Examination of Counterfeit Banknotes Printed by All-in-One Color Inkjet Printers

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An increasing number of cases related to counterfeit Hong Kong banknotes produced by all-in-one inkjet color printers have been encountered recently. Unlike those generated by color laser printers or photocopiers, characteristic dot patterns or irregularities are not present on counterfeit banknotes generated by color inkjet printers, thus creating difficulties in the identification of the printer. This paper describes the relationship between the counterfeit banknotes and printers seized in local clandestine factories. The conventional thin layer chromatography (TLC) method was employed to study the ink profiles of the inks present on the counterfeit banknotes and was found to be a useful tool for distinguishing different printer inks.

Introduction

Printing technologies for personal computers are constantly improving. The incorporation of other technologies endows modern inkjet printers with the ability not just for printing but also for performing multiple tasks. For example, when scanning capability is introduced to a color inkjet printer, it can function as a color photocopier. This is known as an "all-in-one" multifunctional inkjet printer. Today, most all-in-one printers can produce high-quality images for home users at an affordable price. As with many new technologies, the advent of this modern equipment provides us with convenience at work; however, it is also applicable in illegal activities such as the printing of counterfeit banknotes.

Recently the authors encountered in their laboratory a few cases involving the use of all-in-one color inkjet printers as photocopiers for producing counterfeit Hong Kong banknotes. These printers include Epson, Hewlett-Packard, and Lexmark. This paper describes the effort and experience in characterizing the printing features depicted on the counterfeit banknotes encountered in four clandestine cases.

Methods and Materials

The microscopic examination was conducted using a Nikon SMZ645 stereomicroscope.

Using thin-layer chromatography (TLC), ink samples of 0.5x0.5 cm^2 were removed from each of the counterfeit banknotes and control printouts and extracted with a mixture of pyridine and water (4:3). The TLC plates [Alugran Silica Gel Plate/UV_{254} (0.20 mm thickness, Macherey-Nagel, Germany)] were kept in a dry cabinet at 70 °C for two hours before use. Two mobile phases, namely (a) a mixture of n-butanol, ethanol, and water (10:2:3) and (b) a mixture of ethyl acetate, ethanol, and water (70:35:30), were chosen for the study. The spots on the developed plates were examined under normal and ultraviolet lighting.

Results and Discussion

Of the four cases studied, interesting features were found on the counterfeit banknotes, namely i) they were printed with color inkjet printers, ii) nonfluorescent paper was used to imitate the nonfluorescent properties of genuine banknotes, and iii) different makes of printers were employed for printing particular types of banknotes.

Case One

Unlike color laser printers or photocopiers in which the defects or damages on the photosensitive drum generally can be used in establishing a link between a laser-printed document and the individual laser printer (Arbouine and Day, 1994),

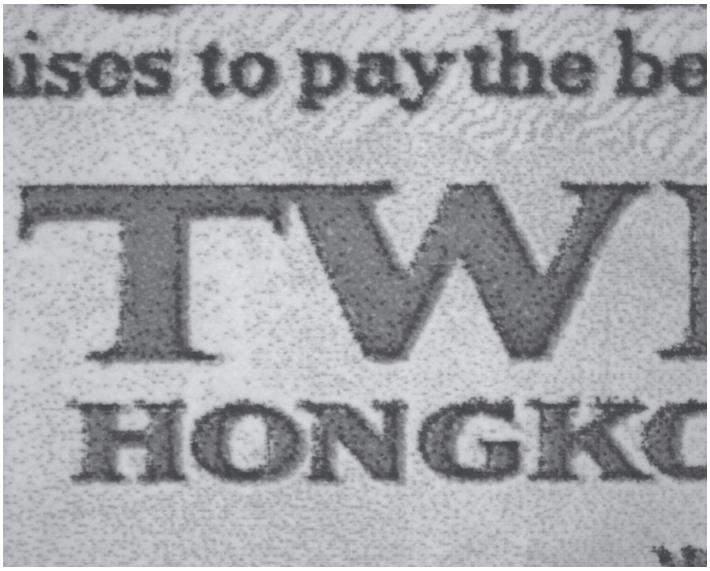

Figure 1a. Questioned HSBC HK$20 banknote.

