E57 Analysis of Smokeless Powder Components by Ion Mobility Spectrometry (IMS)

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After attending this presentation, attendees will better understand methods to improve detection algorithms for smokeless powders using IMS.

This presentation will impact the forensic science community by providing a more robust method to detect smokeless powders using IMS.

Smokeless powders are an easily available source of explosives used in the making of Improvised Explosive Devices (IEDs). The bombs used in a recent terrorist attack, the Boston Marathon bombing, used black powder as the weapon of choice. Smokeless powders can be categorized into three classes based on their chemical composition: single-based powder which contains nitrocellulose as its sole explosive propellant ingredient, double-based powder containing nitrocellulose and nitroglycerin, and triple-based powder containing nitrocellulose, nitroglycerin, and nitroguanidine.

There is a need to assess the ability of currently deployed Explosives Trace Detection (ETD) systems to detect a variety of volatile components found in smokeless powders. The threat libraries of current systems already include nitroglycerin, identified by the presence of a NO_2- peak; however, nitro peaks are non-selective as they can derive from many sources making them a common IMS background peak. The goal of this study is to characterize the IMS response of other volatile components found in smokeless powders to improve detection algorithms and provide a more selective identification. Also, single-based powders that do not contain nitroglycerin require the addition of other components to the threat library to illicit an alarm.

Commercial standards of compounds found in smokeless powders were analyzed using Morpho Detection's Itemiser^{Ò} Dx to determine compound-specific responses. The instrument was operated in dual mode using default settings and calibrated daily based on the manufacturer's recommendations. Background peaks produced by the Teflon®-coated swabs (matrix) and solvent background were evaluated first in order to subtract these peaks from standard and sample spectra. Standard solutions were diluted in a variety of organic solvents and deposited onto sample swabs to determine whether the instrument response to these compounds was linear. The mass loading analyzed ranged between 0.5ng and 700ng. Commercially available smokeless powders were prepared gravimetrically dissolving the solid powders in a High-Performance Liquid Chromatography (HPLC) -grade solvent. Appropriate dilutions were made to deposit the desired mass onto Teflon®-coated fiberglass swabs.

This study identified seven important compounds found in smokeless powders including Nitro+, DNT+, diphenylamine, methylcentralite, and ethylcentralite by IMS and defined their detection parameters. Some known additives were not IMS amenable, such as potassium nitrate. The measured response curves demonstrate typical IMS behavior, in which there is a linear response at low masses and a saturated or near-saturated response at the higher masses. The reproducibility of the measurements is good as determined by error bars in the response curves (Relative Standard Deviation (RSD) ~10%). Prior to this work, the IMS threat library only contained nitroglycerin and black powder, causing single-based smokeless powders to not alarm. With the addition of these additives to the library, improved detection was achieved. Operating Explosive Trace Detection (ETD) systems in dual mode (explosives/negative and narcotics/positive) is critical since most additives can only be detected in positive mode. Future work includes identifying unknown peaks found in IMS plasmagrams by Gas Chromatography/Mass Spectrometry (GC/MS) and/or Electrospray Ionization/Mass Spectrometry (ESI/MS).

Smokeless Powders, Ion Mobility Spectrometry, Explosives

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