Decontamination Assurance Spray

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TDA Research

Introduction

We are currently developing a family of colorimetric indicators that respond to chemical warfare (CW) agents. These indicators are designed to signal the presence of small amounts (microgram levels) of residual agents remaining on surfaces after the surface has been decontaminated. The spray is designed to be applied to surfaces after decon and will rapidly show if and where any residual CW agent remains on the surface.

Our design concept has been to develop a colorimetric indicator that responds only to live CW agents. The indicator is reactive, and upon reaction with a CW agent it releases a highly colored dye. The raw materials that we use are commodity chemicals, and our product is inexpensive to formulate and implement.

Technical Approach

We have designed colorless compounds that react with a suite of CW agents, releasing strong chromophores. Our approach to developing the decontamination assurance spray has been to first study and optimize the reactivity of the indicators in solution against simulants, and later against live CW agents. Using this procedure we have discovered a series of highly active materials. Our next step was to identify a solid support for these indicators. The support is inexpensive and it retains the dye once the indicator reacts, which prevents staining of the surface.

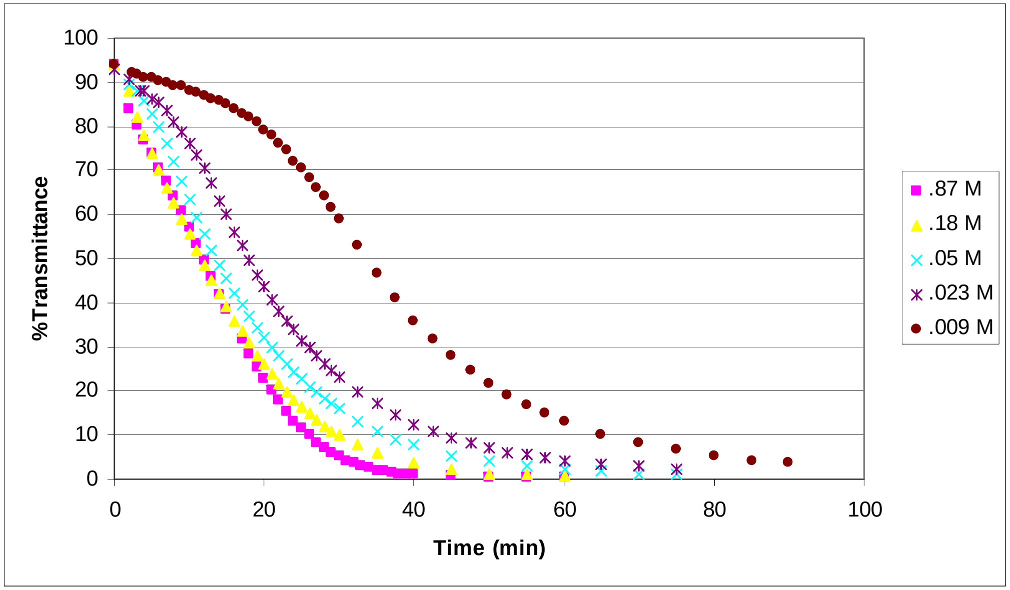

Figure 1. Response of one of TDA's colorimetric indicators to CEES (2-chloroethyethyl sulfide), an HD surrogate. The indicator shows a rapid response when the CEES concentration is varied from ~0.9 M to 0.02 M, and slows when the concentration drops to 0.01 M.

Solution Studies

We developed our indicators by first studying their solution reactivity. In our initial studies, we have measured the optical response of a series of indicators towards CEES. Indicator solutions were treated with varying concentrations of CEES, and the optical response was followed as a function of time. We followed the reactions by measuring the %Transmittance of the solutions at the λMAX of the dye released by the reaction.

The response of our indicators towards CEES is fast, even at a low CEES concentration such as 0.02 M (Figure 1). In actual practice, surface concentrations are significantly higher. Despite the fact that any residual contamination will likely be present in low quantities, the actual local concentration of the agent will be quite high.

