X-ray Fluorescence and Raman spectroscopy data fusion for analysis of duct tapes: intra roll and inter product correlations.

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X-Ray Fluorescence (XRF) and Raman spectroscopies are useful tools for recognizing substances and confirming their identity with little or no sample preparation. XRF provides information about elemental composition of the material, whereas Raman spectroscopy offers molecular information. Both techniques record spectra of small particles, hyper-spectral images, and collect average spectrum over specific area. Data fusion is the process of integrating two or more data sources to produce results that are more consistent and accurate than the ones provided by any individual data source. The analyses of micro-XRF and Raman data of duct tapes allow one to identify the source of the duct tape or the vendor of the product.

X-ray fluorescence and Raman analytical microscopes were used in this study. X-ray fluorescence spectra of the materials were collected using XGT-7200V equipped with 50 W air-cooled X-ray generator (Rh) X-Ray fluorescence microscope. The Acquisition conditions were as follows: 1) 30 keV acceleration voltage; 2) X-ray spot size of 1.2 mm; and 3) 100 s per point. XRF analysis was performed in the range of 1.00-40.96 keV. There are no spectral features found in the energy range above 15 keV. Spectra were truncated and analyzed in spectral range of 1.00—15 keV. Raman spectra were collected using LabRam Evolution equipped with 1800 gr/mm, TE cooled CCD (Synapse), and 632.8 nm (He-Ne) laser. Small pieces of glue from the tapes were collected and Raman spectra of this material were measured in the range of 100-3500 cm^{-1}. Seven different commercially available duct tapes were used as the samples.

The spectra of duct tapes from different sources were collected and analyzed by micro-XRF and Raman spectroscopy. Some tapes contain elements Ti, Ca, S, and Al in a fiber substrate, which may be used for duct tapes differentiation. Classification of duct tapes, based on Principal Component Analysis of the spectra, will be shown. Multivariate analysis was applied to these spectra to extract differences in connection with different source of the tapes. The data shows that PCA allows to differentiate the samples, as seen in duct tapes #1020, #1110, and #1230. The PCA of duct tapes shows significant separation between duct tapes of different vendors and brands. Raman spectra of the material shows many common features with some differences, which may be originated from the filler. Data fusion technology was applied to the set of XRF and Raman data to create PCA and PLS-DA model. Misclassification in PLS-DA models was studied using randomly selected samples from available data. Results of single source and data fused analysis are compared and discussed. In conclusion, this study provides methods that allow one to differentiate duct tapes based on spectra analysis of micro-XRF and micro-Raman data.