**Materials**
- Al: coating materials were applied to Si wafers which cleave along the (100) crystal axis to provide a cross-sectional view.
- SEM chamber and vacuum system: for deconstruction of the material.
- Mapping procedures: elemental analysis was performed by scanning electron microscopy (SEM) coupled with energy dispersive spectroscopy (EDS).

**Experimental Procedure**
- Deconstruction method: characterization of the absorption of highly toxic chemicals into permeable coatings that are used on military vehicles.
- EDS analysis: full formulation (Coating B), but without the porosity.

**Determination of Diffusion Coefficients**
- Diffusion coefficients: for a total of either 31, 35, or 60 minutes.
- The calculated approximations correspond to diffusion coefficients for heterogeneous materials.

**Results and Conclusions**
- Spatially: maps of contaminated Coating A exhibited circular voids within the contaminant distribution that corresponded to the presence of porosity.
- Simulant uptake did not always match agent uptake.
- Lower resistivity to VX contamination over HD and DMMP indicates mass transport is affected by factors other than just contaminant penetration.

**Visualization of the Absorption of Chemical Warfare Agents and Associated Simulants in Heterogeneous Coatings**

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**Introduction**
Characterization of the absorption of highly toxic chemicals into permeable materials is paramount for hazard assessments due to the types of contaminants/materials as well as design and processing parameters. Of particular interest is the uptake of chemical warfare agents (CWAs) and their simulants into permeable, polymeric coatings that are used on military assets.

**Materials**
- All coating materials were applied to Si wafers which cleave along the (100) crystal axis to provide a cross-sectional interface for SEM-EDS examination.
- Samples represent full formulations of three coatings and three deconstructed coatings (Coating B).
- Full formulations were deposited onto substrate and deconstructed coatings were applied to the substrate with a toluene-based solvent to decouple chemistry and morphology.

**Coating B, a porous polyurethane formulation was deconstructed down to basic components to understand the effect of specific components on mass transport.
- SEM examination showed that the addition of the matting agent (Coating B) produced microstructure similar to the full formulation (Coating B), but without the porosity.

**Experimental Overview**
- For deconstructed SEM examination showed that the addition of the matting agent (Coating E) produced microstructure similar to the full formulation (Coating B), but without the porosity.

**Coating Against Agent Uptake**
- All topical layers exhibited a measured increase in contaminant signals after exposure.
- Similar uptake did not always match agent uptake.

**Contaminant Depth Profiling**
- CWA elemental signature was mostly isolated to the topcoat layer.
- Depth profiles indicate polymeric chemistries influence contaminant penetration.

**Approximations of Diffusion Coefficients**
- Diffusion profiles provide penetration depth for order of magnitude approximations of contaminant diffusion coefficients for heterogeneous materials.

**Data Analysis**
- Spectra from each point of the elemental map are grouped by a specific region of interest: paint layer or depth profile.
- Mapping residence time: 50 ms.
- Spectra is collected at each point in a 128 x 128 matrix, representing a 9.75 x 9.75 μm region of cross-section.

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**Full Formulation vs. Deconstructed Coating**
- The deconstructed primer analysis (Coating F) demonstrated high resistance to HD penetration, as indicated by full formulation testing.
- Addition of the matting agent to the polyurethane base changed mass transport behavior and matched what was observed in the full formulation.

**Simulant vs. Agent Uptake**
- All topical layers exhibited a measured increase in contaminant signals after exposure.
- Similar uptake did not always match agent uptake.

**Spatially-Varying Mass Transport**
- Elemental maps of contaminated Coating A exhibited circular voids within the contaminant distribution that corresponded to the presence of porosity.
- This behavior indicates a heterogenous contamination system where different coating components exhibit different transport mechanisms across the contaminant molecule.