Tests Against Live Agents

We have conducted initial tests against live agents with some of our indicators. Below is a picture of a sequence of tests of a green and a red indicator against HD, GB and VX (Figure 3; on the right in each group of 4 is a solution of untreated indicator). In each test, 1 mL of the solution was treated with 25 ųL of agent. The green indicator (top set of 4) responded strongly to HD and GB, but not to VX during the 1 h test period. The red indicator (bottom) responded strongly to HD and GB, but also showed a slight response to VX, despite the low agent concentration (0.01 M).

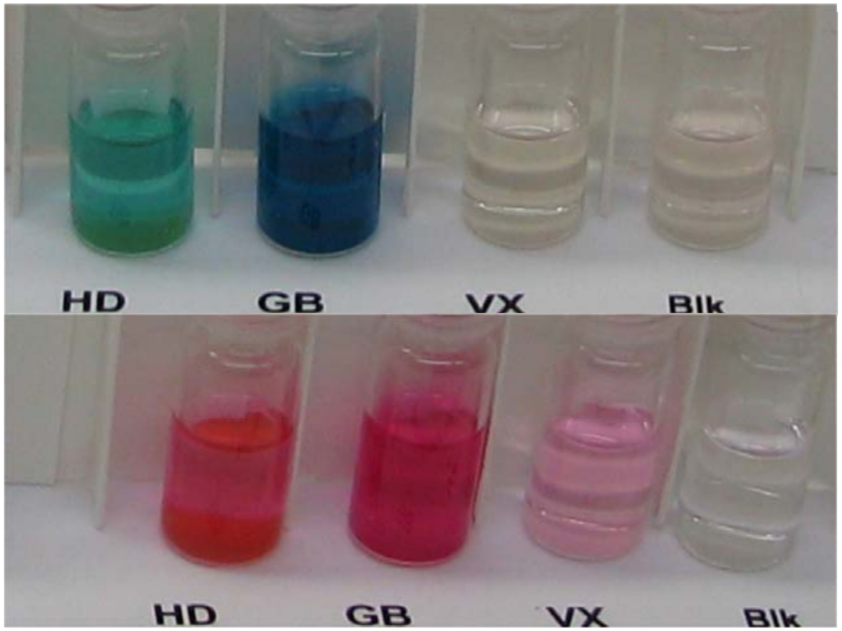

Figure 2. Colorimetric response of two different indicators to HD, GB and VX (controls on right).

Studies on Surfaces

On the left (Figure 3) is shown a CARC-coated test panel that has been treated with a series of micro-gram sized droplets of diphenyl chlorophosphate, a G-agent simulant. These droplets range in size from 2-50 µg. The panel (3”X6”) was treated with the spray, and the photo on the right of the figure taken after 10 min. All of the droplets are plainly visible, including the 2 µg ones. The size and shapes of the droplets are seen when the indicator changes color.

