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Forensic Examination of Blue Ballpoint Pen Inks on Various Surfaces by ATR FTIR Microscopy

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Abstract

Forged documents play a crucial role in forensic document examination because they are related to our daily life. Most of them usually are made by adding to or erasing from the original documents which cannot be observed by the naked eye. Nowadays, TLC, HPLC, FTIR and X-ray Microanalysis are commonly used in document examination. In principle, most of them are inconvenient and destructive methods. Moreover, they require sample preparation so that subsequent experiments cannot be done. The ATR FTIR technique is available to solve this problem because it is a non-destructive method and the radiation can penetrate the sample surface to less than 2 μm. In this study, four blue ballpoint pen inks written on various surfaces were analyzed by using this method. The ATR FTIR spectra of each ink are differentiated. The results show that the possibility that one ink could be distinguished from the other three was about 78% (32 of 41 samples) and the highest possibility of distinguishing all the four inks was about 31% (12 of 41 samples) and this method can be applied better to glossy than to non glossy surfaces. From this study, it can be concluded that the ATR FTIR technique is useful in examining fraudulent documents written by blue ballpoint pens on the same surface.

Keywords: ATR FTIR, forged document, blue ballpoint pen, document examination

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การตรวจสอบหมึกปากกาลูกลื่นสีน้ำเงินบนพื้นผิวต่างๆในเชิงนิติวิทยาศาสตร์ ด้วยวิธี เอทีอาร์-เอฟทีไออาร์ สเปกโทรสโกปี

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Introduction

Document is unavoidable evidence in forensic caseworks because it correlated to human daily life. Most of them are made from paper and completed in ink that were written by writing instruments such as pencil, ball-point pen, fountain pen, gel pen or other substances which can be used for the same purpose [1]. Nowadays, forged documents are a crucial problem in forensic science. Some area of them are usually added with or erased from the original document which cannot be observed by the naked eye. However, they are significantly different in chemical composition when laboratory testing is performed. Thin Layer Chromatography (TLC), High Performance Liquid Chromatography (HPLC), X-Ray Microanalysis, and Fourier Transform Infrared Spectroscopy (FTIR) are commonly used for ink analysis [2-6]. But some of these techniques are destructive and require sample preparation that are not suitable for forged documents because this document may be required for further testing in forensic identification processes. Because of the non-destructive nature and the sample penetration (less than 0.5 - 2 microns) into the surface, an Attenuated Total Reflectance Fourier Transform Infrared microspectroscopy (ATR-FTIR) is useful to Forensic Document Examination (FDE) [7,8].

Objective

The aim of this study is to differentiate ATR-FTIR spectra of different inks on the same surface.

Research Methods

Four blue ballpoint pens were used as the source of the ink samples in this study: 045 Reynolds 0.8 mm FINE CARBURE (Ink 1), Horse Hand Crystal N500 (Ink 2), Horse-Ball Pen H-501 (Ink 3) and Horse Broad Point 1.0 mm (Ink 4). All four inks were used to write the numbers 1, 2, 3 and 4 on each of the forty surface samples which were divided into 17 glossy paper surfaces and 24 non glossy paper surfaces. The written numbers were analyzed by ATR FT-IR spectroscopy (Hyperion Series ATR FT-IR Microscope, BRUKER).

Results

The ATR-FTIR spectra of all blue ballpoint pen inks which were written on each sample surfaces can be divided into four groups.

Group I: In this group, one of the inks had a spectrum clearly different from the other three. Examples are given in Fig 1 when the sample surface was in the inside of a Mister Donut container box. For other surfaces the distinguishable spectrum might be only one of these inks. The surfaces were food packaging material with foil, medicine box container and gift wrap, yellow post-it, Bualoung Bank ATM slip, telephone paper book and inside of Mister Donuts container box.

