B30 Development of Paper Microfluidic Devices for the Detection of Organic and Inorganic Gunshot Residue

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After attending this presentation, attendees will better understand current research on the development of paper microfluidic devices as a simple and inexpensive alternative to existing presumptive tests for Gunshot Residue (GSR). Minimal training is required to operate these devices and they are ideal for use in the field by military and law enforcement entities. Attendees will also gain a basic understanding of the analysis of lead-based and lead-free ammunition.

This presentation will impact the forensic science community by providing insight into the possibility of inexpensive, user-friendly, presumptive testing devices for GSR.

Colorimetric tests implemented on paper microfluidic devices permits residue from both inorganic and organic GSR to be detected in the field. Paper microfluidic devices are typically prepared from chromatographic paper creating hydrophilic channels through the use of wax printing and lamination at elevated temperatures. Capillary action is then used to mobilize liquids containing dissolved analytes through the wax ink channels of the device. Colorimetric reagents are placed at the terminal end of each channel for detection of the individual analytes. These devices were initially designed for application in medicinal and disease testing in remote areas where the lack of refrigeration limits the ability to store expensive reagents. Because reagents are dried on the device prior to use, shelf lives are increased when compared to liquid reagents. Various forensic applications of this technology have been explored. In this project, a paper microfluidic chip has been developed that involves presumptive, colorimetric tests for multiple different compounds contained in GSRs. Colorimetric tests have been designed for a variety of components in GSR. These tests were first prepared in solution and then optimized for use on paper.

GSR consists of organic and inorganic components that are left behind following the discharge of a firearm. Results are typically detected by atomic spectroscopy, mass spectrometry, or Scanning Electron Microscopy with Energy-Dispersive X-ray Spectroscopy (SEM/EDX) in the laboratory. Paper microfluidic devices have thus been developed for lead, barium, antimony, manganese, and zinc. Lead is detected via potassium iodide as well as through the use of a buffered mixture of sodium rhodizonate, which yields a yellow color and a pink color, respectively, upon reaction. Barium is also detected via the sodium rhodizonate mixture, yielding an orange color upon reaction. Antimony is confirmed via sodium sulfide which yields an orange/brown color upon reaction. Manganese is detected via potassium periodate which yields a brown color upon reaction. Lastly, zinc is detected with dithizone which yields a bright pink/purple color upon reaction. Work is also underway on a similar device to detect organic GSR including organic nitrates, nitrate esters, and diphenylamine.

This device, when optimized for reproducibility, stability, and sensitivity, should prove useful in the analysis of GSR, as the chip is not much larger than a postage stamp and minimal time is needed to produce results. The ultimate goal of the project is to design and test a set of these devices for the presumptive detection of lead-based and lead-free GSR in the field.

Gunshot Residue, Paper Microfluidics, Smokeless Powder