A Better Method for Self-Decontamination

WHEN a person is exposed to dangerous chemicals, time is of the essence. Once hazardous substances make contact with skin, they may cause severe burns or even death. In the event of a chemical attack, people need immediate treatment to prevent further harm. Decontamination showers are effective at removing chemicals but are not feasible when treating large numbers of people. Easy-to-use, personal decontamination kits could be the solution in these emergency situations.

Decontamination kits used by the military allow personnel to treat themselves or their equipment when exposed to chemical agents. In the U.S., these kits contain an extremely porous carbon material, usually in powdered or granular form. The carbon has been activated—that is, it has a large surface area—and a high affinity for a range of chemicals. In powdered form, it is effective at adsorbing and eventually neutralizing chemical agents. However, particulates from the powder can create additional health risks if they are inhaled or spread to other parts of the body.

Another method is a liquid decontaminant called Reactive Skin Decontamination Lotion® (RSDL), which was invented at the Ottawa Laboratory of Defence Research and Development Canada and developed at that institution's Suffield Laboratory with support from the Department of Defense for licensing the product in the U.S. Manufactured by Bracco Diagnostics, Inc., RSDL is free of particulates and effective for a broad spectrum of chemical warfare agents. However, it has not been tested on a wide range of toxic industrial chemicals, nor is it ideal for use on water-sensitive equipment.

Laboratory researchers in the Engineering Directorate, in collaboration with research institutions and manufacturers, are developing an improved system. In a project funded by the Department of Homeland Security and overseen by the U.S. Technical Support Working Group, they have designed a prototype kit that physically removes most of a chemical and neutralizes any residuals on a surface without leaving behind particulate matter. This approach has the potential for use on numerous industrial chemicals and would ensure that treatment is effective, even when an individual cannot identify the specific agent or industrial chemical to which he or she has been exposed.

The Livermore team's prototype design, called the low-cost personal decontamination system (LPDS), is a portable kit that civilians and military personnel could use in the event of a chemical attack. The LPDS concept integrates two separate products—a dry fabric wipe and RSDL—into one kit that can treat a broad range of chemical agents, including toxic industrial compounds such as sulfuric acid. According to William Smith, a chemical engineer who led the LPDS development team, "By combining the existing military decontamination system with the wipe, there is promise for treating nearly every chemical. In some cases, individuals may be in much better shape with both technologies than with either one alone."

Serving a Dual Purpose

Each LPDS prototype kit includes a dry wipe, an RSDL-saturated sponge, and a step-by-step instruction card. All three items are contained in a sealable quart-size bag, and the entire prototype weighs less than 2 ounces. A final approved kit as compact and lightweight as the prototype would be easy to store and readily accessible in an emergency.

The dry wipe, developed by Seshadri Ramkumar at Texas Tech University and manufactured by Hobbs Bonded Fibers, Inc., is a layered, composite fabric that serves two main functions: absorption and adsorption. The top and bottom layers are made from porous and absorbent fabrics that work to remove the bulk of the chemical on a contaminated surface. Sandwiched between the two layers is a nonparticulate fabric form of activated carbon that adsorbs toxic vapors from the absorbed liquid. The activated carbon layer is bound to the absorbent fabrics by a technique called needle punching.

In the needle-punching process, barbed needles pull and loop the fibers, resulting in a tightly interlocked fabric structure. Because this process does not involve thermal or resin bonding, it creates a flexible pad and keeps the pores open in the fabric and carbon layers. The composite fabric can effectively wick away liquid chemicals and draw in toxic vapors. In addition, the multilayer pad could potentially be applied to mucous membranes such as on wounds or the eyes. Unlike older decontamination kits that use powdered carbon materials, the wipe will not leave behind particulate matter on these sensitive areas because the activated carbon is contained between the fabric layers.

Using LPDS is a simple process that takes just minutes. First, a victim or first responder presses the dry wipe onto the contaminated surface, whether skin or equipment, to remove the bulk of the chemical. The person then scrubs the affected surface with the RSDL-saturated sponge. The lotion neutralizes the chemical agents and can decontaminate hard-to-reach areas, such as cracks in the surface of skin. The used wipe and sponge are resealed inside the original bag, keeping the toxins contained until they can be disposed of properly.