Group II: In this group, two inks exhibited spectra of significantly different shapes but the spectra of the other two inks were essentially the same. Fig. 2 shows examples for inks written on pieces of Double A paper. The surfaces used were Double A A4 paper, hospital band bill, printed label on plastic envelope, colorless plastic envelope, calendar, cash sale roll paper, normal page of the Seventeen Magazine, glossary card paper, the outside cover page of Honda Magazine, inside cover page of Honda magazine and outside of Mister Donuts container box.

Group III For surfaces in this group, all the fours inks exhibited significant different spectra and the inks were distinguishable. The sample surfaces were Supermarket hand bill, color ink jet printed paper, normal page of Honda Magazine, cdolor lab photographic paper, Thai Military Bank deposit slip, Thai Military Bank withdrawal slip, Thanachart Bank transaction record, cash sales bill, Bualoung Bank inquiry deposit slip with stamp, Thairath newspaper 1 and 2, electricity bill (receipt) and white plain roll tissue paper.

Group IV: In this group, the surfaces used were white plastic envelope, oated food packaging material cover page of the Seventeen Magazine, the outside of Karft envelope, inside of Kraft envelope, Back side of gift wrap, Thai airways boarding pass, the back side of Coated food packaging material and the back side of BAY Sales flip flap slip customer copy. On these surfaces, all the inks gave spectra of essentially the same shape. None could be distinguished from the others. The data are not shown.

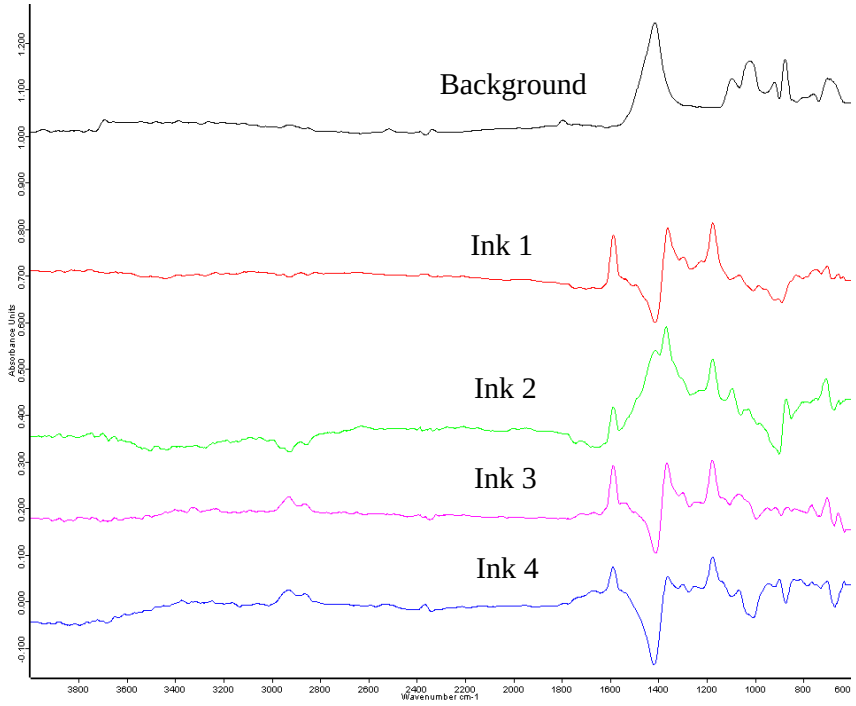

FIGURE 1. The ATR-FTIR spectra of inks which were written on the inside of Mister Donuts container box (Group I).