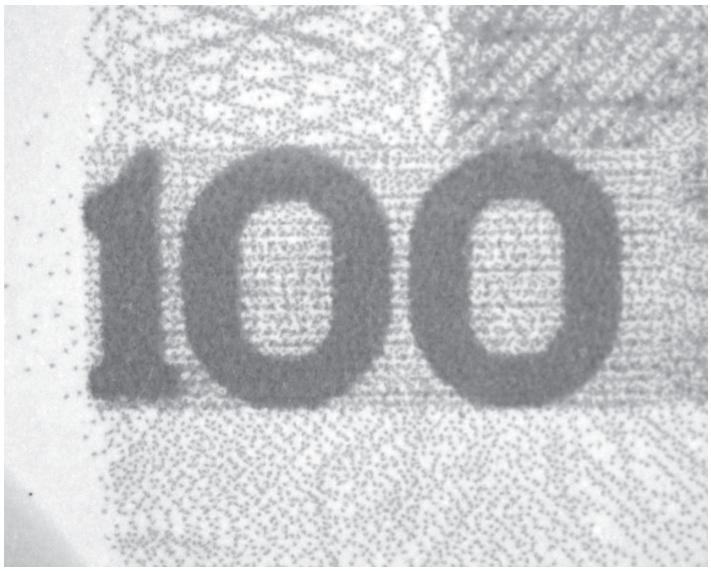

Figure 1b. Questioned BOC HK$100 banknote.

irregularities or printing defects on a document generated from inkjet printers are rare (Parker, 2001). In the present case, a seizure from a clandestine factory yielded several packs of Hong Kong counterfeit banknotes with denominations of HK$20, issued by the Hong Kong and Shanghai Banking Corporation (HSBC), and HK$100, issued by the Bank of China (BOC), along with two all-in-one color inkjet printers—Hewlett-Packard PSC1210 and Epson Stylus CX3100. Examination of all these counterfeit banknotes revealed neither printing defects nor irregularities useful for the identification of the printers. However, it was interesting to note that the counterfeit HSBC HK$20 banknotes (Figure 1a) consisted of four full-color components (cyan, yellow, magenta, and black, abbreviated CYMK respectively); whereas the counterfeit BOC HK$100 banknotes (Figure 1b) were made using three color components, CYM. In addition, the color tones of the

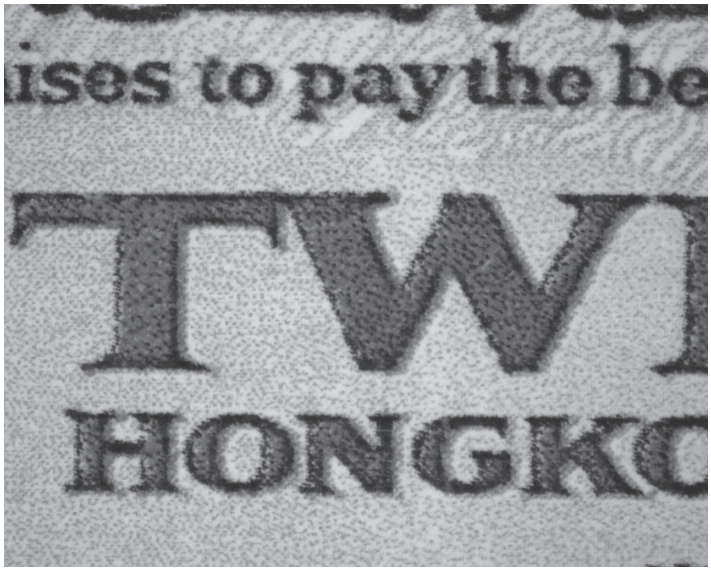

Figure 2a. Control HSBC HK$20 banknote prepared from Hewlett-Packard PSC 1210 all-in-one color injet printer.

