PROTECTION - SCIENCE AND TECHNOLOGY ADVANCES FOR CHEMICAL AND BIOLOGICAL PROTECTION

Single-atom-catalyst Membranes For Chem/bio Protection

Francesco Fornasiero Lawrence Livermore National Laboratory **Anthony Varni** Lawrence Livermore National Laboratory
Derrick Kaseman Lawrence Livermore National Laboratory **Carlos Valdez** Lawrence Livermore National Laboratory

Heterogeneous single-atom catalysts incorporated into metal-organic frameworks have shown great promise for rapid chemical agent degradation. Essentially all work so far focused on demonstrating coated fibers and porous adsorbents in powder form. Little attention has been given to the formation of thin selective membranes from single-atom catalysts, yet materials of this type could enable a new paradigm of personnel protection by combining rapid catalytic degradation with size sieving into a single, breathable layer.

Here we present progress toward a proof-of-concept demonstration of an ultrathin, breathable membrane made of covalently bonded, customizable single-atom catalytic monomers for personnel protection against chemical and biological agents. Dye rejection studies confirm that the nanometer-sized pores of these membranes block penetration of molecules with diameters smaller than biological threats (i.e., aerosols, bacteria, viruses, and toxins). Moreover, the intrinsic catalytic activity is expected to lead to chemical agent degradation upon contact, thus reducing risk of secondary exposure and enabling regeneration for extended use. These membranes are fabricated by interfacial polymerization, a highly scalable method that leads to formation of ultrathin films (~ 100 nm). The membrane's high porosity and thinness also enable to minimize weight and thermal burden. Measured moisture vapor transport rates exceed 5,000 gr/m2 day when measured at 30 °C with a 50% relative humidity gradient in a dynamic moisture permeation cell.

These results suggest that the proposed lightweight, single-atom-catalyst membranes may provide a path toward improving safety, reducing risk of secondary exposure, and extending comfortable operation in contaminated environments for military, medical, and civilian personnel.

This work was performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52 -07NA27344 and was enabled by the financial support from the Chemical and Biological Technologies Department of the Defense Threat Reduction Agency (DTRA-CB) via grant DTRA13081 – 45527.