells and bioactive molecules. Likewise, our society high demand of hygienic patterns, has raised the intensive research and development of antimicrobial textiles. Applications are being extended to underwear, sportswear, home furnishing, protective clothes, wound-dressings and in areas with high risk of microbial infection, as hospitals, schools and hotels.

Throughout last decades hospitals have faced tough challenges concerning microbial multi-resistance, especially in immunodepressed patients. The strongest cause for microbial resistance may be due to the abuse of antibiotics uptake, either by humans to treat something non appropriately, as by animals, to earn weight. The development of antimicrobial textiles arise as a promising solution that may significantly decrease the risk of nosocomial infections. Several antimicrobial agents have been applied in textiles, namely quaternary ammonium compounds, silver, polyhexamethylene biguanides and triclosan. However, they have shown a reduced spectrum of microbial inhibition which cause resistances, cytotoxicity causing skin irritation, as well as toxic to the environment. Furthermore, these compounds gradually lose their bioactivity with use and launderings.

L-cysteine (L-Cys) that is found in several living organisms is a natural defensive thiolated aminoacid never studied before as a potential antimicrobial agent for textiles, which can grant antibacterial properties without cytotoxicity. Furthermore, antimicrobial peptides (AMPs) belong to innate immune system of multicellular organisms and appear as an alternative to antibiotics. They are small, amphipathic, and strongly cationic which bind to negatively charged phospholipid headgroups of microbial membranes. Although the mechanism of AMPs-microbial killing is still not known, many hypotheses have been proposed: (i) membrane depolarization, (ii) formation of physical holes at the membrane, (iii) programmed bacterial death processes, (iv) phospholipidic redistribution, and (v) internalization of the AMP. They have broad-spectrum antimicrobial activity. Once their target is the bacterial membrane microorganisms hardly develop resistance, otherwise they would have to change all their lipidic composition and/or organization, which is high demanding and not energetically worth it.

During this work, non-covalently adsorbed L-Cys to wool (patent PAT 104540 A) and to cotton showed to be non-toxic to human cells, and had antimicrobial effects against Gram-negative and Gram-positive bacteria and its main mechanism of action on cotton was assessed by flow citometry. Antimicrobial peptides (AMPs) will also be immobilized on textiles, in order to find if textile imobilized-AMP can attract and kill bacteria. Natural polymers have shown few adverse reactions, once they have excellent humidity control, biocompatibility and low-allergic responses, due to their similarity to macromolecules which biological environment is prepared to recognize and to deal with metabolically.

AMPs will be selected, based on their 3D structure, terminal charge and size. Best-studied AMPs are cationic due to their action on negative surface charged microorganisms. Evaluation of minimal inhibitory concentration (MIC) of AMPs will elucidate the amount of AMPs to be used to functionalize textile substrates and cytotoxicity studies will provide the toxicity of functionalized textiles to human cells. In order to develop long-lasting and washable functionalized textiles we propose the covalent binding of AMPs on textiles through selected chemistries already employed on surface modifying of medical devices elsewhere. Alternatively, we will use plasma treatment, which is usually used to modify many surface properties of polymeric materials.

This study may allow the development of innovative antimicrobial textiles, simulating microbial-free microenvironments in order to develop, in the future, antimicrobial fabrics to avoid airborne spreading and improve patient's quality of life in a hospital context.

Keywords antimicrobial textiles; surface modification, non-covalent; covalent; L-Cys; AMPs