Figure 2b. Control BOC HK$100 banknote prepared from Epson Stylus CX3100 all-in-one inkjet printer.

printing inks on the counterfeit HSBC HK$20 banknotes were found to be different from those on the counterfeit BOC HK$100 banknotes. These findings indicate that the counterfeit HSBC HK$20 and BOC HK$100 banknotes were unlikely printed with the same printer.

In an attempt to study the relationship between the counterfeit banknotes and the seized color inkjet printers, control printouts were prepared from the two inkjet printers. It was found that the color tones of the control printouts prepared from the Hewlett-Packard PSC1210 printer agreed with those on the counterfeit HSBC HK$20 banknotes (Figures 2a versus 1a), while those of the control printouts prepared from the Epson Stylus CX3100 printer agreed with the counterfeit BOC HK$100 banknotes (Figures 2b versus 1b). Therefore, it is possible that the counterfeit HSBC HK$20 and BOC HK$100 banknotes were produced

Figure 3a. Genuine HSBC HK$20 banknote.

Figure 3b. Counterfeit HSBC HK$20 banknote.

Figure 3c. Genuine BOC HK$20 banknote.

Figure 3d. Counterfeit BOC HK$20 banknote.

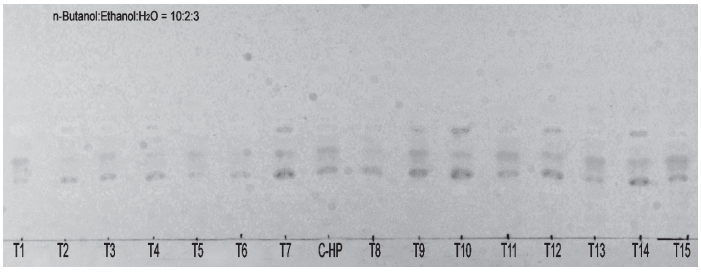

Figure 4a. Under normal lighting.

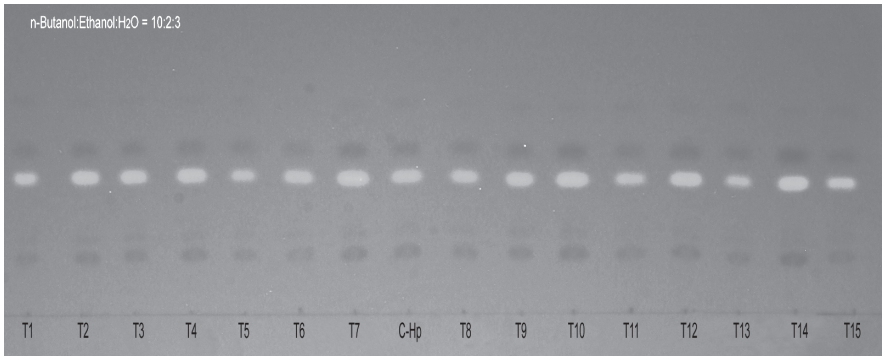

Figure 4b. Under ultraviolet lighting.

Figures 4a and 4b. T1-T15 ink samples obtained from counterfeit HSBC HK$20 banknotes; C-HP ink samples obtained from the seized HP PSC 1210 printer.

