GUARDION™-7 Hand-Portable Gas Chromatograph-Toroid Ion Trap Mass Spectrometer (GC-TMS): Recent Enhancements and New Applications

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The demand for miniaturized mass spectrometers that are highly selective, sensitive and can make rapid measurements in harsh environments is increasing for a variety of applications. At the 2007 HEMS conference, Torion reported on the development of the world's smallest hand-portable GC-TMS. The instrument features a low thermal mass capillary gas chromatograph (GC) with rapid temperature programming and a miniature toroidal ion trap mass spectrometer (TMS) with a mass range from 45 to 500 Daltons. The configuration of the miniature toroidal ion trap mass spectrometer (TMS) allows more ions to be stored for a given trap radius. The 2 mm r° of this analyzer also allows operation at significantly lower RF voltages than laboratory-scale instruments. The GC-TMS system is totally self-contained with dimensions of 18.5 x 14 x 7 in, weighs less than 28 pounds, is battery operated, and hand-portable. Samples are injected using a novel SPME fiber syringe. The GC-TMS analysis cycle time is 4-5 min, including GC cool down time and data processing. This hand-portable GC-TMS is ideally suited for rapid measurements of chemical agents, explosives, and hazardous substances in harsh environments encountered in field testing.

Since the last HEMS conference several enhancements have been implemented that improve the performance of this miniaturized GC-TMS. For example, a constant mass flow of helium from the GC column improves the mass spectral reproducibility of the TMS. This is because charge exchange between the ionized helium from the GC carrier gas and the separated compounds entering the toroidal ion trap is the primary ionization mechanism. A constant pressure in the TMS results in a more constant collision rate between the helium background gas and ions in the trap, which keeps mass resolution consistent over the analytical run. Constant mass flow during the GC temperature program is now possible with electronic pressure control (EPC) of the helium carrier gas. Better chromatographic performance in terms of chromatographic and mass resolution, as well as improved chromatographic peak shape at higher GC temperatures, has been achieved with EPC.

From the TMS side, a better understanding of the toroidal ion trap technology has resulted in other performance improvements. A major advantage of the toroid over a standard Paul ion trap is that ion storage capacity, before space charge effects become critical, is greatly increased because the ions are stored in a toroidal geometry as opposed to a spherical geometry. Modeling experiments of the TMS system using SIMION and comparison with as-built data have now been completed. Information gleaned from these experiments has led to not only a better understanding of the fundamental operational mechanism of the toroidal ion trap, but also improvements in the traps surface finish, GC interface positioning, and optimization of the mechanical aspects of the entrance lenses and exit slits. Such improvements have extended the operational time between maintenance cycles and improved the instruments mass resolution.