LVAP Method for Protective Equipment

By: Terrence D'Onofrio, Ph.D.

Researchers at the Edgewood Chemical Biological Center (ECBC) recently developed a new test fixture and experimental method, named the Low-Volatility Agent Permeation (LVAP) method, for testing and evaluating VX (nerve agents) permeation through protective equipment. A U.S. patent on the LVAP fixture and method was issued in May 2015. [1] LVAP has shown increased accuracy for measuring the permeation of low-volatility contaminants, such as VX. The LVAP method built upon multiple years of ECBC research, with support from the Joint Science and Technology Office (JSTO), Natick Soldier Research and Development Center (NSRDC), Deputy Under Secretary of the Army for Test and Evaluation (DUSA TE) and the Joint Project Manager for Protection (JPM-P).

LVAP is a contact-based method, using a sorbent pad under a swatch of protective material to collect the total permeated mass of contaminant. A stainless steel weight is applied on top of the contaminated region, ensuring that all layers are in good contact. This weight corresponds to 1 psi, which is consistent with the pressure that would be applied when grasping an object with the hand. The pressure makes the testing more realistic for gloves or other protective equipment, which are in contact with the skin. All of the components are sealed in an inverted 240 mL glass jar to facilitate handling and prevent vapor cross-contamination during the testing period. Each cell is placed into an incubator to maintain an isothermal environment during the experiment. The incubator was modified with sliding shelves to allow for up to 40 cells per experiment. At the desired time point, a cell is disassembled, the sorbent pad is removed, extracted in solvent, and analyzed to measure the total permeated mass. Traditional methods of measuring permeation are dependent on collecting vapors of the permeated contaminant. Vapor collection can be less accurate for low volatility contaminants, since the vapor concentration may not represent the potential hazard that has already permeated through.

LVAP recently completed an official verification and validation (V&V), under the auspices of DUSA TE. [2] Using standard ISO calculations, the V&V documented the variability of the method to be ±8.2%, which is much improved from the ±80% for similar materials using a traditional permeation method. As part of the V&V study, a physics-based model was developed to predict neat agent permeation through the test materials. This was based on a Fickian diffusion model where the diffusivity and solubility of VX in the latex material was estimated by correlation with published values. The model was successful in predicting the measured permeation for VX through latex at 24 hour and 48 hour time points, prior to the experiments being conducted. [3] This modeling effort was conducted in collaboration with scientists from the Decontamination Sciences Branch.

“The modeling of this method was remarkable,” said Terrence D’Onofrio, Ph.D, principal investigator for this research. “We can describe how VX interacts with different materials, and predict how much will come through over time, using these physics-based approaches.”

The modeling predicted the levels of permeation that occur over time, guiding experiments to focus on critical time points. The modeling also enables comparison with data obtained by traditional vapor-collection methods. The Decontamination Branch has a long history of understanding and characterizing how contaminants interact with substrates, which is a critical step for understanding how to neutralize or remove the contaminant from the material. The permeation program was able to leverage the interaction models to help predict the breakthrough at various times.

“This ability to predict the changes over time fills a huge gap from the previous methods,” D’Onofrio said. LVAP has already had an impact on personal...
protective equipment and laboratory procedures used at ECBC. D’Onofrio and his colleagues within ECBC’s Engineering Directorate used LVAP as part of a safety initiative to test laboratory gloves against high concentration VX solutions. Through the use of LVAP, they were able to demonstrate that the gloves offered protection for the laboratory scenario tested.

Beyond DoD, domestic elements such as the Federal Bureau of Investigation and the Department of Homeland Security, have discussed using LVAP to test their First Responder suits. British Agencies have also expressed interest in the method.

About the Author:
Dr. D’Onofrio has been researching permeation of contaminants through protective equipment since 2007. He was presented a Department of the Army Achievement Medal for Civilian Service by DUSA TE in recognition for the successful invention, development, and transition of this method to the T&E community.

References: