Y21 Further Development of Scoring Rules for Sample Comparisons Using Automated Particle Micromorphometry of Aluminum (Al) Powders

Kayla M. Moquin, Quantico, VA 22135; Cami Fuglsby, MS*, South Dakota State University, Brookings, SD 57007; JenaMarie Baldaino, MS, Quantico, VA 22135; Danica Ommen, PhD, Iowa State University, Statistics, Ames, IA 50011; Christopher P. Saunders, PhD, Brookings, SD 57006; Jack Hietpas, PhD, Penn State University, University Park, PA 16802; JoAnn Buscaglia, PhD, FBI Laboratory, Counterterrorism & Forensic Science Research Unit, Quantico, VA 22135*

Learning Overview: After attending this presentation, attendees will better understand various strategies currently being researched for the interpretation and discrimination of forensic explosive evidence associated with Al powders. Attendees will also gain an understanding of how automated microscopical imaging, in combination with various statistical methods, may aid in forensic investigations.

Impact on the Forensic Science Community: This presentation will impact the forensic science community by demonstrating the application of Al particle micromorphometry as a quantitative method for the characterization and comparison of explosive evidence, which may also provide valuable lead information for forensic investigations.

Hypothesis Statement: The use of automated microscopy in combination with various processing and statistical techniques will provide further source discrimination and investigative leads in source identification involving the use of Al powders in Improvised Explosive Devices (IEDs).

IEDs are often composed of commercial or readily available materials. One such material that can be obtained from multiple sources is Al powder; a common metallic fuel, it has many legitimate uses and applications, making it an easily accessible material. Although many of these sources are marketed in powder form, sources not already in powder form can be easily and inexpensively produced via simple methods found online. This circulation of amateur methodologies for the production and usage of Al powder has put dangerous and destructive tools in the hands of homemade bomb makers, creating the need for new and quantitative identification and analysis methods. For this reason, it has become increasingly important to evaluate not only the composition of such devices, but also to analyze and distinguish between various forms of Al powder for additional investigative and intelligence value.

Previous work done on this research project has displayed the ability to differentiate between methods of Al powder manufacturing (i.e., industrial vs. homemade) through the use of various microscopy techniques: automated particle micromorphometric analysis as well as Scanning Electron Microscopy/Energy Dispersive X-Ray Spectroscopy (SEM/EDS). These techniques have shown differentiation in morphology and surface characteristics among these powders. Further, the comparison of similarities and dissimilarities has been statistically scored and evaluated to determine the viability of the method to distinguish between two samples/sources based on 17 characteristics. This presentation aims to build upon previously presented work: the analysis of more Al powder samples has allowed for a more robust data set, and additional statistical approaches have been developed and tested on these high-dimensional, large data sets.

In this work, slides intended for automated imaging were prepped using ~1,000µg of bulk Al powder placed into a microtube containing Permount® mounting medium, then mixed thoroughly to avoid uneven dispersion before a set aliquot (via pipet) was placed dropwise onto a slide with a coverslip firmly set over it. This process was conducted such that for each sample, there were a total of seven subsamples (microtubes) and three aliquots (taken from the same microtube), for a total of 21 coverslips per sample. Once mounted, the Al samples were imaged using a transmitted light microscope fitted with an automated stage and automated z-focus. For each coverslip, 200 images were taken at random Fields Of View (FOV) to statistically characterize the distribution of particles in a subsample. Once imaging was complete for each subsample, the resulting data was batch processed using a commercial image analysis software with customized code to fit the parameters to be measured; the image was converted to a binary image, and particles were then measured and counted for each field of view. Seventeen parameters were measured, accounting for various size and shape characteristics of the particles.

Using various statistical means (various machine learning methods applied to summary statistics of subsamples and score-based methods for measuring the dissimilarity of distributions of particles), empirical tests have thus far shown that the ability of the proposed method to correctly characterize the type of powder based upon the 17 parameters is significant. Further, it has displayed that in most instances of incorrect or misidentification for data attribution to a certain sample, the sample has been misidentified with another sample of the same type (e.g., foil sample A misattributed to foil sample C). Both within-source and between-source score distributions were analyzed statistically to further determine how to improve upon the method; various trials utilizing different portions of data were implemented to determine which factors affected results and how those findings may allow for improvement of the analytical and interpretative methods.

Improvised Explosive Devices, Aluminum Powder, Micromorphometric Analysis