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*Abstract*

# Multifunctional Coated Textiles for Active Biological Protection †

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The rising threats to the worldwide security (military and civilian) attest the need to develop efficient and versatile technological solutions to protect the human being. Specifically, those who put themselves in situations of most exposure—those protecting and caring for the safety of others—should be adequately protected, so that infectious diseases cannot be spread or misused so easily. Current technology in biological protective garments is traditionally based on a multilayered fabric integrating activated carbon as the sorptive agent, and a separate filtrating layer for passive protection. However, the adsorbed contaminants accumulate within the carbon filler over time, turning into secondary contaminants. The clothing becomes too heavy and warm to wear, not breathable, hindering them from performing active work for extended hours. Hence, there is a strong need to select and create innovative materials, fibrous structures with incorporated active agents, offering efficient filtering capability and bioactive protective skills. A rational design of layered compositions is key to ensure lightweight, comfortable, breathable and multifunctional fabrics [1,2].

Our proposal relies on the use of textile-based macro-to-nanoscale structures, acting in consonance to reach the intended biocidal effects. A twill fabric composed of cotton and polyamide fibers, hydrophobic but breathable, constitutes the first passive protective barrier. Internally, by resorting to zinc oxide nanoparticles (ZnO NPs) [3] and a polyurethane-based paste, an active protective barrier was spread by knife coating, using 0.5–2% $w/v$ ZnO NPs and 0.25–0.5 mm of thickness. A coating thickness of ≈13 nm was obtained, and parameters such as fabric wettability (water contact angle of ≈130°) and breathability (air permeability of ≈30 $L/m^2/s$) remained unaffected. Qualitative and quantitatively tests (JIS L 1902 standard) using two representative bacteria species, the gram-positive *Staphylococcus aureus* and the gram-negative *Escherichia coli* evaluated the front and back sides of the coated textiles following 24 h of incubation, as typically done to screen technical textiles' action against biological threats [4]. Those with ZnO NPs successfully eradicated all *S. aureus* and *E. coli* colonies. Collectively, the strategy here presented is intended to enhance current textile-based options under the scope of bioterrorism, opening new perspectives for the safety of those potentially exposed to biological warfare agents.

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