CBD S&T CONFERENCE
TODAY'S INNOVATION, TOMORROW'S WARFIGHTER CAPABILITIES

Advances in Fundamental Materials Research

Stimulus Responsive Nanoporous Membranes Fabrication

Yuk Mun Li, Cornell University
Qi Zhang, Cornell University
Yibei Gu, Cornell University
Jennifer Poole, FLIR Systems, Inc.
David Wilson, FLIR Systems, Inc.
Jermaine Johnson, FLIR Systems, Inc.
Rachel Dorin, TeraPore Technologies, Inc.
Ilhem Hakem, Carnegie Mellon University
Michael Bockstaller, Carnegie Mellon University
Jeremy Walker, FLIR Systems, Inc.
Ulrich Wiesner, Cornell University

Membranes immobilized with active enzymes can enable multifunctional dynamically responsive chemical and biological (CB) protective materials. These materials are capable of switching from a ready state with high water vapor permeation to a protected state in a specific response to the presence of CB threats. Nanoporous membranes made from block copolymer self-assembly have received significant attention over the past several years due to the potential for significantly improved performance. We apply the combination of self-assembly and non-solvent induced phase separation (SNIPS) to produce integral isoporous membranes. Using this facile and industrially scalable method, membranes have been fabricated from a variety of block copolymers, including poly(isoprene-*b*-styrene-*b*-4-vinylpyridine). These membranes have uniform pore sizes, tunable pore geometries, and tunable mechanical and chemical properties.

Membrane surfaces are decorated with poly(4-vinylpyridine) chains which will extend to close the pores in an acidic environment. The membrane structure is asymmetric with a pore size gradient from nanometer sized pores to micrometer sized macropores. The overall hierarchical structure allows a built-in redundancy to minimize the threats' penetration and breakthrough of the material. Permeation experiments in the simulated open and closed states with a dye solute of a comparable molar mass are provided. This pH responsive property combined with enzymes that can recognize a CB threat to produce a strong acid enables a stimulus responsive material.

Moreover, asymmetric membranes can be fabricated from two or more chemically distinct triblock terpolymers via blending during the standard membrane process. Resulting membranes open a new direction of "mix and match" through the use of mixtures of chemically distinct block copolymers enabling the tailoring of membrane surface chemistries and functionalization. These nanoporous membrane materials provide a great platform where various enzymes could be immobilized to have different functionalities to selectively sense and respond to stimuli specifically and dynamically.

This work was supported by Defense Threat Reduction Agency funding #HDTRA1-13-C-0003. This work utilized the Cornell Center for Materials Research (CCMR) facilities supported by NSF MRSEC program (DMR-1120296). Y.G. acknowledges funding by the National Science Foundation (DMR-1409105).