Chapter 12
End User Commentary on Emerging Approaches in the Analysis of Inks on Questioned Documents

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Forensic analysis of inks in a police laboratory aims to clarify for judicial or civil purposes: (a) whether a document has been tampered; (b) the correlation between documents; (c) the correlation between a document and a writing instrument and (d) the correlation between a document and a printing device. To this end, the study, analysis and investigation of the documents' inks are used in order to address the questions formulated by the criminal investigation or by the court, thus contributing to the resolution of crimes associated with the falsification and counterfeiting of documents such as mockery, forgery of documents, fraud or threats. The forensic analysis of documents in this context encompasses not only the analysis of inks but also the characterization, identification and differentiation of various materials such as paper, glues, coatings, laminates, waxes, amongst others, for which it is necessary to use the traditional imaging techniques and advanced analytical methodologies.

Based on the review developed by Weyerman and Techabowornkiat in this Chapter, the present commentary aims to discuss the operational perspective of a police laboratory through examples of real cases, reporting on the different technologies used, presentation the of results obtained and the difficulties encountered in relation to available techniques and emerging technologies.

Inks—Despite the constant technological advances and the innumerable resources for document production, the manual instruments of writing continue to have great forensic relevance and to subsist in daily life; for this reason their correct and effective identification, characterization, differentiation and dating is of great importance. In the Portuguese laboratory of scientific police, 50% of the cases of this kind of analysis include manual instruments of writing.

In the analysis of a Commercial Lease Agreement, where the court's request was to verify that the signatures had been handwritten with the same ink, it was found that the morphology of the inks and their luminescence reactions were identical. Other

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non-destructive analysis techniques such as micro spectrophotometry and micro-Raman were used, and the results were inconclusive in terms of differentiation.

After requesting a destructive analysis at the court, we proceeded to the analysis of the blue ballpoint inks by HPLC with DAD detector, enabling to conclude that the signature 1 was handwritten with an ink writing instrument different from the one used in the signatures 2 and 3. In this case the partial destruction of the document was authorized, however in many cases this is not possible, which is a limitation to forensic analysis. In cases where the inks have similar luminescence and fluorescence reactions and similar spectral behaviour, it is not possible to state whether the ink is the same. Most black inks are a constant challenge in this type of analysis where it is imperative to resort to non-destructive techniques. Many of them have a similar spectral behaviour and only a small percentage of these inks are distinguishable by micro-Raman with a 685 nm laser. What would be desirable is to resort to another technique capable of chemical analysis such as mass spectrometry in order to identify all constituent components of the ink. As mentioned by Weyerman and Techabowornkiat, there are already some studies in this respect that demonstrate the applicability of non-destructive techniques such as DART-MS or EASI-MS in the analysis of inks in documents. In a forensic police laboratory, it will only make sense to acquire these technologies if they have a wider range of forensic applications because of their cost. On the other hand, since destructive techniques can be used, the variety of technologies that can be used increases. Studies conducted by Canada Customs and Revenue Agency, Brazil's Federal Police and National Centre for Forensic Science of University of Central Florida show that ESI/MS analysis is a fast and effective method for analysis of vehicles as well as dyes in the inks.

Inkjet—The technology associated with inkjet printing has evolved very fast over the past 30 years. At present, inkjet printers can be found on the market at reduced prices, producing excellent print quality. This development has promoted a widespread use both domestically and professionally, so that in this police laboratory there has been an increase in the number of crimes involving this type of printing.

In the course of a criminal investigation, searches were carried out on the premises of a suspect on suspected birth certificates forgery. In this case the expert work consisted in first determining the authenticity of the recovered certificates. The certificates were false and were obtained by monochrome inkjet printing, so it became relevant to determine whether these certificates were printed on the printer found at the suspect's home. In the text printed on the certificates there are visible clouds of droplets. These droplet clouds result from the speed of the printing head, the ink flow, and the motion direction of the printing head and the paper. The spatial distribution of these droplet clouds is similar in the certificates found and in the subsequent printing made by the investigators using the suspect printer. The HPTLC technique was used in the analysis of the black inks of the certificates and the black ink in the cartridge of the suspect's EPSON T040 printer, revealing a chemical similarity between them. In this case the use of a non-destructive technique was not a problem since the documents under analysis were false.

