## J11 Discrimination of Paper Document by Inorganic and Isotope Analysis

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After attending this presentation, attendees will have an appreciation of the strong potential of modern analytical technique combinations for forensic paper investigation.

This presentation will impact the forensic community and/or humanity by demonstrating the strong discriminating power of modern technique combinations for forensic paper investigations and in this way can provide important forensic evidence, especially in cases involving anonymous letters, the counterfeit manufacture of paper banknotes and document fraud.

The ability to discriminate between sheets of paper and to determine the origin of pages of paper can provide important forensic evidence, especially in cases involving anonymous letters, the counterfeit manufacture of paper banknotes and document fraud. This field becomes more and more important because of the increase in threatening letters addressed to public figures such as politicians and the relation to terrorist activities. One of the possibilities in these investigations is the chemical or physical analysis of the paper. This may serve to establish a relation between different anonymous letters or to compare with paper that has been seized at a suspect's residence. There are many analytical techniques that can be used for a chemical or physical analysis of paper. However, the question is which methods or combination of methods has the highest discriminating power and which method combinations should be used.

The goal is to assess the discrimination powers of the different techniques whilst also searching for combinations of largely complementary methods so that a fast, efficient, sensitive, and reproducible analytical protocol can be established for the forensic identification and comparison of paper samples.

In this work the potential of a selection of inorganic analysis techniques is evaluated. Later it will also be combined with organic and physical characterization results of the paper. The following techniques were applied: LA-ICP-MS (Laser Ablation Inductively Coupled Mass Spectrometry), XRF (X-ray Flurorescence), XRD (X-ray Diffraction), and IRMS (Isotope Ratio Mass Spectrometry). With these techniques both major as well as trace elements present in the paper can be analyzed. A set of 25 different paper types from the European market was used for the comparisons. From two paper types also several paper batches were measured.

Multivariate statistical techniques such as cluster analysis, principal component analysis (PCA) and discriminant analysis (DA) were used to establish the discriminating power of each technique as well as combinations of techniques.

LA-ICP-MS provides the highest single discriminating power. At least 23 out of the total of 25 paper types could be fully discriminated using only this technique. In addition LA-ICP-MS is also a fast and robust technique with easy sample preparation.

Despite its lower sensitivity XRF also showed good discriminating power but the correlation with LA-ICP-MS is high and a larger sample area is necessary. XRF has added value though, especially for S, Cl and Br. Using the XRF and LA-ICP-MS combination all 25 papers can be discriminated. Interesting is that in this combination S, Cl, and Br as determined using XRF provide the highest contribution to discrimination of the technique combination.

The combination of LA-ICP-MS and IRMS provides another powerful, complementary, and strongly discriminating set of techniques, easily discriminating all 25 papers. In this combination H and C isotope ratios as determined using IRMS provide the highest contribution to discrimination of the technique combination.

Apart from the 25 paper types, samples from four UPM-Kymmene production batches were analyzed. All four batches could be discriminated using e.g., the combination of LA-ICP-MS and XRF.

The value of inorganic analysis for document paper discrimination will be further illustrated with several casework examples.

**Elements, Isotopes, Paper**

 ** Presenting Author*