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Protective Clothing against Chemical and Biological Agents using Nanocomposite Nanofibrous Membranes

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Abstract

Protective clothing against chemical and biological hazards are critical for a wide variety of occupations such as industry workers, farmers, healthcare personnel, researchers in laboratories, firefighters, and soldiers. Solutions currently available to protect against chemical and biological agents range from air-permeable membranes combined with a sorptive material to full encapsulation with impermeable materials and sealed clothing constructions. However, chemical/biological protection is often achieved at the expense of the clothing wearer's comfort. Nanotechnology offers the opportunity to increase protection without jeopardizing comfort. First, nanofibers can filter solid particulates and aerosols more efficiently than microfiber nonwovens thanks to their high surface-area-to-volume ratio and low pore size. In addition, their impact on moisture vapor diffusion is minimal, which allows preserving the breathability of the membrane, thus the thermophysiological comfort of the clothing wearer. Nanofibrous membranes can be manufactured easily and economically using electrospinning. Second, some metal and metal oxide nanoparticles (NPs) such as magnesium oxide (MgO) and silver (Ag) decompose chemical and biological compounds upon contact and can be embedded in the nanofibers to add a detoxification function to the membrane.

In this study, the performance of nanocomposite nanofibrous membranes composed of MgO and Ag NPs embedded in polyacrylonitrile (PAN) nanofibers is assessed in terms of protection and comfort. The protection is characterized by measuring the filtration efficiency against aerosols (e.g. following ASTM F2299), neutralization rate of liquid and vapor chemical agents, and antibacterial activity (e.g. following AATCC TM 100). The comfort is measured through air permeability, water vapor transmission rate, evaporative resistance, flexibility, and 3D bending. The tensile and tear strength as well as the resistance to abrasion are also assessed. The use of this membrane as part of a multilayer chemical and biological protective clothing will ensure that the thermo-physiological comfort and health of people exposed to chemical and biological hazards is not put at stake because of their protective clothing. This work is part of the Canadian Department of National Defence (DND) IDEaS COMFORTS (Comfort-Optimized Materials For Operational Resilience, Thermal-transport, and Survivability) project.

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