B23 The Development of a Rule-Based Protocol for Evaluating Fire Debris Using Known Ground Truth Samples and a Best Factors Algorithm

Taylor A. Wood, National Center of Forensic Science, Orlando, FL 32826; Mary R. Williams, MS, National Center for Forensic Science, Orlando, FL 32816-2367; Michael E. Sigman, PhD, University of Central Florida, Orlando, FL 32816*

Learning Overview: After attending this presentation, attendees will understand how the development of a dataset of known ground truth samples can assist in developing a rule-based classification model. The use of a genetic algorithm to choose an optimal set of factors for the rule-based model will also be demonstrated.

Impact on the Forensic Science Community: This presentation will impact the forensic science community by demonstrating the production of a decision tree model based on laboratory practices in fire debris analysis.

ASTM E1618-14 is the standard test method for fire debris analysis used by most fire debris analysts in the classification of neat ignitable liquids but is limited in the assistance it provides for detecting limited amounts of ignitable liquids relative to substrate pyrolysis products. Common practice is to examine total ion chromatogram (TIC) and extracted ion profiles (EIPs) for an ignitable liquid pattern, such as a distillate or gasoline pattern. However, the detection of a weak pattern attributable to ignitable liquid residue becomes difficult with substantial background from the pyrolysis product.[1] In this study, samples with known ground truth (i.e., the presence or absence of residues from an ignitable liquid from a specified ASTM E1618 class), were created in a known and controlled ratio of ignitable liquid to substrate. The known ground truth samples assist in the development and validation of rule-based and decision tree classification methods. The ratio of ignitable liquid to substrate was varied to provide a set of casework relevant samples. Each known ground truth sample was prepared from a single, weathered, ignitable liquid and single or multiple substrates. Known ground truth samples were classified as "IL" (containing ignitable liquid residue) or "SUB" (containing only substrate pyrolysis products). Limiting the problem to determination of two classes facilitates development of a dichotomous classification model that addresses the most forensically-significant question: does the sample contain ignitable liquid residue?

This research will outline how the method uses a genetic algorithm to choose the best factors to incorporate into the model. The best factors were chosen from a set of ASTM E1618 Table 2 ions. ASTM E1618 Table 2 lists the most common ions present in ignitable liquids and limited substrates. Many of these ions are used when constructing EIPs for the classification of ignitable liquids in the Ignitable Liquids Reference Collection Database and for identifying ignitable liquid patterns in the Substrate Database.[1-3] The genetic algorithm chose the best factors by minimizing the quantity 1-AUC, defined as the area under a receiver operating characteristic (ROC) curve that was generated by cross validating a decision tree model based on a select set of ions. This presentation will focus on models based upon a C 5.0 decision tree and the associated rules derived from the model. The use of the validated model will be demonstrated by evaluating large-scale burn data.[4-7]

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Fire Debris, Ground Truth, Rule-Based Methods