B175 A Forensic Sample Comparison of Heroin by the Analysis of Its Elemental Composition

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Learning Overview: After attending this presentation, attendees will understand the methods of sample preparation, instrumental analysis and statistical tools required to perform forensic comparisons of heroin evidence. The goal is to provide a simple means of associating related samples of drugs, as well as discriminating between unrelated samples on the basis of the trace elemental profiles in the evidence.

Impact on the Forensic Science Community: This presentation will impact the forensic science community by providing a means to chemically associate two or more pieces of drug evidence, making possible the establishment of evidence linkages on a micro-scale between a user and a dealer or on the macro-scale between a trafficker and producer.

The goal of this research was to aid in the fight against the heroin and opioid epidemic by developing new methodology for performing forensic sample comparisons of seized heroin evidence. Quantitative elemental data from 120 samples, 30 from each of the four major heroin-producing regions in world (Mexico, South America, Southeast Asia and Southwest Asia), were compared to assess the rate of discrimination (5400 total comparisons).

Forensic sample comparison of illegal drug evidence can be used to associate samples of drug taken at different points of seizure. The development and performance of a statistical means of conducting pair-wise comparisons of heroin samples based on their elemental compositions will be discussed during this presentation. A profile of 11 isotopes, ^{23}Na, ^{24}Mg, ^{27}Al, ^{51}V, ^{52}Cr, ^{55}Mn, ^{66}Zn, ^{88}Sr, ^{90}Zr, ^{111}Cd and ^{137}Ba was determined to be most useful in correctly associating as well as discriminating between heroin samples in forensic pairwise comparisons. Heroin samples, provided by the U.S. Drug Enforcement Administration Special Testing and Research Laboratory, were prepared by microwave-assisted acid digestion and quantitatively analyzed by inductively coupled plasma-mass spectrometry to measure the elemental abundance within each sample. Both the instrumentation and skills required to perform the analysis are readily available or within the budgetary capacity of full-service crime labs.

Using a match criterion of ±3 standard deviations about the mean, only 14 of the 5,400 possible comparison pairs were not discriminated, resulting in a discrimination rate of 99.7%. For determining the rate of correct associations, three replicates of 24 duplicate samples were prepared and analyzed on separate days. Only one of the 24 correct pairs were not associated, resulting in a correct association rate of 95.8%. Type 1 error rates (false exclusion) were found to be 4.2% and type 2 error (false inclusion) rates were 0.03%.

Furthermore, a set of unknown samples suspected of having commonality were compared to test the performance of the method with simulated casework samples. Several of the unknown samples were found to be indistinguishable. Sample to sample similarity in the set of unknown samples was also demonstrated with unsupervised multivariate statistical analysis. This is the first known work to report a method for performing pair-wise forensic sample comparison of heroin by targeting elemental impurities. It is also the first to use authentic heroin samples to develop and test the method and report error rates using a large test set. The availability of a method in which samples can be prepared, analyzed, and compared in less than 24 hours with no necessary chemical derivatizations nor separations is expected to be of great use to forensic drug chemists.

Following this presentation, the audience will be informed of the methods of sample preparation, instrumental analysis and statistical analysis for performing forensic sample comparisons of heroin evidence. In addition, the methods for sample preparation and analysis have been validated for both heroin and SRM NIST 1570a, trace elements in spinach leaves. This suggests that the method of performing sample comparisons is amenable to other small molecule drugs as well as vegetable material, both of which are commonly analyzed by forensic drug chemists.

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Forensic Comparison, Heroin Evidence, Trace Elements