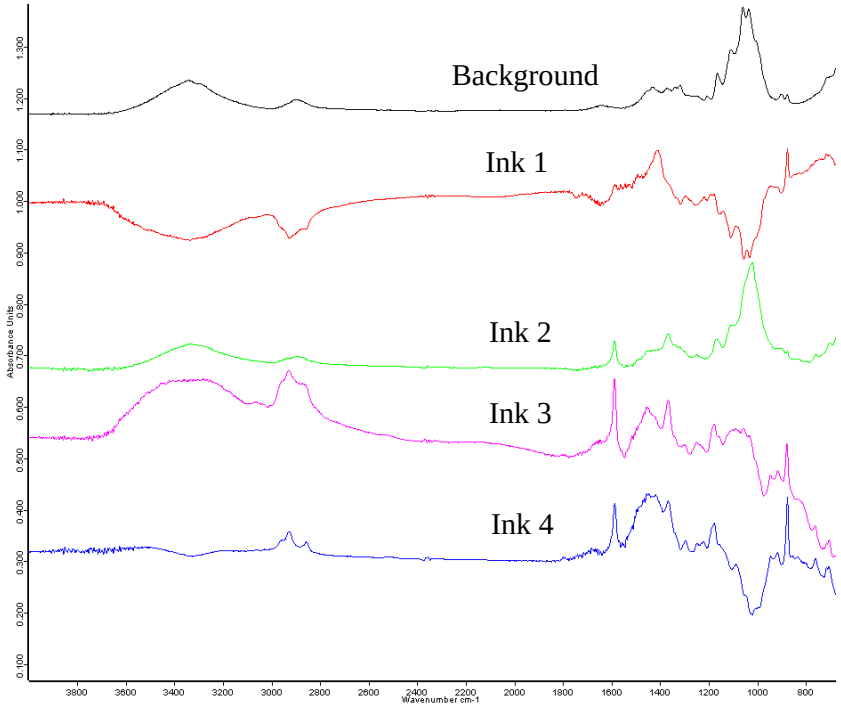

FIGURE 2. The ATR-FTIR spectra of inks which were written on Double A A4 paper (Group II).

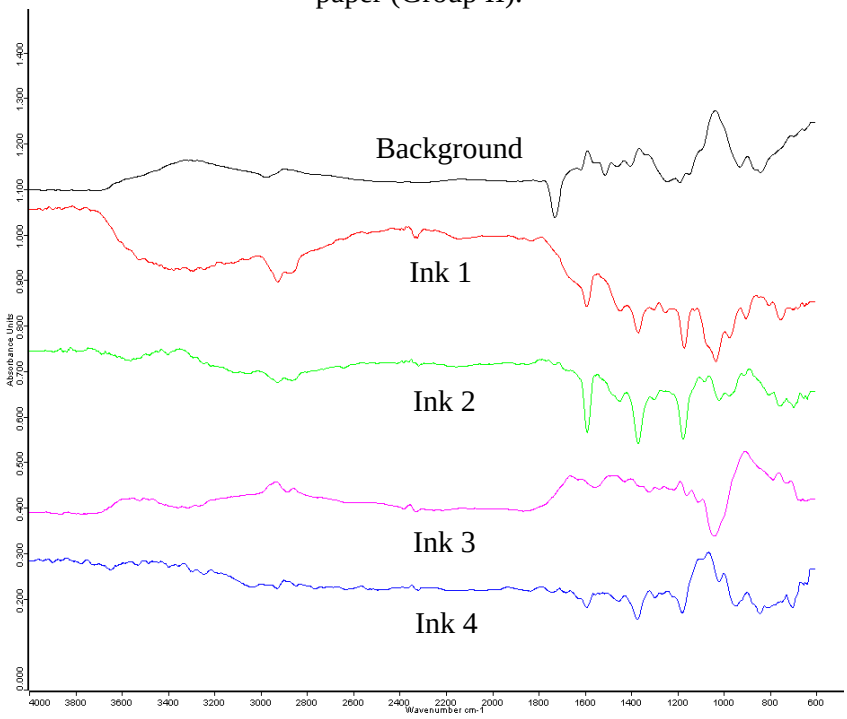

FIGURE 3. The ATR-FTIR spectra of inks which were written on white plain roll tissue paper (Group III).

