Assessing the Individual And Joint Use of UV-Vis Microspectrophotometry and Scanning Electron Microscopy/Energy Dispersive Spectroscopy to the Differentiation of Colored Spray Paint

Morgan Carpenter, B.S.*, Jared Estevanes, B.S., Patrick Buzzini, Ph.D.

Department of Forensic Science, Sam Houston State University, Huntsville, TX 77340

MEMBER THE TEXAS STATE UNIVERSITY SYSTEM

INTRODUCTION

Color analysis is a crucial first step in forensic paint examination due to the majority of evidence collected involving the colored basecoat layer. UV-Visible microspectrophotometry (UV-Vis MSP) and scanning electron microscopy/energy dispersive spectroscopy (SEM/EDS) are the two most common instruments encountered in forensic laboratories for color comparison and to potentially identify pigments respectively.

Three standard guides pertaining to the forensic examination of paint are available:

- ASTM E1610: Standard Guide for Forensic Paint Analysis and Comparison[1]
- ASTM E2808-21a: Standard Guide for Microspectrophotometry in Forensic Paint Analysis[2]
- ASTM E2809-22: Standard Guide for Using Scanning Electron Microscopy/Energy Dispersive X-Ray Spectroscopy (SEM/EDS) in Forensic Polymer Examination[3]

While these standards address in detail many technical aspects such as sample preparation and instrumental set-up, information related to the assessment of the value of the detected features is minimal.

Hence, this project aimed assessing the potential redundancy obtained during the joint use of UV-Vis MSP and SEM-EDS.

MATERIALS & METHODS

Samples:

- Spray paints from Ace, Behr, Colorshot, and Rust Oleum and a Standox Standohyd automotive basecoat refinishing paint of 5 colors blue, black, gray/silver, red, and white.

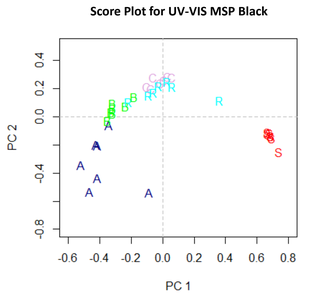
Analytical methods:

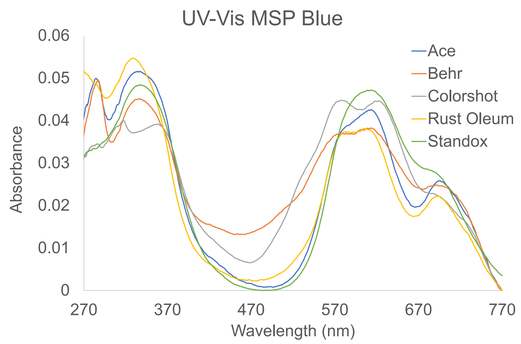
- CRAIC FLEX UV-Vis MSP (270–770nm) in transmittance mode.
- Hitachi SU3500S SEM/EDS coupled to a Bruker XFlash 6|30 X-ray detector.
- Seven replicates were taken at random points on each sample.

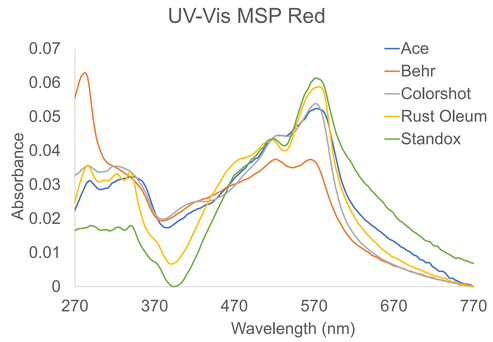
Data analysis:

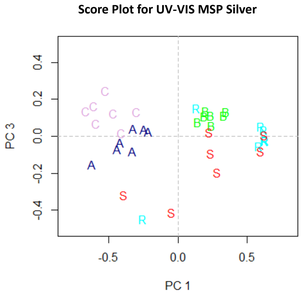
- Datasets were created based on color blocks.
- All spectra were baselined and normalized.
- Principal component analysis (PCA) was used as a data reduction method to observe possible groupings.
- PCA was computed and plotted using R Statistical software[4] with the integrated MASS package[5].