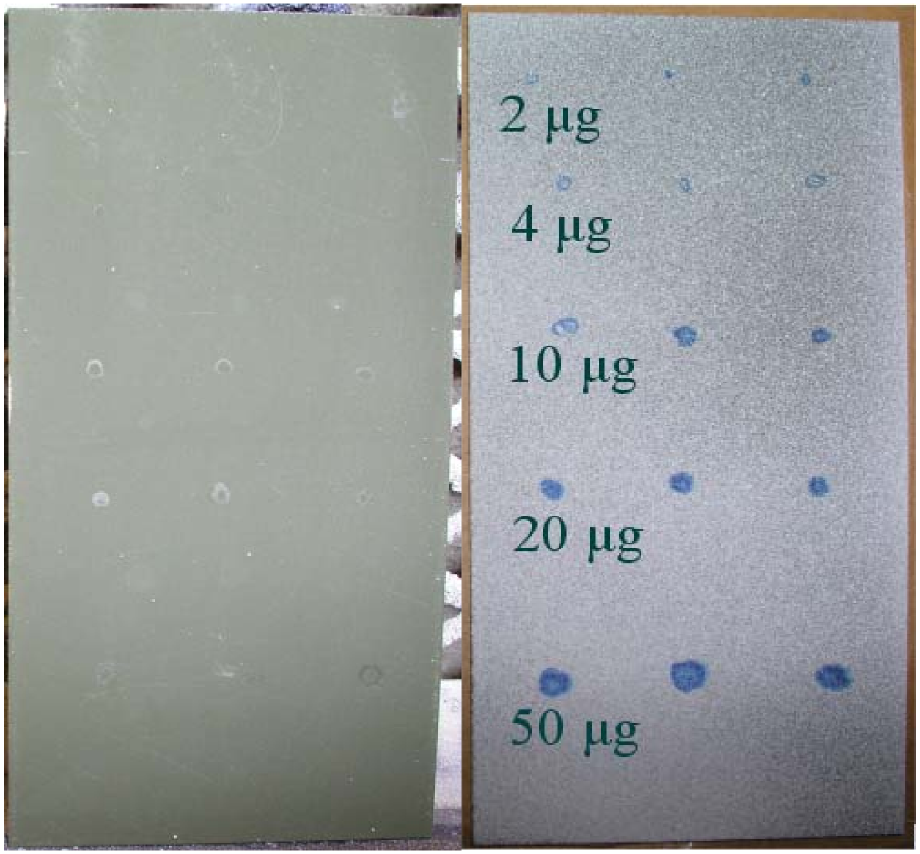

Figure 3. Colorimetric response of a test spray to micro-gram sized droplets of a CW agent simulant (diphenylchlorophosphate) deposited on a CARC-coated aluminum panel.

Timeline of a Spray-out

The response of our indicator is very fast, as shown in the sequence of screen-captures by a video camera below in Figure 4. The application of the spray to the two panels took only 3-4 seconds, and below are shown a sequence of captures immediately after the spray-out and in discrete time intervals. 10 seconds after the application, the largest droplets (50 µg) are starting to become visible. After 20 sec, the next largest droplets (20 µg) are also visible. After 1 min, the next row of droplets (10 µg) are visible, and after 2 min, all of them can be seen.

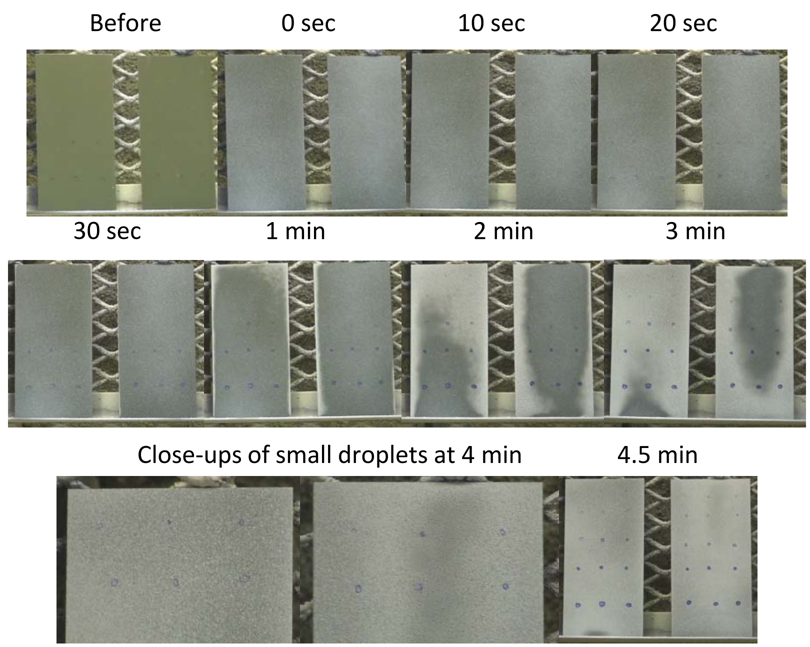

Figure 4. Timeline in the development of the color of one of our CW agent indicator sprays. The indicator is dry after ~ 4 min, and all of the simulant droplets (diphenylchlorophosphate) are visible on the dry surface. A close-up of the smallest droplets are shown on the bottom left 4 min after treatment.

Future Work

Our future efforts will be focused on validating our indicators against live CW agents at CUBRC. We will conduct more quantitative tests on the reactivity of the indicators in solution, and will follow the reaction kinetics spectroscopically at different agent concentrations. We will then conduct tests of the solid indicators against HD, GB and VX. In these tests, we will determine the response rates and the sensitivity of our best indicator. We will also conduct tests at TDA to identify possible interferents with our indicator.

Acknowledgements

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