A cart-portable TOF-MS coupled with a thermal desorber for in-field analysis of CBRNE threat materials

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Abstract

A field-deployable mass spectrometer (MS) would provide first responders and law enforcement with a portable tool for rapid and accurate identification of chemical, biological, radiological, nuclear, or explosive (CBRNE) threats. It would provide preliminary field data to both guide the best course of action and focus any subsequent forensics analysis. CNL is developing a cart-portable high-resolution time-of-flight MS (portable TOF-MS) system that can be rapidly deployed for in-field measurements. The equipment consists of a commercial off-the-shelf compact multi-turn TOF-MS weighing 40 kg and housed in a robust shock-absorbing cart with an onboard UPS that allows for hours of self-powered operation. The capability of portable TOF-MS in measurement of gas samples has been tested. Measured Xe, Kr, and Ar isotopic compositions demonstrated its ability to reproducibly detect and quantify isotope ratios of the gas samples in different atmospheric conditions, ranging from indoor laboratory conditions to outdoor field conditions. For liquid samples, dissolved organic compounds were directly introduced into the TOF-MS electron ionization source and successfully detected. However, by introducing analytes in this manner the system suffered from memory effects, clogging and loss of vacuum.

The sample introduction of the system was further modified externally to accommodate more sample types and enable rapid in-field sampling. A commercially available thermal desorber (TD) unit was coupled to the ionization source through a custom transfer-line. The coupling of TD and TOF-MS into a congruent functional TD-TOF-MS system was successful. Using a sample tube, controlled amounts of samples can be loaded into the TD. The sample tube is heated in a flow of carrier gas and desorbed analytes are swept into an electrically cooled focusing trap. The focusing trap is then heated rapidly in a reverse flow of carrier gas to transfer neutral analytes into ionization source. The TD-TOF-MS offers a system that could rapidly evolve analytes from samples followed by field measurements. Current testing of the TD-TOF-MS system with calibration standards and organic samples indicate the system's potential for measurements of an array of sample types, though some materials may need to be derivatized to increase their volatility to allow for desorption. Further optimization in the lab will be followed by field testing campaign of CBRNE samples. The current progress towards development of this field-deployable mass spectrometer will be presented.

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Biography - Bett Kimutai

Bett Kimutai has a background in analytical chemistry and biochemistry. He received his PhD from Wayne State University in 2019. He initially worked as an analytical chemist in a diagnostic and drug testing lab. In 2023, he joined the nuclear response and analysis branch at Canadian Nuclear Laboratories. As part of the nuclear forensics team, he has roles in advancing nuclear forensics

capabilities for investigation of nuclear and radiological materials. Some of his projects develop methodologies for characterization of nuclear and radiological materials using ICP-MS and develop field deployable capabilities for detection of CBRNE using portable TOF-MS.

Keywords

Portable, TOF-MS, Desorption, Field-deployable