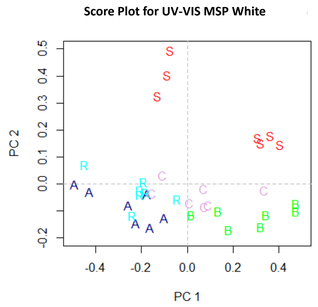
RESULTS & DISCUSSION

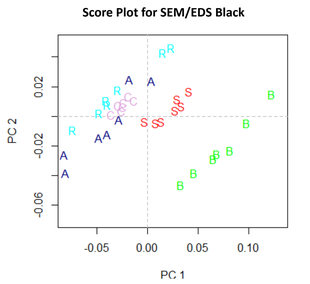


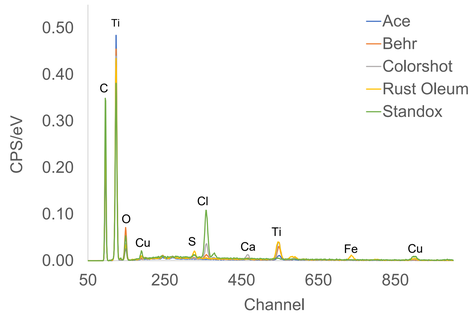


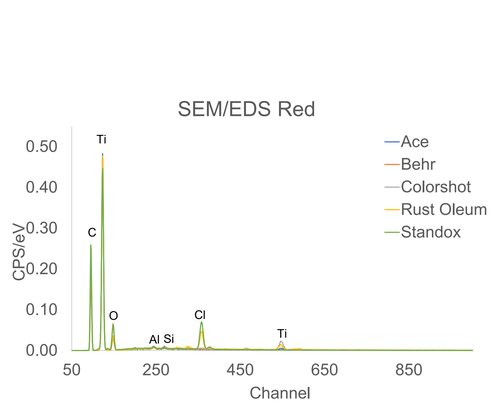


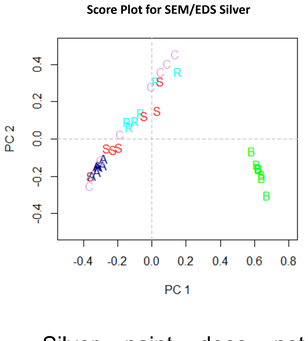


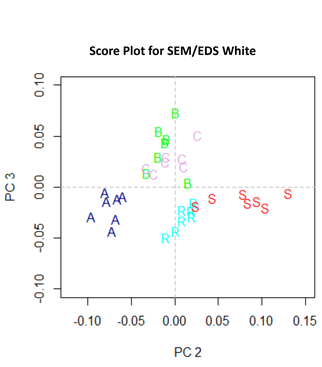


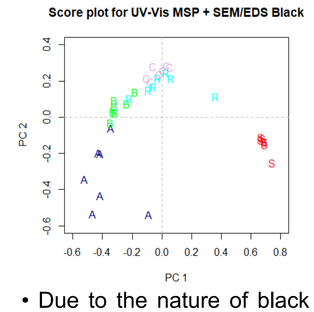


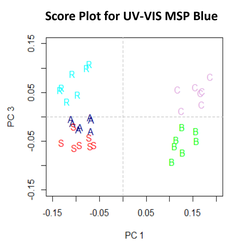


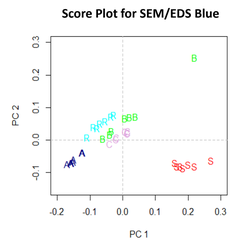












- Due to the nature of black paint, the joint use of UV-Vis MSP and SEM/EDS helps with differentiation.
- SEM-EDS primarily detects carbon black and other extenders which are already detectable using FTIR.

- While both UV-Vis MSP and SEM/EDS yield differentiating information, it is recommended that SEM/EDS be the first step of analysis due to the information on both pigment composition and extenders information.

- Based on qualitative assessment, UV-VIS MSP offers differentiating spectra while SEM/EDS produces the same elemental profile for each of the red samples analyzed. Although more prep work is needed for UV-Vis MSP, there is more benefit of only utilizing this analytical technique when applicable.

- Silver paint does not produce useful results from UV-Vis MSP nor SEM/EDS. The exception is when it comes to varying metallic flakes. SEM/EDS has the benefit over UV-Vis MSP in being able to characterize what metal is present. If it is a non-metallic sample, the results could differ (e.g., chromium instead of aluminum).

- Neither UV-Vis MSP nor SEM/EDS produce valuable information for white samples.
- FTIR spectroscopy, Py-GC-MS or Raman spectroscopy appear more promising.

CONCLUSIONS

- Based on the color of the sample, the varying contributions of UV-Vis MSP and SEM/EDS may not be the most suitable methods to detect selective features in paint formulations.
- SEM/EDS has the large disadvantage of the analyst having to infer the chemical components of both the extenders and pigments present.
- The use of FITR and Raman spectroscopy is needed for the reliable formal identification of paint components.

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