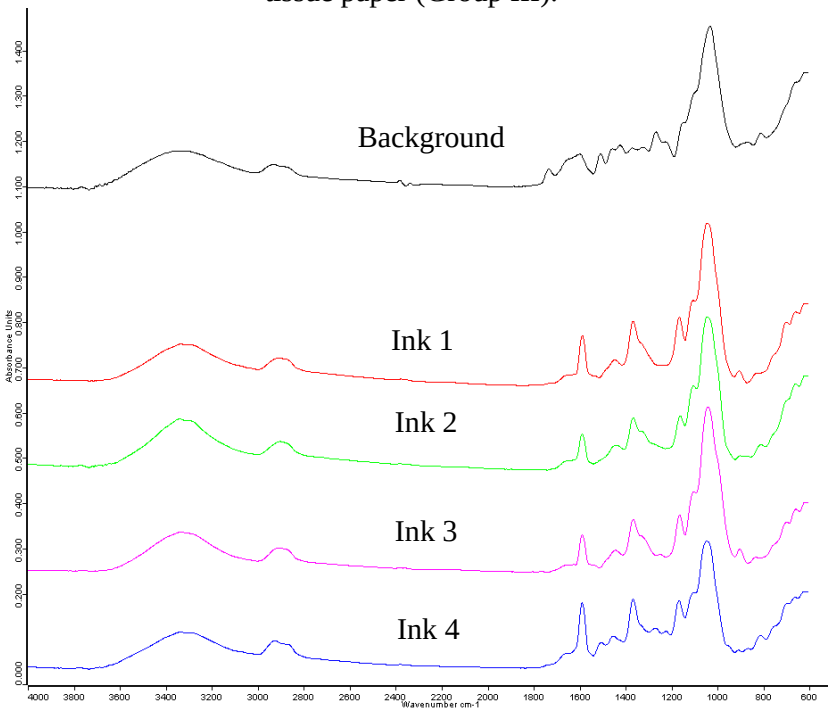

FIGURE 4. The ATR-FTIR spectra of inks which were written on the inside of Kraft envelope (VI).

Table 1 Showed the number and percentage of each sample group.

Differentiated spectra	Glossy sample surface		Non glossy sample surface		Total	
	Number	%	Number	%	Number	%
I	3	17.65	4	16.67	7	17.07
II	7	41.18	5	20.83	12	29.27
III	4	23.52	9	37.50	13	31.71
IV	3	17.65	6	25.00	9	21.95
Total	**17**	**100**	**24**	**100**	**41**	**100**

Table 2 Summary of differentiated and non differentiated spectra of all sample based on the paper surfaces (Glossy and Non glossy).

Differentiated spectra	**Glossy sample surface** (%)	**Non glossy sample surface** (%)
I+II+III+IV	82.35	75.00
Zero	17.65	25.00
Total	**100**	**100**

Discussion and Conclusion

In this study, the ATR-FTIR spectra of 4 inks samples written on 41 of glossy and non glossy sample surfaces were differentiated. The spectra can be divided into 4 groups depending on the spectral pattern of each sample as described. Results from Table 1 suggesting that for the glossy sample surface, two types of ink can be highly differentiated (41.18 %) while, ATR-FTIR can highly distinguished all of ink samples on non glossy sample surface (37.50%). The cause of this phenomenon may be the coated layer of the glossy surface that affected to the analysis [9]. However, for 9 sample surfaces the spectra could not be differentiated for the 4 ink samples. The result suggests that the ATR-FTIR technique can be appropriately applied to both glossy and non glossy paper but is better for glossy paper (Table 2).

From the results, it can be concluded that the ATR-FTIR technique can be used effectively analyze fraudulent documents written in blue ballpoint pens on the same surface. However, ATR-FTIR technique can detected only organic but not inorganic compound in each ink sample. Use of other techniques such as Thin Layer Chromatography (TLC) combines with ATR-FTIR to increase the efficiency of the spectra separation. For further experiment, comparison of ATR-FTIR spectra of each ink sample on different surfaces should be done.

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