J15 Examination of Blue Gel Inks

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After attending this presentation, attendees will understand the composition of blue gel inks and become aware of the best combination of analytical methods to be used to identify the brand of blue gel pen used to create a handwritten text.

This presentation will impact the forensic science community by highlighting the problems faced by conventional methods of ink analysis (such as solubility and thin-layer chromatography) in analyzing blue gel inks and by demonstrating that brand identification of blue gel inks can be accomplished using a combination of analytical techniques.

The ability to identify a specific brand and/or batch of writing ink based on its physical and chemical properties has allowed questioned document examiners to gather a wealth of forensically useful information. For example, it may be possible to determine the earliest date of creation of a document (which may conflict with the alleged date of creation). It may also be possible to detect additions to or alterations of document by demonstrating the presence of differing ink characteristics. For many years, forensic document examiners have relied on simple tests such as the solubility of inks in different solvents, appearance of inked writings under different illuminants and the separation of dyes in thin-layer chromatography. These low-technology tests sufficed for fountain pen inks, ball pen inks and fiber-tip pen inks. However, the introduction of gel inks has required forensic document examiners to add more sophisticated (and expensive) analytical tools to their repertoires. Gel ink pens, which were patented in 1984, are environmentally friendly: organic solvents are not used in the ink formulations. Because the colorants in these pens are comprised either wholly or partly of pigments, gel pens produce writing of archival quality. The presence of pigments in these inks makes thin-layer chromatography less useful as a tool for differentiating brands of gel inks. Gel pen inks are also available in a wide range of colors and produce smoother writing than other pen inks. The qualities of gel ink make gel ink pens very marketable items, whose popularity can only be expected to grow.

In this research, thin-layer chromatography (TLC), scanning electron microscopy (SEM), visible-near infrared (VIS-NIR) reflectance spectrophotometry, and gas chromatography-mass spectrometry (GCMS) were used to analyze sixty-four blue gel ink samples. The sixty-four blue gel ink samples represented ten brands of blue gel ink pens. The blue gel pens were purchased in packs of four or more pens (as the pens are normally sold in office supply stores) and each pen in each pack was used to create a 'scribble sheet' on filter paper. The "scribble sheets" were used in all of the analyses. The VIS-NIR reflectance and GCMS data were subjected to k-means cluster analysis, principal component analysis (PCA), and hierarchical cluster analysis. The factors extracted by PCA were used to construct discriminant functions that could be used to assign writing made with blue gel pens to particular brands. The VIS-NIR reflectance measurements produced five distinct clusters of gel pens. Of the five, three were comprised of only one ink, one cluster contained two ink brands and the largest cluster contained five ink brands. When the gas chromatograms and mass spectra (GC-MS) of the samples were compared visually, the ten different brands of blue gel pens could be broken down into seven groups, depending on the presence or absence of particular peaks in the gas chromatograms. When GC-MS data were analyzed by PCA three clusters of inks were identified. However, only one cluster was comprised of a single ink brand. The additional clusters analyzed were comprised of five and four samples, respectively. The discrepancy between visual assessment of the gas chromatograms and PCA illustrates a limitation of PCA as tool for data reduction. Further analysis of the data determined that GC-MS and VIS-NIR reflectance measurements could be successfully combined to differentiate among brands of blue gel ink. Furthermore, the discriminant functions produced from the VIS- NIR reflectance data and the GCMS data can be used to assign an unknown ink sample to its correct brand. When VIS-NIR reflectance spectrophotometry, GC-MS, TLC, and SEM were used together, all ten blue gel ink brands could be successfully differentiated. Future research will focus on adding to the brands of blue gel pens and on assessing the effect of storage conditions on the gel ink samples.

Gel Pens, Spectrophotometry, GCMS

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