PROTECTION - SCIENCE AND TECHNOLOGY ADVANCES FOR CHEMICAL AND BIOLOGICAL PROTECTION

PFAS-free Omniphobic Surfaces Via Micro- And Nano-engineered Coatings

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High-performance consumer fabrics are typically water-repellent to provide a wearer additional protection from elements and greater comfort. Specialty materials for gear such as military BDUs, however, have higher demands; for example, protection from chemical agents, flame retardancy, oil- and fuel-repellency, and compatibility with other operational materiel and requirements. Formerly, fluoro-polymer based coatings (e.g., polytetrafluoroethylene (PTFE)) provided the omniphobic and resilient characteristics for the demanding applications. The environmental and health risks associated with fluoro-organic chemicals now drives efforts to develop new material options that meet protective and performance requirements without per- and polyfluoroalkyl substances (PFAS) in the formulations.

The principles quantified in the Cassie-Baxter equation reveal that an ordered, micro-scale, surface topology can yield a liquid-repellent material. The present work aims to use advanced synthetic chemistry methods to engineer surface coatings that will be applied to textiles and yield resilient, omniphobic materials. Previously our laboratory team used aqueous-based siloxane chemistry to coat fibers and fabrics with conformal layers of silica. The process was promoted further by using microwave irradiation to catalyze crosslinking and condensation reactions. The fundamental approach was expanded to entrain nanomaterials within the siloxane interpenetrating network. The resulting nano- and micro-structured roughness may yield the low surface energy coating and desired omniphobic characteristics. Potential nanomaterial candidates include functionalized polyhedral oligomeric silsesquioxanes, chitosan, and chitin; each may provide specific dimensions or chemical functionalities for required performance. A methodical test series will reveal treatment conditions and material combinations that yield the best performing coating. That formulation can subsequently transition to a commercially-scalable process for fabrics that can be evaluated in representative field demonstrations.

Prior unpublished work by the team revealed fluorine-free textile treatment formulations that yield materials that were superhydrophobic (contact angles of >150° for 8 μL droplets), highly repellent to 2-propanol, but showed minimal repellency to saturated hydrocarbons. The team has recently received a SERDP Exploratory Development (SEED) grant (FY2024 new start) from the Strategic Environmental Research and Development Program (SERDP) to further explore the feasibility and expand performance of the concept, e.g., demonstrate repellency to petroleum oils and lubricants (POLs) and select threat agents. The envisioned engineered coating will act as a breathable, omniphobic barrier that resists penetration by a broad spectrum of liquids, including chemical warfare agents. The product is ultimately applicable to individual and collective protection of the warfighter. Eliminating the requirement for PFAS and incorporating sustainable biomaterials for the coating align with the DoD drive to minimize human health and environmental risks. The investigated technology addresses the requirement throughout acquisition lifecycle.

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