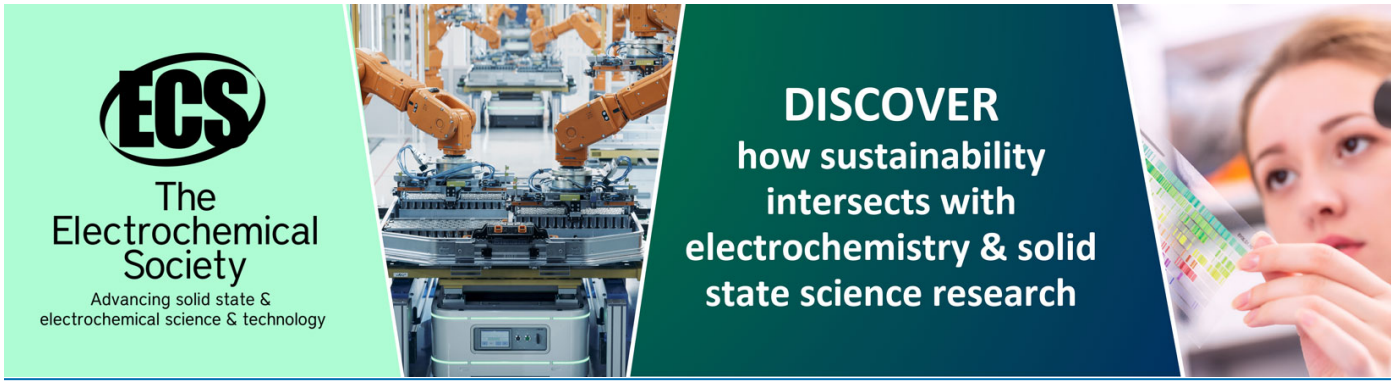
Defects in UV-vis-NIR reflectance spectra as method for forgery detections in writing documents



Corrigendum: Defects in UV-vis-NIR reflectance spectra as method for forgery detections in writing documents (2010 *J. Phys.: Conf. Ser.* **249** 012060)

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The authors would like to acknowledge that the first four sentences of the introduction 'Ever since paper was invented, documents have...a very large domain of forensic science called questioned documents' are a direct quotation from Weyermann C 2005 [1] ([6] in the original paper). The authors apologize for failing to attribute this source properly.

References

[1] Weyermann C 2005 Mass spectrometric investigation of the aging processes of ballpoint ink for the examination of questioned documents Ph. D. Thesis, Faculty of Biology and Chemistry, Justus-Liebig-University Giessen

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Defects in UV-vis-NIR reflectance spectra as method for forgery detections in writing documents

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Abstract. Documents have taken up a very important place in our society. Frauds committed in connection with documents are not at all uncommon, and, in fact, represent a very large domain of the forensic science called "questioned documents". In the field of forensic examination of questioned documents, the legitimacy of an ink entry is often an essential question. A common type of forgery consists in materially altering an existing writing or adding a new writing. These changes can be characterized by means of optical spectroscopy. The aim of this work is to perform the UV-vis-NIR reflectance spectrophotometry to analyze a range of blue and black commercial ballpoint pens, in order to investigate the discriminating abilities of the different inks found on the same document.

1.Introduction

Ever since paper was invented, documents have taken up a very important place in our society. They play a decisive role in fields such as communication, education, culture, art, sanitation, hygiene, or packaging, and it is almost impossible to imagine life without them. Today, the advances of computer science have put the digital exchange of information into a privileged position in all our societies, yet paper is still a preferred medium in many applications: books, notes, contracts, testaments, receipts, letters, tickets, banknotes, and so on. A great number of transactions can be digitally executed, but in many cases a signature is required for proof of consent. Therefore, frauds committed in connection with documents are not at all uncommon, and in fact represent a very large domain of forensic science called "questioned documents". A common type of forgery consists in materially altering an existing writing or adding a new writing. Therefore, ink analysis is an important forensic procedure that can reveal useful information about questioned document [1]. In the last years, numerous techniques have been proposed for forensic ink examination [2]. The wide array of materials used in inks, coupled with possible contamination from the writing surface confronts forensic ink chemists with a complex analytical challenge to carry out this type of analysis. But the aim of most analyses is to determine whether two pieces of written text originated from the same ink, therefore, comparison of different writing inks on a document is the main goal of most investigations. In these cases, inks can be differentiated by determining their macro and/or micro optical properties. In particular, for ballpoint pen ink the UV–vis–NIR absorption/reflection spectrum is immensely informative and, though features may be highly convoluted, the spectrum from around 300 nm to 1200 nm is a reliable quantitative measure of the mix of dyes in that sample [3-6]. This technique is straightforward to execute and provides fairly rapid and repeatable results, performed in scientific laboratory or also in field with portable spectrophotometer.

2.Material and methods

In order to assess the ability of UV-vis-NIR spectroscopy to distinguish between different ballpoint pen inks a Perkin Elmer Lambda 900 Spectrophotometer was used. In Figure 1 we present the reflectance spectra obtained directly from the ink lines of three different ballpoint.

