B55 Data Fusion From Spectroscopic Techniques for the Discrimination of Colored Automotive Paint Mixtures

Morgan N. Carpenter, BS, Sam Houston State University, Huntsville, TX 77340; Patrick Buzzini, PhD, Sam Houston State University, Huntsville, TX 77340*

Learning Overview: After attending this presentation, attendees will be better informed regarding the importance of how to combine analytical data from two different spectroscopic methods when applied in the context of automotive paint examinations.

Impact on the Forensic Science Community: This presentation will impact the forensic science community, in particular trace evidence examiners, by exploring the potential to properly carry out data fusion to obtain data sets of discriminating features in light of addressing interpretive aspects (i.e., source attribution questions) following comparative examinations of paint specimens.

Paint evidence examinations are conducted following an analytical sequence that typically starts with microscopical examinations, followed by methods of instrumental analysis. While comparing sets of questioned and reference items, data obtained from the various techniques are usually evaluated sequentially, in the sense that when differences are noted between compared sets, there is no need to proceed with further testing. In cases in which the forensic scientist cannot differentiate the compared sets, a subsequent method of the adopted sequence is applied. When the compared sets are indistinguishable at the end of the chosen sequence, an overall evaluation of the data is made to address the question of a common source. The rarity factor of the different features measured with the various methods in a population of interest is of utmost importance to address the "source" question: estimating the chances to observe another coated object in the relevant population that exhibits the same properties as those observed within the questioned specimens as a function, for example, the observed microscopic features *and* infrared profile *and* elemental profile. The present study focuses on the method of combining data obtained from different techniques, where the measured features are typically known to be dependent. The confined scope of this study is to investigate whether the method of combining data from two analytical techniques may affect the outcomes of data analysis for grouping or classification purposes. The way to combine data from different methods is considered critical. These measurements are not carried out on the same area of the specimen simultaneously; hence, it is hypothesized that this process has a greater variability than if measurements using multiple methods would be collected simultaneously.

Automotive repair paint samples collected from auto body shops were mixed at known proportions. Three sets of mixtures were created from the following pairs of base colors: yellow and blue; yellow and red; and blue and green. Proportions at 70%:30%, 50%:50%, and 30%:70% by weight were prepared. Reflectance visible Microspectrophotometry (MSP) (spectral range 400–700nm) and micro Raman spectroscopy using a near-infrared laser source at 785nm (spectral range 2,000–250cm^{-1}) were used. Seven replicates of the base color paint and the three mixtures were collected for both techniques. These two methods were selected because of the assumed dependencies between the collected data since both techniques inform about the colorant components. Raman spectroscopy allowed identifying the monoclinic polymorph of bismuth vanadate (BiVO4) or C.I. Pigment Yellow 184 for the yellow base paint, the blue phthalocyanine or C.I. Pigment Blue 15 for the blue base paint, the green phthalocyanine or C.I. Pigment Green 36 for the green base paint, and the Diketo-Pyrrolo-Pyrrol (DPP) or C.I. Pigment Red 254 for the red base paint. The classic data analysis procedure of Principal Components Analysis (PCA) followed by Linear Discriminant Analysis (LDA) was used. LDA was conducted on a derived data set consisting of the three principal components that cover about 95% of the total variance of each data set. Data analysis was carried out on the MSP data set, the Raman data set, and a combination of data from these two methods when measurements 1 to *m* of sample 1 to *n* using MSP are combined sequentially side-by-side with measurements 1 to *m* of sample 1 to *n* using Raman. Four additional data sets were created by randomly pairing MSP and Raman data. For LDA, the data sets were randomly split in training sets of four samples and in testing sets of the three remaining samples.

Overall, the accuracies of the PCA-LDA models vary between the side-by-side combinations and those obtained randomly. Low accuracy values were observed; MSP was not sensitive to the color nuances resulting from mixing the paint components, and the pigments detected using Raman underwent known selective resonance effects that would enhance Raman bands from one particular pigment, irrespective of the mixed proportions.

Trace Evidence, Automotive Paint, Data Fusion

*Presenting Author