Production of Uniform Test Particle Standards by Ink-Jet Printing

NIST is developing a new technology for rapid screening of high explosives and drugs, since currently there are no standard test particulate materials for calibrating or verifying walk-through Trace Explosive Detection Portals (TEDP). The challenge is making test particles which have the desired composition and size, and that are presented on suitable substrates in known numbers. Particulate test materials with these characteristics are needed for research into the sampling and particle transport efficiencies in these Portal systems, and for removal studies using swipe sampling technologies. The purpose of this effort is to develop a method to produce accurate and precise particle standards of known composition, size and number for testing trace analysis instruments, particle swipe testing and for pharmaceutical and materials research.

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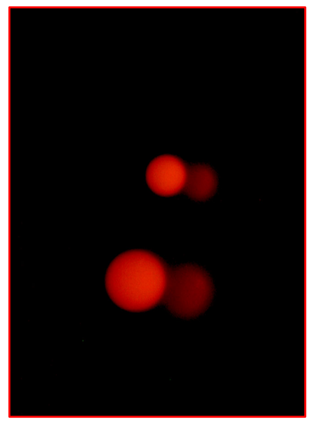
The Ink-jet Particle Printer (IJPP) can produce monodisperse particles from ≈1 µm to 30 µm made by drop-on-demand technology. The solution of the desired particle composition is delivered by the ink-jet printer as well-defined droplets that are subsequently dried in heated air to produce an aerosol particle. Each particle contains the same amount of compound because the drop formation is precise (ejection volume reproducibility <2 %); the particle size and composition is controlled by the solute concentration in solution. The IJPP marries a drop-on-demand printer head made by MicroFab and the heating and aerosol handling column built by J. Bottinger at Edgewood Arsenal. The photograph is of the Ink-Jet Particle printer, along with a fluorescence optical micrograph of rhodamine-SEMTEX particles produced by the IJPP.

The Bottinger column integrates an optical particle sensor to count droplets. Two high explosives, C-4 and SEMTEX, placed in solution and tagged with rhodamine dye, have been made into particulate materials. The optical micrograph shown is of the tagged SEMTEX particles. The number of particles made per second is controlled by the excitation frequency applied to the piezoelectric crystal driving the ink-jet. These particles of known composition are collected on a substrate such as a filter or impacted onto a plate or surface. We are characterizing the properties of these particles by optical, electron, and ion microscopies. Figure 2 shows a high-tilt fluorescence microscopy image of a rhodamine dye aerosol particle. NIST has three TEDP systems to test the utility of these test particles.



Fluorescence micrograph of pure rhodamine spheres produced by the IJPP. The sample is tilted to see the contact surface and the three-dimensional shape.

The operating characteristics and verification of particle-making capabilities using the IJPP has been demonstrated for C4 and SEMTEX high explosives. Using a thermal ink-jet printer, close to 100 % collection efficiency of the particles was demonstrated by the correspondence between optical particle counter results (made at the position of particle production) and microscopy-based counts of the collected particles on filters. The ability to quantitatively collect the particles is critical to production of standard test materials, as the number of particles can be controlled and counted. These particle-filter collections were examined by a commercial explosives detection instrument and gave a positive alarm for the explosive.

The ability to make quantifiable trace explosives particle standard test materials is projected to be very important for the testing and verification of trace detectors. The NIST method will not just verify, but actually quantify the sampling and detection performance.

Future Plans: This research is ramping up in hopes of meeting the need for trace particle detection of high explosives. Additional study will be necessary to completely validate the approach and demonstrate its utility for making relevant test particles.