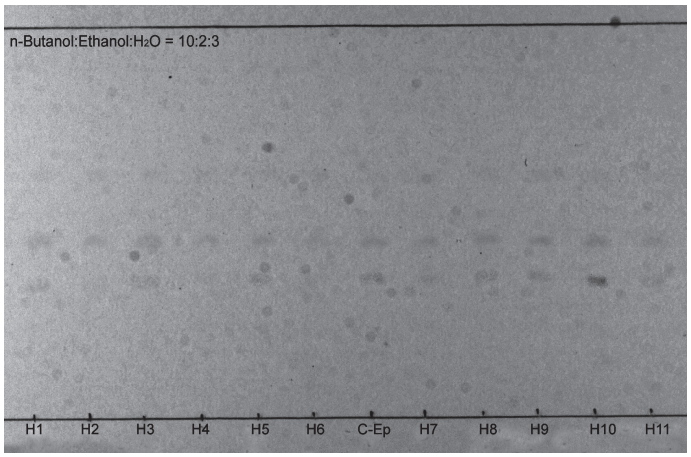

Figure 5a. Under normal lighting.

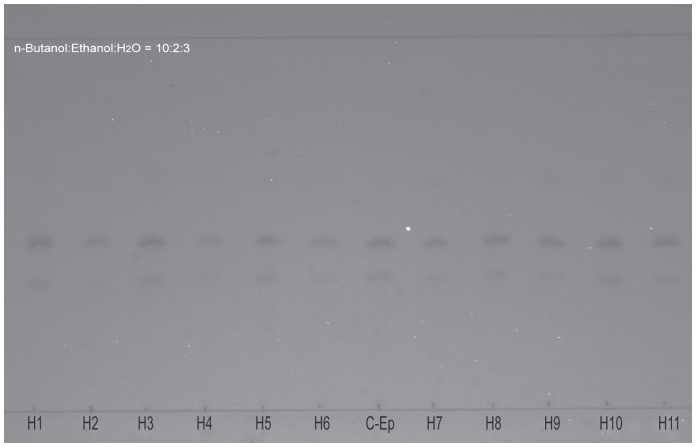

Figure 5b. Under ultraviolet lighting.

Figure 5a and 5b. H1-H11 ink samples obtained from counterfeit BOC HK$100 banknotes; C-Ep ink samples obtained from the seized Epson Stylus CX3100 printer.

respectively from the seized Hewlett-Packard PSC1210 and the Epson Stylus CX3100 printers.

It was intriguing to determine why the different types of counterfeit banknotes should be produced by two different color printers. The answer was found in the color tones of the genuine banknotes when compared to the counterfeit banknotes. It was noted that the Hewlett-Packard PSC1210 printer produced counterfeit HSBC HK$20 banknotes with color tones similar to those of the genuine HSBC HK$20 banknotes (Figures 3a versus 3b), and the Epson Stylus CX3100 printer produced counterfeit BOC HK$100 banknotes with color tones matching those of the genuine BOC HK$100 banknotes (Figures 3c versus 3d). Thus, to produce colors that best match those on the genuine banknotes, it was likely that the forgers employed different printers to achieve this purpose.

Apart from physical examination, the ink profiles of the printing inks on the counterfeit banknotes and those of the control printouts were also studied and compared using thin-layer chromatography (TLC). The TLC results (Figures 4a and 4b) from the printing ink profiles of the counterfeit HSBC HK$20 banknotes were in agreement with those of the Hewlett-Packard PSC1210 printer (Figures 5a and 5b). Similar results were obtained from those of the counterfeit BOC HK$100 banknotes and the Epson Stylus CX3100

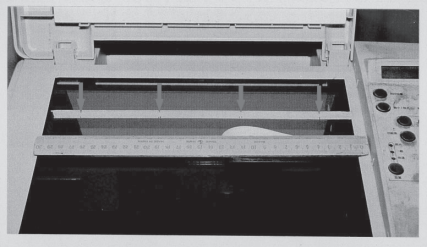

Figure 6a. Examination of the flat bed of the scanning surface of the color injet printer revealed the presence of a long strip of adhesie tape with pencil marks across the glass plate.

