'Scrubbing' chemical-contaminated buildings clean with lasers

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A "neodymium-YAG" laser will decompose VX nerve agent in this vinyl tile. Normally near-infrared, the laser turns ultraviolet as the frequency is increased. The UV light breaks the molecular bonds, decomposing the deadly nerve agent until it is just a harmless brown stain. Credit: INL

Dhiren Barot was an al Qaeda operative involved in plots to blow up the London subway, among other targets. To maximize the damage and the terror, he planned to pack some of his bombs with toxic gas. Fortunately, in August 2004, British authorities nabbed Barot and his accomplices before they could carry out their attacks.

But the threat of a gas attack remains. Where Barot failed, at some point someone might succeed. The right response to such an attack could minimize exposure and save hundreds of thousands of American lives.

With funding and guidance from the Department of Homeland Security's Science and Technology Directorate (S&T), chemists at Idaho National Laboratory (INL) are researching ways to help the nation

respond to and clean up after potential chemical attacks. They have been studying decontamination techniques for almost a decade.

Cleaning up chemical-contaminated structures can be difficult, costly, and time-consuming. For one thing, most preferred methods employ other chemicals, like bleach solutions, which can be corrosive and aggressive. Many building materials—like cement and brick—are extremely porous and getting contaminants off such surfaces is difficult, as contaminants will seep into cracks and pores.

According to Donald Bansleben, program manager in S&T's Chemical and Biological Division, lasers could one day play a big role. "Lasers could help to scrub chemical-contaminated buildings clean and become a tool in the toolbox to speed a facility's return to normal operations."

Just as contaminants might get into those cracks and pores, water, too, can penetrate, and that's where lasers come in. Laser pulses can flash that water into steam, carrying the contaminants back to the surface for removal by chelation or other means. "It's a kind of laser steam-cleaning," says chemist Bob Fox.

When INL began investigating lasers, researchers were looking for ways to dispose of radioactive contamination after a dirty bomb. Under the new S&T program, the team has been extending its work to chemical-weapon decontamination. While no terrorist has managed to deploy a dirty bomb, the same cannot be said of chemical agents.

In a series of tests still underway at the Army's Aberdeen Proving Ground, INL researchers have been using ultraviolet-wavelength lasers to scrub surfaces clean of sulfur mustard gas and VX, a nerve agent. The tests have proved successful so far, even on complex, porous surfaces like concrete.

Lasers can degrade weapons like VX in two ways: photochemically or photothermally. In photochemical decomposition, high-energy laser photons blast apart chemical bonds, slicing the agent into pieces. In photothermal decomposition, photons heat up the target surface enough to speed along natural degradation reactions. In some cases, the intense heat by itself can cause contaminant molecules to fall apart.

Knowing how chemical contaminants fall apart is key, because some of the elements resulting from their degradation products can themselves be hazardous. But according to Fox, the tests look good in this regard, too. "The lasers are showing neutralization of the agent without generation of dangerous byproducts," he says.

And even if they're not used to degrade VX or other agents, lasers could still be helpful in cleanup scenarios. Laser light could blast nasty chemicals off a wall, for example, and an integrated vacuum system could suck them up.

Fox and his team are adapting an established technology. Lasers have been used in cleanup capacities for more than a decade. Dentists employ them to kill periodontal bacteria and quash mouth infections. Doctors use them to remove tattoos. And lasers have recently become a common tool to restore precious artwork.

Laser technology has other commercial applications. Some cleanup and restoration firms are already using lasers to scrub soot off building facades. And these industrial operations often use automated lasers, demonstrating that laser work can be done remotely, minimizing risks to remediation personnel responding to a chemical or radiological attack.

Fox stresses that laser decontamination is in the proof-of-principle stage, and is not an anti-terror panacea. Still, several government agencies are paying close attention.

As for biological decontamination, like what was needed in the U.S. after the 2001 anthrax attacks, Fox has not yet tested bacteria-laden surfaces.

"I don't know," he says. "But I'm willing to shine my light on anything."

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