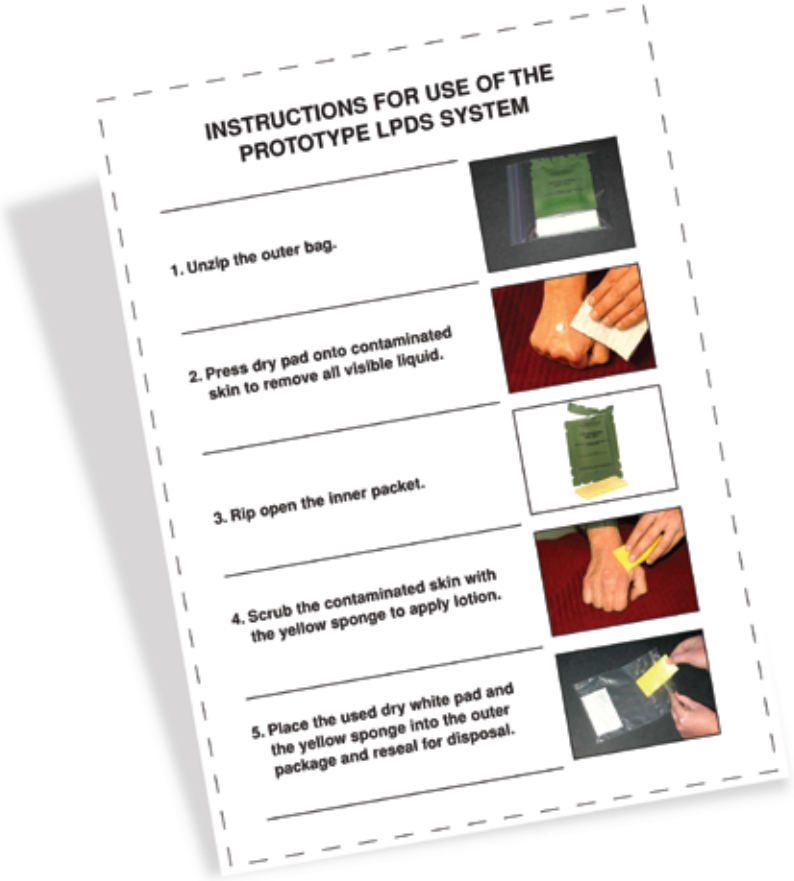
Do No Harm

Because treatment after a chemical attack must be performed quickly, individuals cannot always identify which agents they have been exposed to before they apply decontaminants. Therefore, they must know that the decontamination product will react safely if at all with whatever chemical they may have on their body. Livermore scientist Adam Love, who tested the system components, says, “Our goal was to create a treatment system that provides a physical chemical removal process regardless of the actual chemical a person is exposed to.”

Livermore researchers tested an LPDS prototype at the Laboratory’s Forensic Science Center. The team first evaluated several liquid decontaminants to determine which one was most effective at neutralizing chemicals. For the initial tests, drops of the decontaminants were added to vials containing methyl parathion, sulfuric acid, and sulfur mustard. The most effective liquids from the first round of tests were then applied to samples of human skin. Results showed that RSDL was the most effective liquid formulation. When applied to a highly reactive industrial chemical such as sulfuric acid, RSDL has the potential to prevent acid burns on skin. However, when RSDL was applied to sulfuric acid in the laboratory tests, the mixture increased surface temperature to levels that may pose a burn hazard if used on skin. To mitigate this effect, the team searched for methods to remove most of the industrial chemical before RSDL is applied.

The team evaluated the absorption and adsorption properties of various dry decontaminants using the same toxic chemicals from

The low-cost personal decontamination system (LPDS) is an easy-to-use prototype kit for treating people or equipment after a chemical attack. A dry wipe (top image) removes the bulk of chemicals from the contaminated surface of skin or equipment. The yellow sponge is saturated with Reactive Skin Decontamination Lotion® to neutralize any residual chemicals.



Each LPDS prototype kit includes a step-by-step instruction card so victims of a chemical attack can quickly treat themselves even without training.

the liquid decontaminant experiments. The dry composite fabric wipe developed by Ramkumar performed better than the powdered carbon treatments tested by the team—including the proprietary carbon material in the military's older decontamination kit, which is now being replaced by the liquid RSDL.

Researchers also measured the wipe's reactivity and its ability to remain intact as it absorbs other chemicals. The wipe did not disintegrate even when bleach was added to a pad saturated with sulfur mustard. In addition, the saturated wipe did not exude vapors, which would have indicated chemical reactivity. The team also soaked clean, unsaturated pads in acids and solvents other than bleach. Results demonstrated that the pad remained intact and was not reactive when it came in contact with these chemicals.

The final stage of the Laboratory's testing evaluated how the dry wipe and RSDL worked together on skin samples exposed to sulfur mustard. The two-step process—using the pad first to remove the bulk of the liquid chemical followed by the RSDL sponge to neutralize the rest—was more effective than existing decontamination systems in treating an array of chemicals.

Taking the First Step

Smith notes that LPDS must undergo further testing for safety and with more chemical agents and toxic industrial compounds before the Food and Drug Administration will approve it for use. However, the technology's effectiveness with sulfur mustard—one of the most difficult chemical agents to remove—holds promise for future success.

As designed, LPDS would cost less than $30 per kit. The compact design would allow kits to be available at large outdoor public facilities and in emergency vehicles for first responders to use and distribute to civilians in the event of a chemical attack. "Such kits could prevent panic by providing people the confidence they need to help themselves until more extensive decontamination methods can be set up," says Smith. As a result of the work performed by the Livermore researchers and their collaborators, LPDS could offer military personnel and civilians an effective first step in self-decontamination when time is of the essence.

—Caryn Meissner

Key Words: activated carbon, chemical agents, low-cost personal decontamination system (LPDS), Reactive Skin Decontamination Lotion® (RSDL), toxic industrial compounds.

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