A185 Forensic Attribution of Matchsticks Using Integrated Analysis With Morphological Examination, Fourier Transform Infrared Spectroscopy (FTIR), Scanning Electron Microscopy-Energy Dispersive X-Ray Spectroscopy (SEM-EDS), and Inductively Coupled Plasma-Mass Spectrometry (ICP-MS)

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After this presentation, attendees will be able to recognize the unique physical and chemical features present in match heads with different functions and match heads with the same function but originating from different manufacturers; also learning how these features can be incorporated into a multivariate signature that can be used to identify the specific type and commercial brand of an unknown match.

This presentation will impact the forensic science community by introducing a scientifically and statistically robust analytical scheme for collecting forensically relevant information from question matchsticks. Such forensic signatures can provide investigative leads in criminal cases and better illustrate the association between question and known matches to a jury.

Because matches are designed for quick fire starting, they are quite amenable to criminal activity and are often encountered in arson and bombing cases. Different functional types of matches display physical and chemical differences in both burned and unburned match heads that are specific to that match type. Furthermore, previous research has shown that there are chemical features in match heads that are not shared by matches from different brands; however, no project before this has attempted to combine the physical and chemical characteristics of both spent and unspent match heads in order to create multivariate signatures to be used for functional and commercial brand classifications.

There are three main functional classes of matchsticks: safety, strike-anywhere, and waterproof. Safety matches are the most pervasive and widely used type of match. They often find use in kitchens, places of worship, and most other instances where safe fire starting is required. The components for igniting these matches are separated into a match head and a specially designed striking surface. In contrast, strike-anywhere matches are not common and are generally used by outdoor enthusiasts as a reliable method for starting fire. They have all ignition components in the match head and can be lit on any suitably rough surface. Waterproof matches are safety matches (can only be lit when struck on a specially designed surface) that have been coated with a water-resistant, yet flammable, polymer binder. Like strike-anywhere matches, waterproof matches are used as outdoor survival tools by campers, hikers, and even the military.

For this project, four brands of safety, two brands of strike-anywhere, and four brands of waterproof matches were used. Safety match brands included: Diamond™ Strike On Box, Diamond™ Deluxe Matchbooks, Industrial Revolution/UCO Long-Burn, and HomArt® Fancy Fish Superior Quality. Diamond™ and Redbird were the strike-anywhere match brands, and Coleman®, REI® Stormproof, Proforce Equipment, and Coghlan were the brands of waterproof match. Matches were analyzed using an analytical scheme of stereomicroscopy for documenting visual characteristics, Fourier Transform Infrared Spectroscopy (FTIR) to identify any binder coating present, scanning electron Microscopy-Energy Dispersive X-ray Spectroscopy (SEM-EDS) to determine elemental composition, and Inductively Coupled Plasma-Mass Spectrometry (ICP-MS) to measure multi-elemental concentration profiles.

Results showed that matches do have distinct physical characteristics that are unique for particular commercial brands and types. Match head color, texture, structure, and metrics were particularly excellent markers for indicating a match's functionality and commercial brand. Chemical analyses revealed that different commercial brands of waterproof match have different polymer binders including nitrocellulose (Coleman® and Coghlan), alkyd (REI Stromproof), and shellac (Proforce Equipment). No polymer binder was identified in safety or strike-anywhere matches. Elemental composition was found to be similar among all match types and brands with the majority of the samples containing silicon, potassium, chlorine, magnesium, titanium, iron, zinc, chromium, lead, thorium, and uranium. However, concentrations vary significantly between brands. For example, average ^{70}Zn concentration was 247.7ng·mL^{-1} and 60.2ng·mL^{-1} in Diamond and Redbird strike-anywhere matches respectively. Similar differences were seen for ^{24}Mg, ^{57}Fe, Pb (all isotopes), ^{232}Th, and ^{238}U. Principal component analysis (PCA) and hierarchical clustering analysis (HCA) performed on the multivariate data set produced distinct clades for waterproof match brands, while safety and strike-anywhere match brands were distributed throughout the cladogram. Taken together, these results indicate that robust signatures exist for functional classes of matchsticks and individual commercial brands. Implementation of this analytical scheme with multivariate statistical analysis will increase the evidential value of question matches providing leads for investigators and strengthening conclusions of consistency between question and known evidence.

Matchstick Typing, ICP-MS, Multivariate

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