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Use of Inkjet Printing Technology to Produce Test Materials for Trace Explosive Analysis

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With the threat of global terrorism on the rise, the ability to detect trace levels of explosives has become an issue of critical national importance. This is especially true at screening locations such as airports, seaports, embassies, and other government facilities. Although analytical techniques exist to detect quantities of explosives at or below the nanogram (ng) level, most of these methods are not able to handle the high-throughput sampling demands that exist at explosive screening locations [1]. Ion mobility spectrometry (IMS) is an analytical technique that is capable of rapid (≈ 10 seconds) trace level explosive analysis. For this reason, IMS instruments are widely deployed and it is estimated that over ten thousand are currently in use for trace-level explosive screening purposes [2].

Test materials (traps) containing known and reproducible (typically nanogram) quantities of explosives are critical for calibrating IMS instruments and ensuring that they are operating properly at deployment locations. Desired properties of test materials include: high precision and accuracy, a large dynamic range of explosive quantity, and scalability to allow high throughput for rapid and inexpensive production to accommodate the large number of deployed IMS systems. A variety of different explosive test materials are needed to provide flexibility to respond to the large and often changing number of threats. At NIST, we are using drop-on-demand inkjet printing technology to prepare IMS test materials containing PETN, TNT, RDX, C4, ammonium nitrate, and other explosive materials. To prepare these materials, inkjet printer solutions (inks) are made by dissolving crystalline explosives in solvents that allow stable and reproducible inkjet printer operation (isopropyl alcohol, isobutyl alcohol, etc.). Gravimetric techniques are used to determine the concentration of explosive in the ink. Gas chromatography / mass spectrometry (GC/MS) and ultraviolet-visible absorption spectroscopy are used to verify initial explosive concentration of the inks and then monitor solution concentration over time. After the explosive solution concentration is known, the mass of the drops dispensed by the inkjet printer is measured to determine the quantity of explosive deposited onto the traps. Drop mass is determined by printing a known number of drops directly onto a microbalance. After drop mass determination, test materials containing a large range of explosive quantity can be produced simply by varying the number of drops dispensed. Figure 1 shows a sheet of C4 explosive test materials. Here, samples were printed in an array pattern with each point in the array consisting of a burst of 5 drops of printer solution. In Figure 2, an IMS instrument was calibrated using inkjet produced test materials containing RDX quantities ranging from 0.1 ng to 100 ng. Initial testing over a three day time period using an RDX printer solution (64 ng/μL) showed that the inkjet printer had a reproducibility of better than 2 % (1.8 %) for samples produced within the same day, and a day-to-day reproducibility of just under 3% (2.6 %) for the three day testing period.

References

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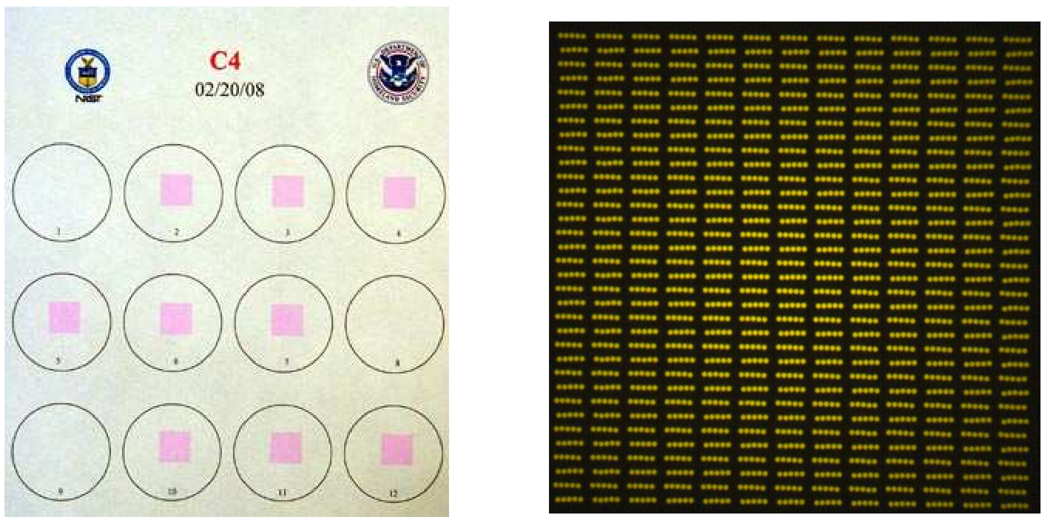
2. G.A. Eiceman and J.A. Stone, *Anal. Chem*., 2004, **76(21),** 390A.



(a) (b)

FIG. 1a. Sheet of inkjet printed explosive samples containing 9 samples with 50 ng of C4 explosive and 3 blanks on a sheet of Whatman 41 filter paper. (b) Enlarged view of a portion of the printed array. Each array location is a burst of 5 drops of inkjet printing solution. Rhodamine dye was added to the printer solution to allow visualization of the printed arrays.

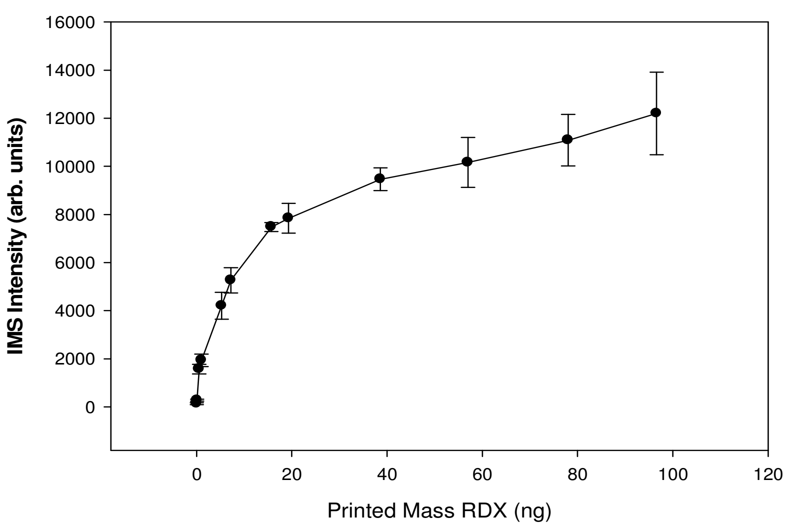


FIG. 2. Calibration of an IMS instrument (Smith's GC IONSCAN 400B) using inkjet generated test materials of RDX. Data points represent the average value of 5 measurements. Uncertainties are the standard deviation of these measurements.