TODAY'S INNOVATION, TOMORROW'S WARFIGHTER CAPABILITIES

Advances in Fundamental Materials Research

Reversible and Bistable Interpenetrating Polymer Network for Chemical Threat Protection

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New materials having nanoscale porosities that can be reversibly changed on command are of great interest in a variety of applications. In the area of CB protection, they may have a major impact. We have developed an interpenetrating network (IPN) polymer membrane material composed of soft polyurethane interspersed with a crosslinked conducting polymer. The material can be reversibly "switched" between its oxidized and reduced states by the application of a small voltage, ~1 to 4 volts. The conducting polymer network contains molecular tethers that each have a charged terminus. When the network is "switched", in our paradigm the polymer chain morphology is altered and the moveable tethers form ion-pairing complexes that either increase or decrease the material's nanoporosity. The material thus has an "open" (oxidized) state that has a relatively high porosity, and a "closed" (reduced)state with a lowered porosity. CB protective clothing, or clothing sections, formed from it will have a high permeability to water vapor in the open state. This provides breathability and is thus comfortable for the wearer, and physical activity can be performed easily. However, if a CB agent appears, application of the small voltage will rapidly "switch" the material to the closed state. When closed, the clothing will block or greatly diminish transport of the agent. The closed state has a large degree of bistability – it is maintained for a period of days without need for voltage application. We have demonstrated that the IPN can be formed, with good adhesion, in common support fabrics such as wool or cotton/nylon. It can also be formed in commercially available electrically conducting fabrics such as those based on nanoporous absorptive carbon fibers or carbon nanotubes. The conducting fabrics enhance the switching ability of the IPN. Also, they can serve as a platform for wearable warfighter electronics such as sensors and communication devices.

In recent efforts, we have focused on the conducting fabrics as supports for the IPN. We have shown that when challenged with simulant vapor, the closed state IPN is able to block 99% of the vapor amount that had passed through the open state. When challenged again after three days, its performance was nearly identical. Thus the closed IPN is bistable for operationally significant time periods. The open state of the material has shown very high breathabilities, in terms of moisture vapor transport (grams water/square meter per day), that meets or exceeds those of state of the art commercial sport clothing. Also, at relative humidities of up to 50%, the closed state demonstrates a substantial breathability as well, more than one-half of that shown by the open state.

We have developed simple methods for forming the IPN within the fabrics, involving casting or spraying the polymer solution. They will allow straight-forward manufacture and scale-up. The IPN forms through chemical crosslinking processes that occur when the solution is deposited. Use of selected solvents for deposition will allow other CB protective elements, such as agent-degrading enzyme, to be introduced into the IPN during its formation.

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