Abstract

As experiencing hot months and thermal stresses is becoming more common, chemically protective fabrics must adapt and provide protections while reducing the heat stress to the body. These concerns affect first responders, warfighters, and workers regularly surrounded by hazardous chemical agents. While adapting traditional garments with cooling devices provides one route to mitigate this issue, these cooling methods add bulk, are time limited, and may not be applicable in locations without logistical support. Here I take inspiration from nature to guide the development of smart fabrics that have high breathability, but self-seal on exposure to target chemical(s), providing a better balance between cooling and protection. Natural barrier materials were explored as a guide, focusing specifically on prickly pear cacti. These cacti have a natural waxy barrier that provides protection from dehydration and physically changes shape to modify surface wettability and water vapor transport. The results of this study provided a basis for a shape changing polymer to be used to respond directly to hazardous chemicals, swelling to contain the agent. To create a stimuli responsive material, a novel superabsorbent polymer was synthesized, based on acrylamide chemistry. The polymer was tested for swelling properties in a wide range of organic liquids and found to highly swell in moderately polar organic liquids. To help predict swelling in untested liquids, the swelling of multiple test liquids were compared with their thermodynamic properties to observe trends. As the smart fabric needs to remain breathable to allow evaporative cooling, while retaining functionality when soaked with sweat, absorption of water, as well as that of an absorbing liquid in the presence of water were tested. Micron sized particles of the developed polymer were deposited on a plastic mesh with pore size and open area similar to common clothing fabric to establish the proof of concept of using a breathable barrier to provide chemical protection. The polymer coated mesh showed minimal additional resistance to water vapor transport, relative to the mesh alone, but blocked more than 99% of a xylene aerosol from penetrating the barrier.