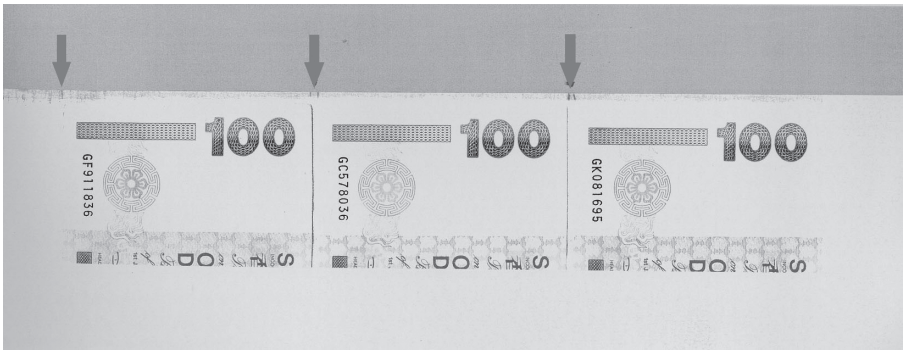

Figure 6b. Untrimmed counterfeit KH$100 banknotes revealed the presence of the image of the adhesive tape with pencil marks.

printer. The use of ink profiling comparison has been demonstrated to be a useful method in distinguishing different brands of inkjet printer cartridges using TLC and high-pressure liquid chromatography (HPLC) (Poon, Li, and Ho, 2004). Although a link between the individual counterfeit banknotes and a particular color inkjet printer was not established with absolute certainty, the high degree of matching the characteristics of the printers and the counterfeit banknotes did provide indirect evidence which could assist the investigation.

Case Two

In a second case, an all-in-one Lexmark model X83 color inkjet printer and some untrimmed color inkjet printed counterfeit HK$100 banknotes were seized from a clandestine factory. Examination of the flatbed of the scanning surface of the color inkjet printer revealed the presence of a long strip of adhesive tape with pencil marks across the glass plate (Figure 6a). It was also found that three HK$100 banknotes could be fitted in between these grids. These findings suggest that the adhesive tape with pencil marks could be used to align the edges of the sample banknotes during the reproduction process. Coincidentally, examination of the untrimmed counterfeit HK$100 banknotes revealed the presence of the image of the adhesive tape with pencil marks (Figure 6b). Similarities in relative alignment of the pencil marks on the untrimmed counterfeit banknotes and those on the adhesive tape are significant, indicating that the counterfeit banknotes were produced by the seized printer.

The ink profiles of the printing inks on the counterfeit banknotes in this case were also studied and compared with those on the control printouts from the seized Lexmark X83 printer, using the TLC method. The consistency of the TLC

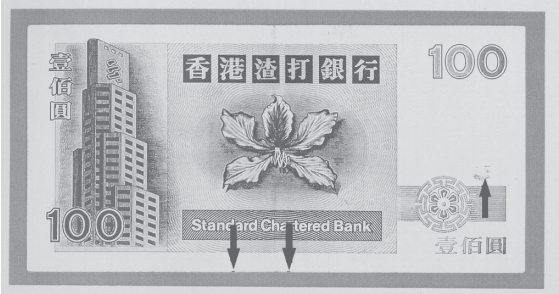

Figure 7a. Seized genuine banknote.

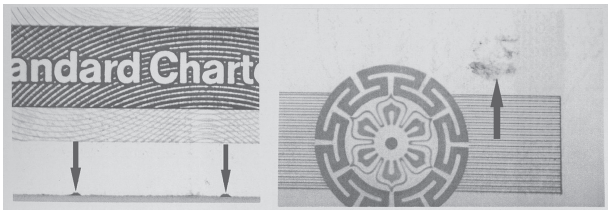

Figure 7b. Defects and dirt marks on the counterfeit banknote.

results of the printing inks on the counterfeit banknotes and those of the Lexmark X83 printer provided additional evidence of proof that the counterfeit banknotes were generated from the seized Lexmark X83 printer.

