Mainstreaming Chemical Detection - "a Killer Application?"

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Introduction

A "killer application" creates a paradigm shift in the way users think about and or use it; examples include the PC, Mobile, and Wireless technologies.

In the field of analytical instrumentation, users are faced with the current paradigm that highly specific, high performance, sensitive chemical detection is limited to large, complex, expensive instruments (e.g., mass spectrometers). Conversely, users that require low cost, small, versatile, easy to use instruments are required to utilise instruments that are limited in the number of chemicals that can be detected, prone to false alarms, and exhibit poor specificity.

This poster describes a Miniature Chemical Detector (MCD) that simplifies the science; while at the same time ensuring excellent analytical accuracy. In short, mainstreaming chemical detection in the fields of Security, Industrial, Infrastructure, and Point of Care Diagnostics.

Miniature Mass Spectrometer

The instrument developed by the authors is a small (< 20 l volume, < 8 kg weight) mass spectrometer based on an ion trap architecture. In short, the instrument is capable of:

- 10 – 450 amu mass range (covering most explosives, TICs, and CWAs)
- < 1 amu resolution (FWHM)
- Sample-to-sample time: < 1 second (30 seconds with pre-concentrator)
- Power consumption: < 45 W
- Sensitivity: < 200 ppb VOCs (< 1 ppb with pre-concentrator)

Figure 1 – Photographs of 3 variants of 1st Detect miniature mass spectrometer including bench-top (left), handheld (center), and sub-component (right)
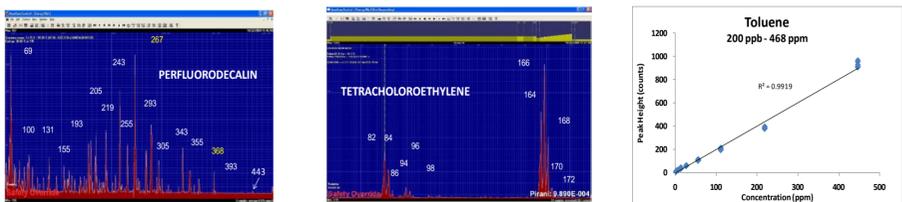

Figure 2 – representative spectra including perflourodecalin (left), tetra-chloroethylene (center), and a calibration for toluene (right) showing linear response over 200 ppb – 468 ppm
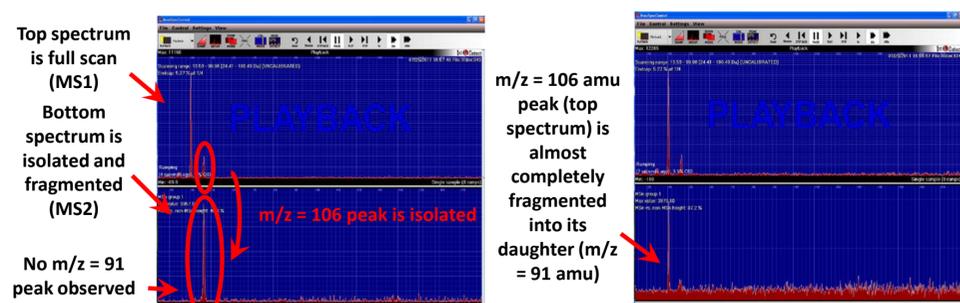

Top spectrum is full scan (MS1)

Bottom spectrum is isolated and fragmented (MS2)

No m/z = 91 peak observed (as expected)

m/z = 106 peak is isolated

m/z = 106 amu peak (top spectrum) is almost completely fragmented into its daughter (m/z = 91 amu)

Figure 3 – Example of MS^n (MS/MS) mode of operation

Purge and Trap

The enable collection of threats agents from non-gaseous media, a novel purge and trap system has been developed.
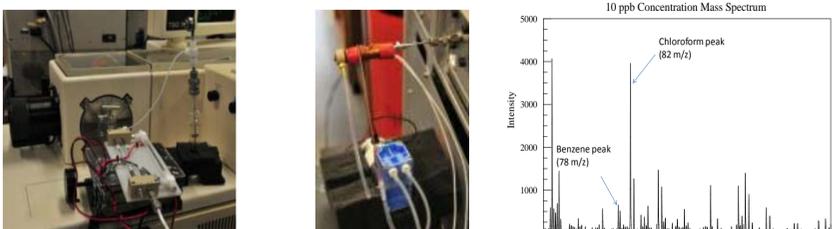

Figure 4 – Photograph (left and center) of water sampler and representative data (right) showing measurement of 10 ppb benzene and chloroform in water

Explosives Sampling

To enable particulate and 'sticky' substances to cross the vacuum barrier into the mass spectrometer, a novel thermal desorption system is being developed. The sample inlet allows collection of explosive particulate using a swipe method similar to those in use today.

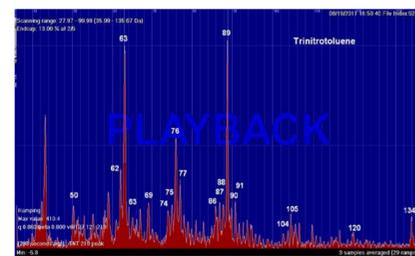Figure 5 – photograph of MCD with evacuated desorber explosives sampler

Figure 6 – mass spectrum of TNT measured on the MCD

Pre-Concentrator

A novel pre-concentrator has been designed that leverages the selective sorptive capabilities of advanced materials with a novel design that significantly reduces the analysis time compared to currently deployed instruments. The novel method of operation yields gains in the range of 10^4. Typical analysis times are less than 30 seconds.
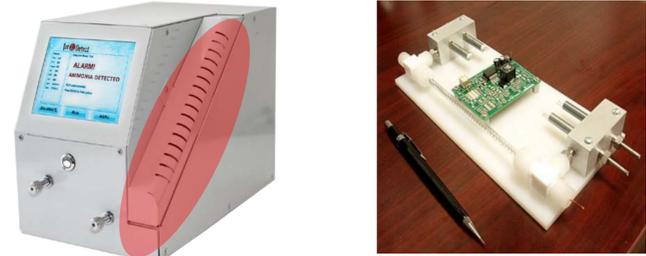

Figure 7 – photograph of pre-concentrator (right) and external location for easy maintenance
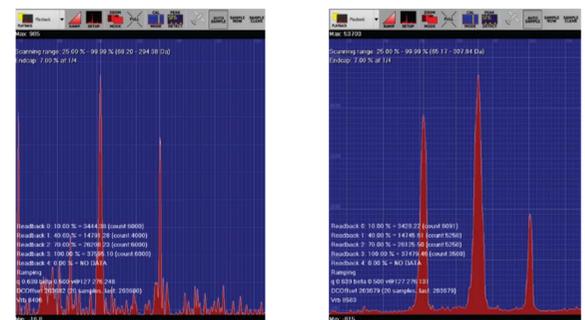

Figure 8 – Low concentration sample showing direct injection (left) and after pre-concentration (right)

Conclusion

The Miniature Chemical Detector (MCD) represents a breakthrough in chemical detection allowing high performance analysis to be deployed in applications where simplicity, ease of use, and low size & cost are critical drivers. By leveraging the specificity of an ion trap mass spectrometer in a small, portable package, laboratory quality analysis can be performed in the locations away from a controlled environment.

Contact Us

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