B76 Probabilistic Assertions in Fire Debris Analysis Based on Chemical Compound Occurrence

Michael E. Sigman, PhD, University of Central Florida, National Center for Forensic Science, PO Box 162367, Orlando, FL 32816; Mary R. Williams, MS, National Center for Forensic Science, PO Box 162367, Orlando, FL 32816-2367; and Alysaa Allen, National Center for Forensic Science, 12354 Research Parkway, #225, Orlando, FL 32826*

After attending this presentation, attendees will better understand one way to arrive at a probabilistic assertion regarding the presence or absence of ignitable liquid residue in fire debris based on knowledge of the frequency of occurrence of chemical compounds.

This presentation will impact the forensic science community by providing information that can assist in the development of statistical methods in trace analysis.

Ignitable liquids are often complex mixtures of many different chemical compounds. Similarly, the pyrolysis and partial combustion of common household furnishings and building materials often produce many different chemical compounds. The frequency of occurrence of 255 compounds has been determined in the Ignitable Liquids Reference Collection (ILRC) and the Substrate Database.[1,2] An analysis of the compounds in both databases demonstrates that some of the compounds are only observed in ignitable liquids, some are only observed in substrate pyrolysis samples, and some are observed in both types of samples. Failure to see a compound in ignitable liquids or in substrate pyrolysis does not mean that it will never be observed in these sample types. It is possible to estimate the frequency of occurrence in a population for compounds that were not seen in a sample of the population.[3] The approach of Good and Turing uses the maximum likelihood approximation for compounds that occur frequently and an approximation for the frequency of occurrence of compounds that are observed rarely or unseen in a sample.[3] This approach has, for the first time, allowed the determination of the frequency of occurrence of 255 compounds in ignitable liquids and substrates.

The frequencies of occurrence can then be used to classify a sample as positive or negative for ignitable liquid residue. It is also possible to calculate a likelihood ratio for a fire debris sample being positive or negative for ignitable liquid residue. Both of these calculations rely on the identification of a subset of the 255 compounds in a fire debris sample, the frequencies of occurrence of those compounds, and the naïve Bayes approximation. The naïve Bayes approximation assumes independence of the frequencies of occurrence of the 255 compounds. The naïve Bayes assumption is often not true, as is the case here; however, models based on the assumption often work very well. Analysis of 129 fire debris samples from large-scale test burns were performed. The results allow the calculation of likelihood ratios and the subsequent formulation of probabilistic assertions regarding the presence of ignitable liquid residue in each sample. The results will be discussed and evaluated using conventional methods, such as Receiver Operator Curves (ROCs) and Tippett plots. This method will be compared to previously published methods based on the total ion spectrum.[4]

This work was supported by the National Institute of Justice, Office of Justice Programs. The content of this publication does not necessarily reflect the position or the policy of the Government and no official endorsement should be inferred. Support is also acknowledged from the University of Central Florida, National Center for Forensic Science, a State of Florida Type II Research Center.

Reference(s):

1. The Ignitable Liquids Reference Collection Database can be found at the universal resource locator. Available from: http://ilrc.ucf.edu.
2. The Substrate Database can be found at the universal resource locator. Available from http://ilrc.ucf.edu/substrate/.
3. Gale W.A., Sampson G. Good-Turing Frequency Estimation Without Tears. *Journal of Quantitative Linguistics.* 1995, vol. 2, pp. 217 – 37.
4. Sigman M.E., Williams M.R. Assessing Evidentiary Value in Fire Debris Analysis by Chemometric Approaches. *Forensic Sci. International.* (2016) 264, 113 – 121.

Fire Debris, Naïve Bayes, Likelihood Ratio