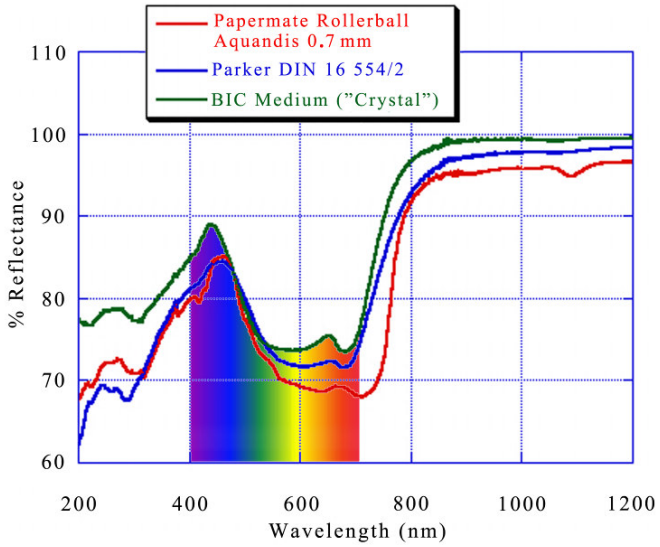

Figure 1. UV-Vis-NIR reflectance spectra relative to three different ballpoint pen inks. Small shift from the base line (100 % reflectance) have been introduced for improving the visibility of spectra.

Observing Figure 1 it is easy to see that the spectrophotometry has the potentiality to distinguish different inks. The different molecules used to obtain inks cause different absorption bands.
The infrared reflectance with illumination in the near infra-red region (700–1000 nm) can be used to detect whether two pieces of the same text are originated by different pen.
Figure 2(a) shows an example of the check with fraudulent changes of the amount: the addition of "1" in front of 100€ and "*Mille*" in front of "*cento*".

Figure 2. Example of check with fraudulent changes. Two black inks of different manufacture have been used. (a) Photo obtained using normal light. (b) Photo obtained in IR light. The difference absorption in the infrared region denote the use of two different pens.

The forgery can be detected also using a portable fiber optics spectrophotometer (see Figure 3). Figure 4 shows the UV-vis-NIR reflectance spectra of the two inks. The visible range exhibit no differences, on the contrary in the IR zone they have meaningful differences.

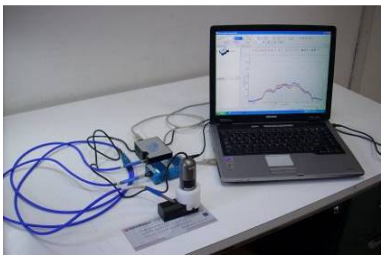

Figure 3. Portable fiber optics spectrophotometer.

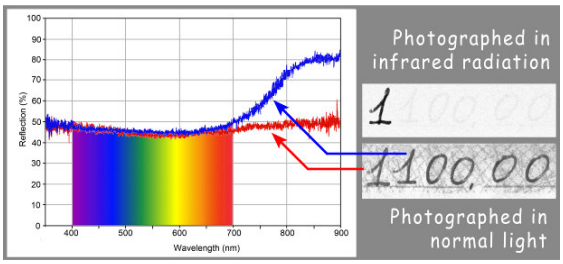

Figure 4. UV-vis-NIR reflectance spectra of the two different pen inks.

Not always the IR photo is able to identify if two pieces of written text was originated by different pens. The Figure 5(a) shows another check, compiled by ballpoint pen with blue ink, with the same kind of change found in the first example. The alteration was made with a second pen having, in visible range, a color "very similar" to that of the original text. In the IR photo (Figure 5(b)) it is not possible to identify any forgery.

Figure 5. Example of check with fraudulent changes. Two blue inks of different manufacture have been used. (a) Photo obtained with white light. (b) Photo in IR light. In this case the IR photo isn't able to enhance the use of two different pens.

Also on the second check we are performed the UV-vis-NIR reflectance spectra with the portable fiber optics spectrophotometer (see Figure 6). As in the previous case, the spectra related to the two different ink lines, in the visible region, are similar. Instead, the measurements in the IR range are more determinant to distinguish between pens from different manufacturers.
Modern demands for specialized writing and printing instruments have resulted in an explosion of ink formulations, each of which may contain dozens of chemical components (e.g., acid or basic dyes, organic or inorganic color pigments, surfactants, antioxidants, viscosity adjusters, resins, glycol and glycerol, waxes, oils, and pigments). The organic components in the ink, generally, can be monitored studying NIR and IR spectra.

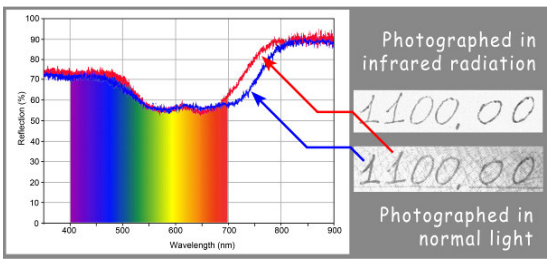

Figure 6. UV-vis-NIR reflectance spectra of the two pen inks used in above check.

3.Conclusion

In this paper the UV-vis-NIR reflectance spectrophotometry has been applied to determine whether two pieces of written text are originated from the same ink. Furthermore, we have set a fiber optics spectophotometer to obtain UV-vis-NIR spectra directly on the ink line of a document. Our experimental approach has the advantage of being non-destructive. The experimental set up has shown the possibility to characterize optically and differentiate the different inks in a fast and straightforward way.

In forensic examination of inks, one of the most challenging investigation is the dating of handwritten documents. With elapsing of time, the inks undergo to some change in their chemist/physical characteristics, related with the variations of document storage. Spectrophotometric measurements, on ink line to determine the age of handwritten documents, are in progress.

4.References

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