B159 On the Development of Score Rules for the Pairwise Sample Comparison of Particle Micromorphometry of Aluminum (Al) Powders

Danica Ommen, PhD, Iowa State University, Department of Statistics, Ames, IA 50011; JenaMarie Baldaino, MS, Quantico, VA 22135; Cami Fuglsby, MS, Department of Mathematics and Statistics, Brookings, SD 57007; Christopher P. Saunders, PhD*, Brookings, SD 57006; Jack Hietpas, PhD, Pennsylvania State University, University Park, PA 16802; JoAnn Buscaglia, PhD*, FBI Laboratory, CFSRU, Quantico, VA 22135*

Learning Overview: After attending this presentation, attendees will understand various strategies for the interpretation and presentation of the forensic evidence associated with the comparison of samples of aluminum powders with an automated particle micromorphometry and the associated statistical analyses.

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

Starting materials for an Improvised Explosive Device (IED) are readily obtainable from local commercial sources. Aluminum (Al) powder, a common metallic fuel, has a wide variety of legitimate uses and is widely available without significant regulatory constraints.[1] Al powders can be obtained from industrial manufacturers or can be produced inexpensively using basic instructional manuals and videos. Due to the on-line sharing of instructional manuals and published books on how to construct IEDs, bomb makers are now informed on the easily accessible household materials that can be used to make explosive chemical mixtures.[2]

Previous results using scanning electron microscopy with energy-dispersive X-ray spectroscopy (SEM/EDS) showed morphology and surface characteristics can differentiate some methods of Al powder manufacturing (i.e., industrial vs. homemade). Particle micromorphometry may be used as a complementary method to gain additional information to differentiate Al powder sources. This presentation builds on our past results and is focused on the development of efficient scoring rules for measuring the similarity (and dissimilarity) between two samples/sources (sets) of Al powder based on the two distributions of particles.

Al powder samples were obtained from legitimate industrial manufacturers, various amateur production methods, and seized IEDs. The amateur methods were replicated in-house to produce Al powder from easily available sources, including different brands of each of Al foil, metallic spray paints, Al ingots melted from Al cans that had been filed or lathed, pyrotechnics, and catalyst packets from two brands of binary exploding targets. To prepare microscope slides for imaging, a subsample containing ~1,000µg from bulk Al powder was placed into a microtube containing Permount® mounting medium. The solution was mixed until evenly dispersed, then an aliquot of the subsample was placed dropwise onto a microscope slide and a coverslip added. A subset of Al powder samples prepared using seven (7) subsamples and three (3) aliquots for each subsample will be considered in this presentation.

Transmitted light microscope images of the Al samples (with approximately 4,200 fields of view/sample) were acquired using an automated stage and automated Z-focus. Dimensional analysis was calibrated using a National Institute of Standards and Technology (NIST) -traceable stage micrometer; polystyrene spheres of 100µm, 50µ, and 10µm were used as secondary standards to assess linear calibration. Images were batch-processed using commercial image analysis software and customized code. Each image was converted to a binary image to enhance edge detection and the particles were counted and measured. Seventeen (17) parameters were measured for each particle within the image field of view, including various size and shape parameters. The large multidimensional datasets with between 90,000 and 500,000 particles per sample were analyzed using an open source statistical package.

The datasets are too large and complex to analyze with standard statistical methods in an efficient and scalable manner. Current work has focused on developing methods that will compare two sets of particles and summarize the difference in the distribution of particles with each particle characterized by 17 morphometric measurements. The approach is focused on using a set of low dimensional projections where the authors can measure the discrepancy between the two distributions of the projections of particles, then assess the performance of an omnibus score for a given class of projections and a corresponding distributional comparison method by comparing the within source and between source score distributions using receiver operator characteristic (ROC) curves. This results in a gross measure of the performance of the score when used for common but unknown source identification problems that commonly arise in forensic applications, such as with IEDs.

New developments in the interpretation of pairwise comparison procedures for this class of forensic applications will also be presented.

Reference(s):

1. Kosanke, K.L, and Kosanke, B.J. 2007. A Study Evaluating Potential for Various Aluminum Metal Powders to Make Exploding Fireworks. *Pyrotechnics Guild International Bulletin*. No. 154.
2. Larabee, A. 2015. The Wrong Hands: Popular Weapons Manuals and Their Historic Challenges to a Democratic Society. Oxford University Press New York, New York.

Improvised Explosive Devices, Aluminum Powder, Micromorphometry