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Advanced Barrier Materials For Chemical Defense

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Barrier materials are typically comprised of adsorptive media and are designed to remove persistent chemical agents by physical adsorption, whereby the agent is retained within the pores of the media. While effective, the adsorbed toxic compounds can be displaced over time, as the compounds are merely retained versus destroyed. The objective of this effort is to develop barrier materials capable of providing enhanced chemical protection by incorporating a reactive component. Barrier materials were prepared comprised of textile loaded with reactive sorbent, carbon, and mixtures of carbon and reactive sorbent. These barrier materials were evaluated for permeation using dimethyl methyl phosphonate (DMMP). The reactive sorbent provides a destructive route; however, the mesoporous structure limits chemical retention. Carbon, on the other hand, is able to strongly retain chemical by physical adsorption but does not provide a destructive route.

Permeation testing was performed by contacting the above barrier materials with DMMP droplets at a loading of 10 g DMMP per m2area. Testing was performed by passing humid air through the barrier materials for 24 hours in the presence and absence of decane vapors, which were used to promote DMMP displacement. In the absence of decane vapors, DMMP permeation was minimal for all barrier materials, with carbon-only and carbon-reactive sorbent barrier materials out-performing a barrier material comprised only of reactive sorbent. Although reactive, rates were not sufficient to prevent permeation. In the presence of decane vapors, DMMP permeation was significant in the case of the carbon only-barrier material – exceeding 70%. This was attributed to the decane vapors displacing DMMP from the pores of the carbon. For the reactive sorbent-only barrier material, DMMP permeation was not significantly impacted by the addition of decane vapors. This was attributed to decane vapors not being strongly retained by the mesoporous media. Barrier materials comprised of carbon and reactive adsorbent displayed minimal DMMP permeation in the presence of decane vapors, demonstrating that a combination of a reactive media and a sorptive media yields optimal performance.

DMMP destruction was monitored by extracting any unreacted DMMP with solvent following completion of the permeation tests. No DMMP was detected on barrier materials comprised of reactive adsorbent-only whether tested in the presence or absence of decane vapors. Conversely, significant amounts of DMMP could be extracted from carbon-only barrier materials. DMMP could be extracted from barrier materials comprised of carbon and reactive adsorbent when tested in the absence of decane vapors. This was attributed to DMMP being associated with both carbon and reactive sorbent, with DMMP associated with carbon being available for extraction. Interestingly, when tested in the presence of decane vapors, only traces of DMMP could be extracted from barrier materials comprised of carbon and reactive sorbent. This was attributed to the decane vapors displacing DMMP from the carbon, with the displaced DMMP being decomposed upon contact with the reactive sorbent.

The authors wish to thank DTRA for funding this effort.