Case Three

During a photocopying process, in addition to reproducing the image of the original document(s), any defect traces such as dirt marks, crease marks, or damage on the original copy might also be reproduced. Therefore, if defect traces were present on a sample genuine banknote, it is expected that photocopies from the genuine sample would also bear the same defect traces. In a third case, three genuine HK$100 banknotes and a number of counterfeit HK$100 banknotes were seized from a clandestine factory. Microscopic examination of these seized genuine banknotes revealed some dirt marks (Figure 7a). Examination of the counterfeit HK$100 banknotes also revealed the presence of similar marks (Figure 7b) in corresponding positions. As the marks on the genuine banknotes were randomly distributed, they were believed to be distinctive. In other words, it is highly unlikely to find two genuine banknotes bearing dirt marks at the same position. Thus, the three genuine HK$100 banknotes seized from the scene must have been used as templates to produce the counterfeit HK$100 banknotes. Although dirt marks or defects might not always be found on genuine banknotes, identification of the presence of such features provides useful evidence.

Case Four

In the fourth case, an all-in-one color inkjet printer, some pieces of A4 paper with untrimmed counterfeit banknotes (each containing three images of HK$20 banknote) (Figure 8a), and a piece of A4 paper with some predesigned grids (Figure 8b) were seized from a clandestine factory. As shown in Figure 8b, some pieces of adhesive tape were found on the A4 paper. It was suspected that the adhesive tape was used for fixing the position of the genuine banknotes during the reproduction process. Examination of the A4 paper containing the untrimmed counterfeit banknotes revealed the presence of the grid lines in which the relative alignments and relative position of the excessive ink deposited on the grid lines were similar to those found on the A4 paper (Figures 8a versus 8b). The hand-drawn lines, together with the presence of excessive ink deposits on the lines, were the

Figure 8a. A4 paper with drawn predesigned grids.

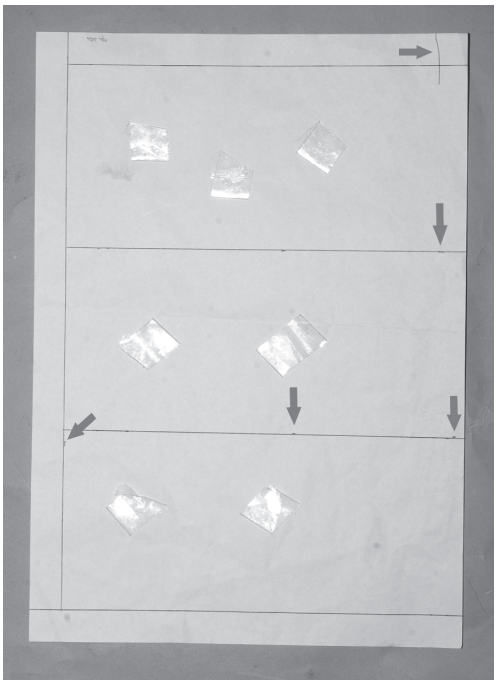

Figure 8b. Pieces of adhesive tape found on A4 paper.

distinctive features of the seized A4 paper; and the agreement of these features with those on the untrimmed counterfeit banknotes indicates that the three banknote templates had once been adhered to the seized A4 paper bearing lines used for aligning the edges of the sample banknotes.

Conclusion

All-in-one color inkjet printers can be used as photocopiers for making counterfeit banknotes. In addition to the images of the sample banknotes, any other extraneous markings such as dirt marks and markings on the flatbeds of the printers will also be reproduced on the counterfeit banknotes during the photocopying process. Agreement in the respective positions of these markings on the sample banknotes and those on the scanning surface of the all-in-one printer and the counterfeit banknotes could provide useful evidence for linking the counterfeit banknotes with the sample banknotes and/or the printers.

The TLC ink profiles of the printer inks have been found to be useful for differentiating various printer inks. Although a close match between the ink profiles of the printer inks in the printer and those of the counterfeit banknotes is not conclusive, the finding does strongly indicate a link between them.

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