B63 Trace Chemical Signatures of Calcium Hypochlorite: Implications for the Attribution of Hypergolic Mixtures

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After attending this presentation, attendees will understand the basis of chemical variation among sources of inorganic chlorine-based incendiary mixtures and the potential for this variation to support forensic investigations.

This presentation will impact the forensic science community by introducing a new signature system that can determine the source of unknown chemical residues from a crime scene which may be used to establish investigative leads.

Criminal use of self-igniting, or hypergolic, mixtures is a significant issue for law enforcement and forensic laboratories. Many of the possible reactants are available as inexpensive commercial products and chemical ignition of the mixture is easy to execute. As such, hypergolic reactions have been encountered in a range of illicit activities including arson, person-on-person crime, and deployment of improvised explosive devices. One of the more common recipes involves combining inorganic pool chlorine, specifically calcium hypochlorite, with ethylene glycol-based products (e.g., automotive brake fluid). Despite their prevalence, there remain few techniques that can be used to analyze chemical evidence from hypergolic reactions for the purposes of attribution.

The goal of this research was to investigate variation in trace metal composition across different sources of calcium hypochlorite both as precursor compounds and within the post-reaction residues. Metals are likely to differ across sources owing to differences in synthesis routes, trace mineral additives, and levels of purity. Four different types of calcium hypochlorite, three household commercial products, and one laboratory-grade sample were prepared in nitric acid for analysis with Inductively Coupled Plasma/Optical Emission Spectroscopy (ICP/OES). Small-scale reactions with two grams of hypochlorite and one milliliter of polyethylene glycol were made and the residues also analyzed with ICP/OES. Results showed that each hypochlorite source exhibited distinct variation in the presence and relative abundance of certain elements that was consistent in both pre-and post-reaction residues. For example, aluminum was enriched in one sample group (~40ppm) compared to the other sources which were all less than 7ppm while boron was enriched in another sample group (~2ppm) compared to the other sources which were all below the limit of detection. Strontium concentrations were slightly elevated in the laboratory-grade samples versus two High Test Hypochlorite (HTH) commercial brands by 1-2-ppm. Similarly, concentrations of iron were enriched in two sample sources, in comparison to the other commercial source (~8-9ppm vs ~6ppm). Error rates for all measured elements were less than 0.01ppm.

To enhance signature detection and differentiation among reaction residues, ICP/OES data across all 13 elements examined was analyzed with Discriminant Function Analysis (DFA). Results showed robust separation among all three reaction sample groups along the first two functions. Function coefficients revealed that Aluminum (Al), Chromium (Cr), Copper (Cu), Potassium (K), Nickel (Ni), and Strontium (Sr) contributed the most variation among the groups. These may be promising candidates for stand-alone chemical markers for comparing residue samples. Overall, this work suggests that trace metal variation can be used to differentiate each source of calcium hypochlorite and that multivariate metal profiles may be a useful forensic signature for the attribution of hypergolic mixtures involving this type of reactant.

Hypergolic Mixtures, ICP/OES, Trace Metal Signatures