B158 Assessing the Forensic Utility of Particle Morphometry for the Characterization of Aluminum Powders in Explosives

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After attending this presentation, attendees will better understand the strengths and limitations of morphometry as a method for the characterization and discrimination of aluminum fuels for explosive compositions.

This presentation will impact the forensic science community by discussing this pilot project that is the first published study to demonstrate the application of aluminum particle morphometry as a quantitative method for the characterization of explosives, which may provide valuable prosecutorial evidence as well as lead identification for forensic investigations.

Aluminum (Al) powder is commonly used in the pyrotechnics and explosives industries where it functions to increase the heat of explosion when mixed with other metallic powders, oxidizers, and explosive components.[1,2] The performance of Al powder as a fuel for explosives depends on powder particle shape and grain size.[2] In addition, Al powder is widely used in the illicit manufacture of improvised explosive devices as well as improvised explosives.[3] Detailed protocols for making and acquiring A1 powder are widely available in the "underground" literature and numerous internet web pages.[4,5] Very little technical knowledge and machinery is required for making A1 powders that are of sufficient grade (i.e., particle size range) to be useful for producing explosive mixtures. Owing to the widespread use and the numerous methods for the production of Al powder, there is the potential for significant variability in particle morphology and size distribution. The goal of this research is to investigate the utility of particle morphometry using automated techniques as a metric to discriminate between samples of Al powder.

Approximately 30 samples of Al powders and pastes were acquired from known legitimate manufacturers, several seized explosive devices, and produced in-house from aluminum flake-containing commercial spray paint and by grinding Al foil. Several of the Al powder samples derived from the devices required isolation from the explosive physical mixtures; isolation involved simple water extraction, manual separation, or mild acetic acid digestion (to remove carbonates without digesting the Al particles). Powder samples were subsequently wet-sieved using disposable polyester mesh of nominal sizes 250µm, 100µm, 50µm, and 10µm in order to assess within sample variability of size fractions, as well as to produce microscope slide preparations of consistent thickness for imaging. Transmitted light microscope images of the Al powder particles were acquired; images were subsequently batch-processed using commercial image analysis software and customized code. Dimensional analysis was calibrated using a National Institute of Standards and Technology-traceable stage micrometer; polystyrene spheres of 100µm, 50µm, and 10µm were used as secondary standards to assess linear calibration. Each image was converted to a binary image and pre-filtered using a high-pass filter to enhance edge detection. The following metrics were measured for each particle within each image field of view: area, aspect ratio, perimeter, roundness, mean diameter, radii (maximum and minimum distance from particle centroid to edge), and radius ratio. The large multidimensional datasets were analyzed using commercial and open-source statistical packages. The results from several multivariate statistical methods will be presented.

Preliminary results from this pilot study show that commercially manufactured Al powders (flake and atomized spherical grains) have a significantly narrower particle size distribution than in-house-produced powders. In addition, the spherical nature of the known atomized melt samples allows for rapid recognition of an industrial-scale manufacturer. The results from this research will provide a foundation in which to investigate further the variability that occurs within and between manufactured Al powders over production timescales.

References:

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