Automated Mapping of Explosives Particles in C-4 Fingerprints

NIST has developed an automated polarized light microscopy procedure to further the technology for detection of trace explosive from fingerprints. Currently, over 10,000 ion mobility spectrometry (IMS)-based explosive trace detectors (ETDs) are deployed at airports worldwide, in addition to the number used by the U.S. military and other federal agencies. The fingerprint is considered one of the primary mechanisms for the transfer of trace amounts of explosives during bomb handling and preparation, and one of the target samples for collection.

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The detection of trace amounts of explosives at airports and other security venues is an important component of counterterrorism efforts. A critical aspect of the deployment of explosive trace detectors (ETDs) is the calibration and testing of those instruments at the relevant threat levels. Critical properties that must be understood about fingerprint samples include the total mass and particle sizes of the explosives. The detection limits of ETDs are based on mass, but the collection of the sample is dependent on particle size.

To further the characterization of trace explosives samples, NIST researchers developed an automated polarized light microscopy (PLM) procedure for counting and sizing explosives particles in fingerprints made from C-4. Both plane polarized light and crossed polarized light are used to produce complete images of the fingerprints, and also the size, shape, and locations of the RDX particles. A series of 50 prints were made at the Transportation Security Laboratory (TSL) from C-4, of which 36 were characterized to determine particle size distributions of the RDX particles. For selected fingerprints, the mass of RDX was determined by two techniques, particle counting and GC μ-ECD (gas chromatography electron capture detection) analysis. The developed methodology can be used to rapidly characterize C-4 fingerprints with relatively little operator input, so that a large number of samples can be evaluated. This will aid in the development of "threat libraries" which can serve to delineate the performance requirements for ETDs. In addition, the analysis is nondestructive and the samples can be used after characterization as test materials for ETDs.

A series of 50 C-4 fingerprints were characterized, and the results show that the transfer of material through fingerprints is quite variable. This suggests that standard test materials cannot be developed simply by controlling the preparation of the fingerprints, and that a method is required for non-destructive analysis after fingerprint generation. Using our PLM method, the particle size distributions and the particle heights measured in the fingerprints can be used to estimate the mass of RDX in the fingerprint. These estimates of mass were found to be generally within ± 60 % relative of the results obtained from GC μ-ECD, which is quite encouraging for a particle counting approach. Our data suggest that the particle diameters to target for improved ETD performance range from 10 μm to 20 μm. These particle sizes are found in sufficient abundance throughout the series of 50 prints, and have sufficient mass for detection purposes.

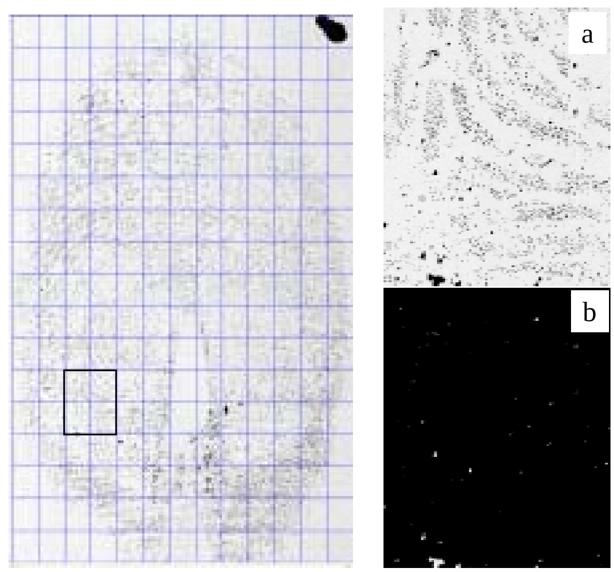

Figure 1. Plane polarized light image of visible fingerprint on left with overlay of grid pattern showing sizes of individual tiles used to collect the image. Selected area marked by bold box is shown in plane polarized light in (a) and crossed polarized light in (b). RDX particles are the birefringent (bright) particles observed in the crossed polarized light image.

The NIST results provide critical information for testing and improving the performance of ETDs, specifically in the development of appropriate test materials. Both ETD manufacturers and agencies responsible for the deployment of the equipment are requesting this information.

NIST efforts to develop test materials are guided by the knowledge of the characteristics of the real samples. This activity will continue in order characterize additional explosive threats (using a list of threats developed by the TSL). We plan to add capability to the method by using a polarized light microscope outfitted with FT-IR detection.