PROTECTION - SCIENCE AND TECHNOLOGY ADVANCES FOR CHEMICAL AND BIOLOGICAL PROTECTION

Reconfigurable, Functionalized Fabric Platform For Broad Spectrum Chemical And Biological Protection

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Current protection suits pose logistical, mobility and thermal burdens, reduce dexterity, take time to don/doff, and carry increased risk for personnel contamination during doffing. The purpose of our effort funded under the DARPA PPB program was to address this gap by developing an operationally versatile, lightweight, durable, and breathable fabric system that protects against a broad-spectrum of chemical and biological (CB) agent threats. Our objective was to develop novel, configurable chassis platform countermeasure technologies integrated onto multilayered light, durable, and breathable laminate configurations that block, degrade, or sequester CB agents. Such platform would reduce agent presence to limit primary exposure risk as well as the risk of contaminating the person wearing or assisting them during doffing as the agent would be neutralized/degraded (versus just absorbed) on the gear. Furthermore, by being reconfigurable, our technologies would be amenable to continuing improvements of their neutralization kinetic properties and specificity toward addressing different, new and/or uncharacterized threats.

In this work, we utilized a silicon nanoparticle chassis functionalized with enzymes and a novel class of catalytic Zr-clusters for rapid hydrolysis of chemical agents, or photosensitizers for broad neutralization of bioagents; porous particles for capture of chemical agents; and micro-channeled textiles for stable nanomaterial loading. These materials are amenable to scaled up production and manufactured in the USA. In addition, the countermeasure technologies are lyophilizable for long-term storage and/or shipment. Importantly, none of these materials contain PFAS.

It was demonstrated that our functionalized laminates: (i) prevent permeation of nerve agents VX and Soman, and Sulfur Mustard at 10g/m2 for ≥ 24 hours, performing better than SOA; as well as reduce agent attachment to the same degree or better than SOA; (ii) demonstrate 20-fold VX reduction within 10 mins; (iii) prevent VX penetration through the skin, reduce the amount of VX that reaches the skin by >10-fold compared to SOA, and reduce VX contained within the laminate by >100-fold compared to SOA; and (iv) demonstrate 99-100% SARS-CoV2 neutralization as well as particle (0.03-0.4 micron) filtration efficiency of >99%. Physical tests showed that the laminates exhibit high retention of the attached nanomaterials upon exposure to abrasion and laundering, resist water penetration, demonstrate a high contact angle, and maintain hydrophobicity after exposure to laundering and detergent. Also, physical testing showed that the laminates have improved moisture transfer rate and thermal resistance over the SOA garments, promoting breathability/comfortability. Importantly, in acute dermal in vitro sensitization tests the materials were categorized as non-sensitizers. Furthermore, both functionalized fabrics and individual components, were fully deconstructed into non-toxic products.

This work can support the JSTO mission and the Joint Force by enhancing protection and operational flexibility of forward-acting personnel, thus enabling persistent operations in environments with diverse, unpredictable, and unknown threats. In addition, it allows for reduced logistical burden for protection in poorly resourced environments as worn fabrics can be treated a non-hazardous materials due to agent neutralization. Benefits can be realized in the form of an integrated full-body suit platform as well as in the form of functionalized accessories/gear.

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