HPTLC associated with image analysis obtained with UV light is widely used in this laboratory and by similar laboratories in the discrimination of polychromatic

inkjet prints. As mentioned by Weyerman and Techabowornkiat, this is a fast, economical and fairly discriminating technique.

However not all inkjet inks have the same type of formulation. An example of this is the solid inkjet, which it was used in the falsification of invoices that we received for analysis. By analysing the image, the manner of depositing the ink on the paper and the graphic effect characteristic of a solid ink inkjet printing were determined. The invoices may have been printed on the Xerox 8550/8560MFP (Multi-Function Product)/8570/8870/8700/8900 and WC2424 solid ink print devices. Using Fourier Transform InfraRed Micro Spectroscopy (FTIR MS) analysis, coupled with the use of ATR (Attenuated Total Reflectance) with germanium crystal, the presence of a wax was detected, however this technique did not allow the discrimination of magenta, cyan and yellow inks.

Different Inks—Other printing techniques are used in documents and subsequently subject of forensic analysis. An example was a case that consisted in comparing inks used in the scraping zone of lottery tickets, with the fragments found at a suspect location associated with the alleged perpetrator of an assault. We analysed the various constituents of the suspected material by Optical Microscopy, Fourier Transform Infrared Micro-Spectroscopy (FTIR) and Scanning Electron Microscopy with RX microanalysis (SEM/EDX) to study its morphology and elemental composition. The lottery tickets have been printed by flexography and the material used to cover the scraping area of these tickets has spectral characteristics similar to those of some acrylic polymers and their elemental composition consists mainly of Titanium (Ti), Calcium (Ca) and Aluminium (Al). These compounds are commonly used in ink systems. It was concluded that the material used to cover the scraping area of these tickets and the suspicious fragments were made of solid acrylic rubber paints. However, it was not possible to determine whether these fragments originated from the lottery tickets. It is noted that the majority of academic articles are naturally focused on the most common type of inks, however in the police laboratory there are numerous types of ink for both print and handwriting analysis such as invisible inks or iron-gallium inks.

Toners—Of the numerous cases with this type of material, one stands out in which part of the forensic analysis was undertaken before a search carried out by the criminal investigation, in order to direct this search. The expert evaluation served the purpose to determine which laser printer of the many (dozens) found at the Company premises the questioned documents under investigation had been printed in decreasing order of probability. Using the non-destructive Micro-FTIR with diamond cell technique and using the existing spectral database in this laboratory, 10 printers were identified that employed a toner with characteristics similar to the toner used in the printing of the documents. It is relevant to know that there may be other spectral characteristics that are not present in our database. With this information a printer was seized from this list as being the most likely to have been used. The comparison of printing and toners started always with the use of optical microscopy and analysis of toner deposition morphology on paper. Also, in this search the analytical procedure as recommended by ENFSI was followed, as well by the police laboratories or forensic institutes that are part of this network. In addition to the chemical compatibility of the toner verified

by the spectral analysis, artefacts produced by the printer on the suspect documents were visualized. Together, the techniques used in the analysis of toner presented a fairly good degree of discrimination. It was rarely necessary to resort to SEM/EDX or felt the need for another technique.

Conclusion—The transversal use of optical microscopy and image analysis as source of results in forensic analysis of inks are highlighted in all presented cases. For the interpretation of these imaging results it is important that the forensic examiner has adequate training in questioned documents as well as advanced scientific training in chemistry and analytical chemistry. All methodologies needs to be validated even if it they have already been described in a scientific article. The quality of the forensic response is also measured by the validation of the expertise of a second expert and by participating in collaborative tests conducted with other similar laboratories.

The emerging techniques mentioned in this chapter indicate optical and spectroscopic methods such as Micro-Raman and Micro-IR spectroscopy as being more than just very promising because they are non-destructive and fast. These techniques are already employed by many forensic laboratories for questioned documents. The optical and chemical imaging methods used already provide a very good response potential.

It is thought that the additional technological advancement in this area will be made by the use of MS techniques to increase the discriminating power and perhaps for dating purposes.