

FROM SENSING TO MAKING SENSE

Leveraging The Diverse Power Of Mass Spectrometry For Simplified Threat Agent Sensing

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Mass spectrometry (MS) is an indispensable and multifaceted tool for detection of a wide range of threats with high sensitivity and specificity. Unfortunately, this technique often requires rigorous sample clean up, long analytical run times, and significant power/vacuum requirements which hinders its deployment in the field. Our work focuses on the use of paper spray mass spectrometry (PS-MS), an ambient ionization technique, that vastly simplifies the analytical workflow and the backend data processing. In PS-MS, a crude sample (10 microliters) is applied to a piece of chromatography paper that is cut to a point. A spray solvent is applied to the rear of the cartridge and wicked through the paper via capillary action, simultaneously extracting the analytes from the sample spot. A high voltage is then applied to the paper to produce an electrospray-like event at the tip of the paper. Sample analysis can be completed in as little as 1 minute. There have been significant advancements in portable instrumentation and automated processes that make PS-MS an attractive technique for the warfighter's toolbox. In this presentation, three projects will be discussed where PS-MS was utilized for detection of threat agents. The first focuses on the detection of nerve agent simulants and nerve agent hydrolysis products from raw soil using PS-MS. In this work low nanogram concentrations were detected in soil in under 2 minutes using automated technology. There were specific peaks used for identification that can be used for a go/no go type of decision. Although this work was performed on a benchtop mass spectrometer, the assay would be transferable to a portable instrument. In the second project, an assay was developed to detect proteinaceous toxins off of surfaces. In this work, the biological toxic simulant and vaccine for Staphylococcal enterotoxin B (SEBv) was wiped off of a surface using a paper substrate, a spray solvent was applied and the protein toxin simulant was detected with the mass spectrometer. In the final project, a PS-MS assay was developed for the rapid and simple detection of per- and polyfluoroalkyl substances (PFAS) in whole blood. PFAS are persistent organic pollutants, with harmful health implications, that are often constituents of firefighting foams used by the military for extinguishing hydrocarbon fires. It would be beneficial to have a cost-effective and minimally invasive technique to detect these harmful chemicals in military firefighter's blood. The works described in this presentation have laid the groundwork and shown the versatility for PS-MS to be used for both small molecule threat agents and biological toxins. Future work will focus on the steps necessary to implement this technology in a real-world scenario.

Forensic Chemistry - Dowling, S., et al., Direct Soil Analysis by Paper Spray Mass Spectrometry: Detection of Drugs and Chemical Warfare Agent Hydrolysis Products. Forensic Chemistry, 2019: p. 100206.

Journal of the American Society for Mass Spectrometry - Wichert, W.R.A., et al., Detection of Protein Toxin Simulants from Contaminated Surfaces by Paper Spray Mass Spectrometry. Journal of The American Society for Mass Spectrometry, 2019. 30(8): p. 1406-1415.