MAR11-2011-020245

Abstract for an Invited Paper
for the MAR11 Meeting of
the American Physical Society

Detecting Chemical Weapons: Threats, Requirements, Solutions, and Future Challenges

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Although chemicals have been reportedly used as weapons for thousands of years, it was not until 1915 at Ypres, France that an industrial chemical, chlorine, was used in World War I as an offensive weapon in significant quantity, causing mass casualties. From that point until today the development, detection, production and protection from chemical weapons has be an organized endeavor of many of the world's armed forces and in more recent times, non-governmental terrorist organizations. The number of Chemical Warfare Agents (CWAs) has steadily increased as research into more toxic substances continued for most of the 20^{th} century. Today there are over 70 substances including harassing agents like tear gas, incapacitating agents, and lethal agents like blister, blood, chocking, and nerve agents. The requirements for detecting chemical weapons vary depending on the context in which they are encountered and the concept of operation of the organization deploying the detection equipment. The US DoD, for example, has as a requirement, that US forces be able to continue their mission, even in the event of a chemical attack. This places stringent requirements on detection equipment. It must be lightweight (<2 lbs), detect a large array of chemical warfare agents and toxic industrial chemicals, detect and warn at concentration levels and time duration to prevent acute health effects, meet military ruggedness specifications and work over a wide range of temperature and humidity, and have a very high probability of detection with a similarly low probability of false positives. The current technology of choice to meet these stringent requirements is Ion Mobility Spectrometry. Many technologies are capable of detecting chemicals at the trace levels required and have been extensively developed for this application, including, but not limited to: mass spectroscopy, IR spectroscopy, RAMAN spectroscopy, MEMs micro-cantilever sensors, surface acoustic wave sensors, differential mobility spectrometry, and amplifying fluorescence polymers. In the future the requirements for detection equipment will continue to become even more stringent. The continuing increase in the sheer number of threats that will need to be detected, the development of binary agents requiring that even the precursor chemicals be detected, the development of new types of agents unlike any of the current chemistries, and the expansion of the list of toxic industrial chemical will require new techniques with higher specificity and more sensitivity.