Forensic application of micro-XRF: from bulk to image analysis.

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X-Ray Fluorescence spectroscopy is a powerful tool for identifying substances and confirming their identity with no sample preparation. The Energy Dispersive X-ray Fluorescence analytical microscope (micro-EDXRF) enables the recording of not only the spectra of tiny particles (as small as 10 microns) but also of a hyperspectral image of any object. A hyperspectral image is a data set containing the spectrum for each pixel in the image of an object. Therefore, the data can be analyzed for unsuspected features after they were collected. Chemometric tools such as Principal Component Analysis (PCA), Classical Least Square Analysis (CLS), and Multi Curve Resolution (MCR) can produce chemical distributions of elements and phases in the materials. The bulk analysis helps identify the make, the model, and the year of a car, based on the analysis of auto paint and composition of window glass. However, imaging technology allows one to identify the counterfeit products based on the analysis of the entire hyperspectral image of objects.

X-ray Fluorescence analytical microscope XGT-9000 was used in this study. The instrument equipped with 50W Rh X-ray source, three fully automated spot sizes (10 microns, 100 microns, and 1.2 mm). A sample can be measured in full vacuum, a partial vacuum, and under ambient conditions.

The profile of multi-layer auto paint was measured using 10-microns X-ray spot size. Patterns of different elements in the multi-layered structure allow one to identify the vehicle. The spectra of small particles of glasses from several car manufacturers were collected in the energy range of 1-15 kV. The PCA model was created based on already known samples and applied to a currently unknown glass particle. The score plot shows the discrimination of the composition of an unknown glass particle from the known materials. It was found that the fillers of authentic and counterfeit pharmaceutical tablets are different. Image analysis of the tablets provides direct evidence of fake products, even though the concentration of Active Pharmaceutical Ingredient (API) is almost the same. Chemical images of several elements of "Fifteen Shillings, N 937, 1773" show the authenticity of two signatures on the banknote. The results of the image analysis will be presented.