Homeland Security
Science and Technology

TechNote

Handheld Ion Mobility Spectrometry Trace Explosives Detectors

Handheld ion mobility spectrometry (IMS) trace explosives detectors are used by security personnel to screen packages, vehicles, clothing, and other items for trace residues of explosives. The premise underlying their use is that individuals handling explosives are likely to contaminate themselves and the objects they handle with microscopic explosives particles. Handheld IMS detectors provide a fast and reliable analysis method to sample objects for explosives residues in a fingerprint or hand smudge.

How They Are Used

Handheld IMS trace explosives detectors (Figure 1) are gas sampling and analysis instruments that can detect and identify a wide range of explosives vapor compounds (i.e., chemical compounds that are emitted in the form of a vapor by commercial, military, or homemade explosives); they are essentially electronic versions of bomb sniffing dogs. They can be operated in one of two modes. In *vapor-sampling mode*, the instrument's gas sampling inlet is held close to the object to be screened, and air is drawn into the instrument and analyzed for explosives vapor compounds. In *particle-sampling mode*, the user swabs the surface of the object to be screened with a small wipe to collect a sample of any explosives residues that may be present. The wipe is inserted into a compartment in the instrument where it is heated to enhance the emission of explosives vapor compounds. Vapors emitted by the wipe are then drawn into the instrument and analyzed.

Figure 1. A Handheld IMS Trace Explosives Detector
Photo Courtesy of Implant Sciences Corporation

How They Work

The basic components of a handheld IMS trace explosives detector are shown in Figure 2. Samples entering the instrument arrive at the ionization region where a radiation source (e.g., a small quantity of a radioactive isotope or an ultraviolet light source) ionizes any explosives vapor compounds in the sample. An electronically operated gating device called a shutter grid transfers the ions produced in the ionization region to the adjoining drift region in timed intervals. The drift region contains electrodes which establish a constant electrical field which draw the ions toward an ion collector located at the opposite end of the drift tube. The ions arriving at the ion collector produce an electrical current that is measured as a function of *drift time* (i.e., the travel time of the ions between the shutter grid and the ion collector). The drift time of an ion is a

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SAVER
System Assessment and Validation for Emergency Responders

The U.S. Department of Homeland Security (DHS) established the System Assessment and Validation for Emergency Responders (SAVER) Program to assist emergency responders making procurement decisions.

Located within the Science and Technology Directorate (S&T) of DHS, the SAVER Program conducts objective assessments and validations on commercial equipment and systems and provides those results along with other relevant equipment information to the emergency response community in an operationally useful form. SAVER provides information on equipment that falls within the categories listed in the DHS Authorized Equipment List (AEL).

The SAVER Program is supported by a network of technical agents who perform assessment and validation activities. Further, SAVER focuses primarily on two main questions for the emergency responder community: "What equipment is available?" and "How does it perform?"

For more information on this and other technologies, contact the SAVER Program Support Office.

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function of its charge, mass, and size; therefore, different ion species can be distinguished from one another based on their different drift times.

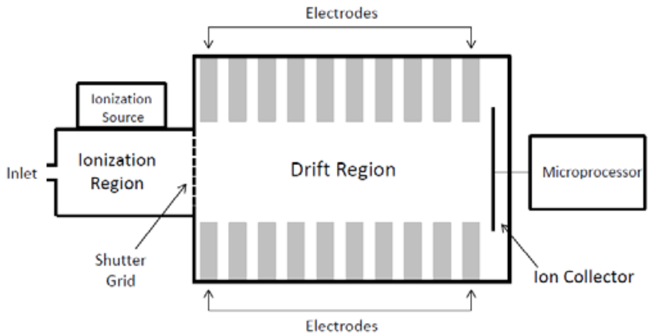

Figure 2. Schematic Diagram of an IMS Detector

An onboard microprocessor converts the electrical signal produced by the ion collector into a plot of ion current versus drift time; this plot is referred to as an ion mobility (IM) spectrum. As shown in Figure 3, the IM spectrum of a chemical compound consists of one or more peaks, each of which indicates the drift time of a particular ion species produced in the ionization region.

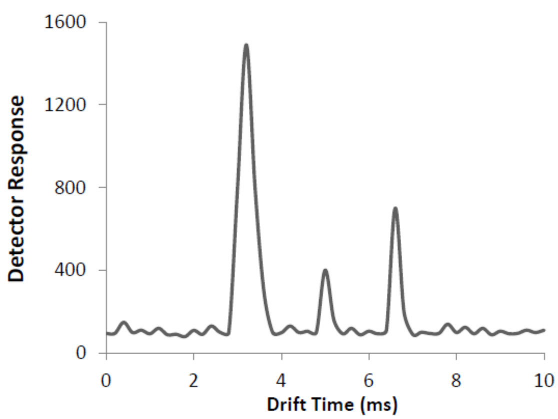

Figure 3. An IM Spectrum

Differences in the structure and elemental composition of chemical compounds cause them to produce different kinds and relative amounts of ions when ionized. As a consequence, many explosives vapor compounds can be identified by the characteristic pattern of peaks present in their IM spectra. The instrument's microprocessor contains a spectrum analysis program that automatically compares each sample's IM spectrum against an internal library of IM spectra of various explosives vapor compounds.

A few commercially available handheld trace explosives detectors are based on variants of the IMS technology described above. One such technology is Ion Trap Mobility Spectrometry® (ITMS), in which the transfer of ions between the ionization region and the drift region is controlled by a device called an ion trap rather than a shutter grid. The ion trap provides more efficient transfer of ions from the ionization region to the drift region compared to a shutter grid, resulting in improved detection sensitivity relative to IMS detectors. Another commercially available detector technology is based upon field asymmetric ion mobility spectrometry (FAIMS). The key difference compared to an IMS instrument is that the electric field in the drift region has both constant and time-varying components. As the relative magnitude of the electric field components are varied, only ions with certain combinations of charge, mass, and size will succeed in transiting the drift region to reach the ion collector. Ion species are identified by determining the electric field voltages that permit successful transit of the drift region rather than by determining drift times, eliminating the need for an ion gating device. This design allows for more efficient collection of the ions produced in the ionization region and thus provides for an improved detection sensitivity compared to IMS detectors.

Features and Use

Most explosives vapor compounds produce negatively charged ions when ionized and therefore all handheld IMS trace explosives detectors are capable of measuring negatively charged ion species. A few explosives vapor compounds produce positively charged ions when ionized and therefore some handheld IMS trace explosives detectors are capable of measuring both negative and positive ion species. Some instruments with positive ion measurement capability can also detect narcotics, chemical warfare agents, or toxic industrial chemicals, all of which produce positive ions when ionized.

Handheld IMS trace explosives detectors can be successfully operated by non-technical personnel with minimal training. Acquired data generally can be exported via a USB cable or a data card. Advanced users may be able to change instrument settings to optimize the instrument for a particular type of measurement, or interactively analyze sample spectra using the instrument's spectral analysis software. Some instruments can be remotely operated in vapor sampling mode, with analysis results reported wirelessly to a central location.

Most instruments can be operated indefinitely on standard AC power or for several hours on a single set of rechargeable batteries. Some instruments have hot swappable battery packs to allow for more extended operation on battery power.