A Non-destructive Bulk Currency Detection System (BCDS) for Screening Smuggled Currency | DHS SBIR Phase I: HSHQDC-13-C-00101

Bulk cash smuggling has been a serious issue in recent years. It is estimated that $6–36B flow illegally from the United States and Mexico each year during otherwise legitimate border crossings. A non-destructive bulk currency detection system (BCDS) for screening pedestrians, vehicles and shipping containers will significantly improve border security, protect domestic economics, and deter criminal and terrorist activity. However, such a practical device is not yet available because neither the target detection technique, nor the instrumentation has been defined.

In a DHS SBIR Phase I project, KWJ provided a basis for selecting the optimal analytical/sensing approach for a practical Clandestine bulk Currency Detection System (CCDS). KWJ has surveyed all available and relevant sensing and analytical instrumental approaches for sensing clandestine currency, and identified an optimal path to a monitoring system which uses one or more chemical and physical parameters of concealed bulk US currency bills to detect their presence and interdict cross-border smuggling of money.

Currency Vapor Signature and Emission Rate Characterization

Because of the decided lack of information about the volatiles emanating from currency, KWJ conducted currency emission characterization, with the help of Berkeley Analytical (Richmond, CA), using thermal desorption GC/MS.

From the data, we determined a tentative fingerprint that represents currency. The analysis shows that a likely US currency vapor signature contains a set of aldehydes, furans, and organic acids, at very low concentrations. A successful practical BCDS based on volatiles must be able to accurately identify and quantify a speciated set of trace chemicals from a complex and highly variable matrix. Variations of GC/MS with SPME preconcentration have been identified as promising methods.

KWJ's characterization is the **first report** of emission rates that can be used to model the emission and design a practical analytical approach.
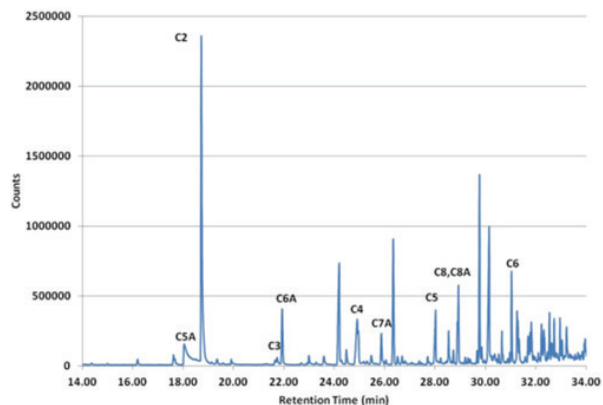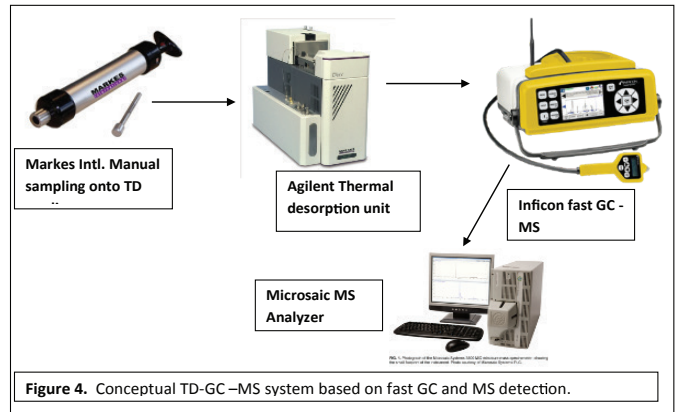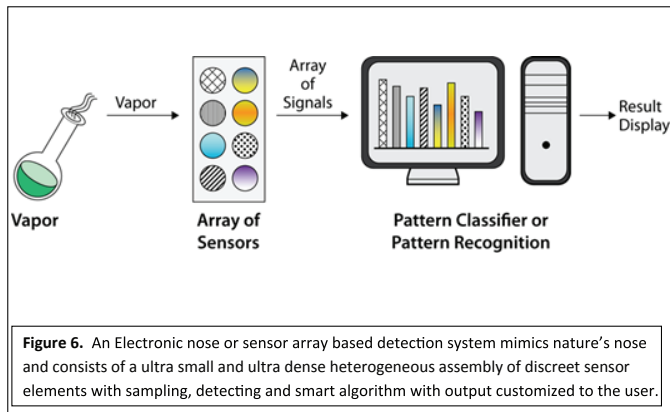

Figure 2. GC-MS (total ion detection) identification of key acids and aldehydes comprising a tentative currency signature. Compounds are denoted by carbon number. 100 $1 bills sampled at room temperature.
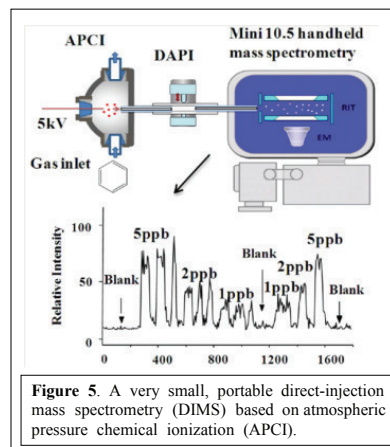
KWJ proposed CCDS for screening smuggled currency

As shown, KWJ conceptualizes a Clandestine Currency Detection System (CCDS) that imitates the trained dog's sniffing function but with none of the drawbacks and has a low cost of ownership [likely to be much less expensive than a dog]. This CCDS contains components that will perform analogous functions of trained dogs sniffing out hidden money, including: a sniffer probe (sampling, pre-concentration), detection system (mass spectrometric sensor array), or an analytical instrument combination with a data analysis component with adaptive cognitive sensing algorithm for interpretation, and communication component with wireless connectivity to make interfaces simple and universal. Compact designs are possible, and the system can be configured for automated operation. The system is without any of the drawbacks of using trained dogs, such as expensive training, sophisticated operators, down time, and communication limitations. As such the new system is designed to provide several new tools to support border interdiction of smuggled currency and can result in improved performance for guards at border crossings.

Figure 6. An Electronic nose or sensor array based detection system mimics nature's nose and consists of a ultra small and ultra dense heterogeneous assembly of discreet sensor elements with sampling, detecting and smart algorithm with output customized to the user.

Figure 4. Conceptual TD-GC –MS system based on fast GC and MS detection.

The envisioned system is based on microextraction (SPME) MS detection and/or standard nonselective detectors (thermal conductivity, photoionization detection, etc.). An example of the types of components envisioned for the system are shown in Figure 4.

Futuristic systems based heterogeneous sensor arrays could be developed based on sensor arrays that can operate similar to the canine nose (Figure 6). However, the E-Nose (1), or "ultra-small and ultra-dense sensing system", will take a longer time to develop.

Figure 5. A very small, portable direct-injection mass spectrometry (DIMS) based on atmospheric pressure chemical ionization (APCI).

The fastest approach is a direct injection MS technique for rapid field screening scenarios. (Figure 5)

1] Joseph R. Stetter, Chapter 1, "Experimental Methods in Chemical Sensor and Sensor Array Evaluation and Development," in"Computational Methods for Sensor Materials Selection,M.A. Ryan, A.V. Shevade, C.J. Taylor, M.L.Homer, M. Blanco, and J. R. Stetter, editors, 2009, pp3-46. DOI 10.1007/978-0-387-73715-7-1