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Developing Fieldable Systems for Chemical Sensing Using Field Asymmetric Ion Mobility Spectrometry and Mass Spectrometry

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Currently, there is an urgent need for field-rugged and field-programmable sensor systems that provide highly selective, universal monitoring of vapors and aerosols at detectable levels from persons or areas involved with illicit chemical/biological/explosives (CBE) production. These devices must be portable, low cost, robust, and provide accurate measurements to avoid both false positive and negative results. Furthermore, the information provided by the devices must be received in a timely manner so that informed decisions can be immediately made and the appropriate actions taken.

Two technologies that are unparalleled in their sensitivity, selectivity, and trace-level detection capabilities are field asymmetric ion mobility spectrometry (FAIMS) and mass spectrometry. Here, we will show progress that has been made toward developing fieldable FAIMS systems and mass spectrometers. Working in collaboration with Sionex Corporation, the microDMx detector was equipped with a continuous air sampling system to develop selective methods for the analysis of compounds of interest. A microdiaphragm pump (KNF Neuberger, Inc.) is used to pull in gas-phase analytes directly from the air for separation and detection with the FAIMS system. The FAIMS evaluation platform (SVAC) unit currently measures 9.8″ × 4.6″ × 3.2″, weighs 3.1 lb, and utilizes a ^{63}Ni source to ionize incoming compounds. Analytes entering the unit are separated and identified by their characteristic response to the compensation voltage (V_c) at a given rf field strength (V_{rf}). This response has been observed to be unique for a wide range of substances studied. If additional verification were required or a targeted analyte present in a complex chemical matrix, a FAIMS unit equipped with a fast gas chromatography column has been evaluated. The unit combines the separation capabilities of gas chromatography with the selectivity of FAIMS. It measures 9.5″ × 5.25″ × 3.5″, weighs 3.8 lb, and uses a 10.6 eV photoionization source. Analytes are identified both by their elution time from the column and by the characteristic response in the FAIMS spectrum. Analysis times required to obtain results for most analytes examined are less than three minutes.

A fieldable mass spectrometer system is also being developed that includes sampling, ionization, mass selection and detection, vacuum technology, and analytical methodology with remote data transmission. Multiple methods for mass selection are being explored, including both Penning and Paul type ion traps as well as a quadrupole system to determine which is best suited for a portable mass spectrometer. Several ionization sources and ion counting methods will also be evaluated to establish their effectiveness with each system. The intended result of this project is a handheld mass spectrometer system capable of field deployment for the detection and identification of a wide range of gas-phase CBE species.

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