Examination of fraud documents by microscopy Raman spectroscopy method

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In recent years, due to the widespread availability of laser printers and photocopiers, offenses in connection to document alterations have become more frequent. Crimes and illegal acts related to document manipulation include fraud, counterfeiting, blackmail, anonymous letters, or acts of terrorism among others. Following the trend of the increasing number of document fraud cases, efficient investigation techniques of printed materials have come into the focus of forensic research.

In cases with suspicions that the content of a signed legal document has been subsequently altered, the determination of the order of crossing lines is an appropriate investigation approach. If the printed text overlaps or intersects with the signature on the document, the alteration may be investigated by examining the areas of intersections. In these cases a number of techniques are available to determine the order of crossing lines. They include standard optical microscopic techniques and some special types of microscopy for example SEM and AFM. Recently we published a new analytical method, the microscopy FTIR-ATR method, which is a suitable technique to determine the sequence of the crossed lines. This can be done by measuring the surface layer at the areas of intersection. In the visual mode of the ATR objective, the exact definition of line crossing points is provided, so the chemical composition of the surface layer can be examined at this point based on the spectrum. Analysing the upper layer, the sequence of crossed lines of printer toner and pen ink can be determined. However, if there was no intersecting area the sequence order of the toner and pen ink layers could not be determined with the application of the above standard methods. In this paper we present a new method that is applicable for the determination of the order of different ink layers even if there is no visible intersection of printed lines. The microscopy-based Raman technique is an eligible method for the determination of the chemical structure of printer toners and pen inks directly on the document. This new method is based on the features of the printing process used by the copiers and laser printers. During this electro-photographic process, dry toner particles of size 6-8 mm diameters are melted and flattened by pressure onto the surface of the document. The polymer resin, the main component of dry printer toners creates a few mm thin surface layer that forms the characters and further thousands of discrete toner particles contaminate the full surface of the paper. These microscopic toner spatters are evenly distributed over the whole document, approximately 100 spatters/ cm2. Such particles can almost surely be found in the critical area of the signature or other lines of high importance. As the chemical structure of these particles is the same as the toner material, these micro-sized toner particles are suitable for the sequencing examination.

Our new method helps to investigate the chronological sequence of two writing media in both possibilities: document with and without intersecting lines. This is a simple, fast, non-destructive method, which doesn’t require sample preparation and provide an objective result leaving the documents intact.

The use of Microscopy-FTIR-ATR technique to determine the sequence of crossed lines

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The determination of the chronological sequence of crossed lines has been a difficult problem in document examination. The similarity of physical and chemical properties of printer toners and pen inks make the work of forensic experts more difficult, because only determinations of minor differences can conduce to identification. In relation to ransoming, anonymous or threatening letters, discrimination and identification of printers or pens is often required. Concerning fraud cases, it has to be determined whether the document has been additionally altered. In the case of counterfeit documents one needs to determine the sequence of crossed printer and pen ink lines to answer the very frequent question ‘signature or printed text was first on the document?’. Up until now, solution of these problems required experts to run time demanding investigations and the results were more or less subjective. Microscopy-based infrared ATR technique as opposite to optical microscopy techniques is a simple, fast, non-destructive method, which does not require sample preparation and provide an objective result, while also leaving the documents intact.

In our experiment spectra were collected using a Bruker Vertex 70 infrared spectrometer equipped with a 20x ATR objective Bruker Hyperion microscope. Before the analysis the measurement spot on the document is defined, while the ATR objective has to be in the visual mode. During the examination the documents contact with the surface of the Ge crystal at 100 mm diameter. Through principle of measurement, infrared spectral information are gathered from ~1 mm depth layer of the surface. In connection to questionable documents the most common and indistinguishable samples are the black printed and black handwriting lines. Since examination of these samples by other optical analytical methods have serious difficulties, in our experiment we investigated black toners of laser printers and black pen inks. Polymer resin the main component in dry black printer toners, create a few mm thin, black surface layer on the paper. Printed matter can be investigated in situ by its infrared spectrum without any disturbing effect, because of the penetration depth of the infrared radiation is smaller than the thickness of the printed layer. The liquid pen inks penetrate into the micro fibres of the paper, so much so that, the upper sides of the cellulose fibres are saturated entirely with pen ink. Because of this fact the disturbing effect of cellulose fibres of paper cannot be removing from the spectrum. For determination of the sequence of crossed lines, the exact definition of line crossing points of document is provided (when ATR objective works in the visual mode), so the chemical composition of the surface layer can also be examined at this point based on the spectrum. Analyzing the upper layer, the sequence of crossed lines of printer toner and pen ink is determined.

The microscopy FTIR-ATR method is a very suitable technique for the examination of printed and hand written documents. Using this technique different types printer toners and pen inks can be distinguished by their chemical fingerprints. The sequence of crossed lines can be determined by measuring the surface layer at the line crossing point. Additionally, the measurement neither destructs the document nor it requires sample preparation. This analytical method is objective and easy to interpret. Application of the method makes easier comparison of questioned documents for forensic experts in criminal cases.