Changing colors to keep first responders safe

SUBMITTED ARTICLE

Savannah River National Laboratory uses color-changing compounds to identify potential radiation risks in emergency situations.

For even the best trained emergency responders, radiation events pose a particularly daunting risk. Radiation defies a responder's five senses; without special equipment, personnel exposure is impossible to confirm, and safety is difficult to assure.

First responders have identified a response technology objective: the ability to integrate detection and identification capability into existing equipment, giving responders the ability to monitor for the presence of radiation in real time.

At the Savannah River National Laboratory, researchers are working to use the color-changing properties of certain compounds to meet the technical challenge that radiation poses for the emergency response community.

The Laboratory's Dr. Aaron L. Washington II, Brent Peters and Dr. J. Connor Nicholson – working with Dr. John Anthony of the University of Kentucky – are focused on the color-changing potential of Organic Radiochromic Compounds (ORCs).

Radiochromic compounds change color in the presence of radiation. Radiation sensing compounds in their base composition as a leuco dye, for example, are a key component in personal dosimeters, the small measuring devices worn by nuclear workers throughout the world. While current radiation absorbers are effective, they also can be limited, lacking many of the attributes that might be critical to a first responder in a radiation event.

Since 2015, Washington, Peters and Nicholson have been working to determine how an ORC color change could be utilized as a versatile, one-minute radiation detection platform. Ideally, the technology could be used to integrate radiation detection and identification capability into either equipment or protective clothing.

Initial research funding came from the Department of Homeland Security Science and Technology Directorate's National Urban Security Technology Laboratory, with follow-on funding from the National Nuclear Security Administration.

"In graduate school, I worked on nanomaterials that were sensitive to photons and changed colors, but I always had the idea of doing something related to color change during radiation exposure," Washington said. "Our original proposal to the DHS had to do with developing organic radiochromic compounds for visual color-changing applications. They had the idea of using the technology for first responders.

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Savannah River National Laboratory researchers are working on how to utilize compounds that can change colors when exposed to radiation. Applying such a compound to protective clothing or equipment could provide a significant level of warning to benefit an emergency responder.

"DHS gave us funding to develop and test, and said 'we'll develop the application later.' They didn't want us to shorten the test period just to get to an application. That's a great example of a customer being more interested in making sure the science is sound," he said.

Initially, the project relied heavily on surveys and interviews with a wide array of first responders, whose answers enabled the SRNL team to develop a list of minimum requirements for an ideal compound. Among other requirements, an ideal product would have to be safe, easy for a user to understand, lightweight, and able to withstand wide variations in environmental factors such as temperature, humidity, moisture and sunlight.

The team agreed that any end product had to effectively change colors within a very short time frame from exposure. Another important goal, Washington said, was to find a compound that would respond effectively, yet would not react to the gamma or ultraviolet radiation associated with prolonged sun exposure (up to four hours).

In conjunction with the University of Kentucky, SRNL began with a list of 60 potential compounds, and narrowed the field to three different families: two different diacetylenes and one leuco dye capable of meeting the most of the minimum and optimum operational requirements. The testing looked at multiple radioactive sources with a wide range of gamma energies.

After extensive high energy and low energy testing, the "winning" compounds have been shown to change color within a dose range that would provide a significant level of warning information to an emergency responder.

"We learned that there are first responders who would go into what we would consider to be extremely high radiation fields and not think twice if they felt they could save a life. We didn't know that," Washington said. "We in the DOE system have been trained to a much more conservative standard."

Among the next steps are to evaluate various ways to encapsulate the ORCs (such as fabrics or polymers).

"It could be deployed through a spray, or a paint. It could be molded into something like your glasses, or your tools. It could be a coating on your vehicle, or a lens on a camera. There are a lot of little manipulations you could do," Washington said.

For now, the color change is a one-time change. Future testing will also look at how to make the color change reversible.

Field testing, to date, has been minimal. One potential next step could be a field test to retrofit selected radioactive laboratories for passive monitoring. Applying an ORC to a glovebox glove or to a floor (similar to a floor wax) could allow more immediate detection and isolation of a glove breach or a spill.

The team is currently funded through NNSA but is continuing to work with the DHS and NNSA to seek out additional research funding opportunities, and other potential customer applications.