

## TECHNICAL NOTE

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# Infrared Luminescence of Indented Writing as Evidence of Document Alteration

**REFERENCE:** Sharf S, Gabbay R, Brown S. Infrared luminescence of indented writing as evidence of document alteration. *J Forensic Sci* 1997;42(4):729-732.

**ABSTRACT:** A case involving the suspected addition of a line to two sales slips of the same transaction was investigated. Using infrared luminescence, indented impressions on one document were found to originate from writing on the second copy, and vice versa. The source of the luminescence most probably originated from the paper which was found to have a coated back of leucodye microcapsules, as such that is found in carbonless copy paper. The context and locations of these indented impressions enabled one to determine the sequence in which the entries were written, and to prove that the questioned entries were added later.

**KEYWORDS:** forensic science, questioned documents, infrared luminescence, indented writing, alteration

Questioned document examiners often face the task of deciphering indented marks. In cases in which these impressions are luminescent, the interpretation process is greatly simplified. The origins of this luminescence might be the transfer of components of the writing ink, such as the vehicle, to the undersheet, or the transfer of components of the paper, such as a coated layer (1,2). In many cases, however, the exact reason cannot be determined as the original document that produced the indented writing is not available for examination. In the case reported here, indented impressions were found on the two documents submitted for examination. The impressions on each one were found to originate from writing on the other. Furthermore, both documents were found to have a coated back of a carbonless copy-like paper.

Carbonless copy paper consists, in general, of a top sheet with a coated back (CB), and an underlying sheet with a coated front (CF). When pressure is applied to the top sheet with the coated back, the impressions of the writing are transferred to the front side of the underlying sheet of coated front paper. The CB paper has microcapsules containing a leucodye, such as crystal violet lactone. This is colorless until treated with a weak acid contained on the face of the CF paper, where it reacts to form a colored compound, which is the writing seen on the carbonless copy (3). When impressions are made on a CB paper which is resting on a

non-CF paper, the writing will not develop visibly, but the leucodye is still transferred. Therefore, even when indented impressions from this writing are not seen with oblique lighting or with the ESDA, they remain highly luminescent in the near IR (1,2).

### Case Report

A taxi driver who sold his partnership in a taxi company lodged a complaint claiming that the sale agreements were altered by addition of a line after he had signed them. During the transaction at least two documents had been handwritten by the purchaser; one was addressed to the company's attorney (labeled "A" in Fig. 1) and the other to the taxi company (labeled "B" in Fig. 1). The documents stated that the vendor transfers his share to the purchaser and henceforth rescinds his rights of ownership. They also state that the vendor received a cash payment of NIS 30,000 from the purchaser. The taxi driver pleaded that the line stating the payment was added after he had signed the documents.

### Examination

The two above-mentioned documents were submitted for examination. The questioned entries are enclosed within the dashed line in Fig. 1; in both documents they appear in the eighth line. Routine examinations began with visual inspection of the documents which were written with blue ball-point ink on plain memo paper belonging to the taxi company. The ink-line in the questioned entry was noted to be darker and thinner than that of the rest of the text, and in spite of the wide spacing in the rest of the writing, the questioned entries seemed somewhat compressed. In "A" the spacing between the questioned entry and its preceding line is significantly smaller in comparison to the other line spacings in both documents, and in "B," the size of the words in the questioned entry and their spacing get progressively smaller towards the end of the line. These findings raised the possibility that the questioned entries in the eighth line in both documents were not written concurrently with the rest of the text.

Both sides of the documents were examined under UV light. The backs of the documents fluoresced whereas the fronts were relatively absorbent. No indented writings were noted under these conditions. Using oblique lighting, several indented impressions were found on document "A," but their content was found to be irrelevant to this case. When both documents were examined with illumination in the visible range using the VSC-1 with its own

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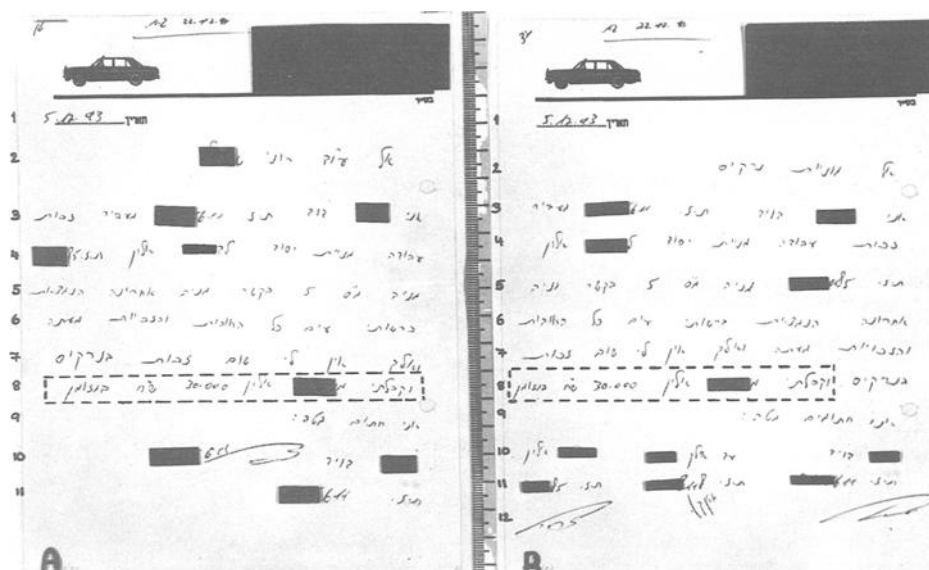


FIG. 1—The two documents in question, labeled "A" and "B."

TABLE 1—Photographic parameters used to differentiate between original writing and indented impressions (Set 1) and between original writing and question entries (Set 2).

	Set 1	Set 2
Barrier filter	Kodak gel filter No. 92 ( $\lambda_{trans} > 620 \text{ nm}$ )	Kodak gel filter No. 70 ( $\lambda_{trans} > 650 \text{ nm}$ )
Bandwidth of photograph	$620 \text{ nm} > \lambda > 690 \text{ nm}$	$650 \text{ nm} > \lambda > 690 \text{ nm}$

In both sets, illumination was with the Polilight at 530 nm, using a Kodak Technical Pan 2415 film.

light source or with the Polilight,<sup>2</sup> these, and also other entries which had not been visible, showed infrared luminescence. None of these impressions were successfully developed using the ESDA.

Initial optical examinations showed that the luminescence of the indented marks was weak relative to that of the writing ink, and that the questioned entries were not significantly different from the rest of the text. Therefore, several sets of photographic conditions were tried in order to enhance the differences between all of these impressions. The optimum conditions that we found are given in Table 1, Sets 1 and 2.

In Set 1, conditions are given that differentiated between the indented impressions and the actual writing. The former showed luminescence, whereas the latter absorbed (Fig. 2). Under the conditions specified in Set 2, the questioned entries mostly absorbed with a slight hint of luminescence, although the rest of the written text showed stronger luminescence (Fig. 3). This corresponded with the darker shade of the questioned ink lines, as mentioned above, and therefore we did not take this result as being conclusive proof of two different types of ink.

A closer look at the luminescent indented impressions on document "A" revealed the line in question in document "B" plus the signature of the purchaser who wrote these documents and was

the suspect in this case. The indented impressions found on document "B," on the other hand, showed the complete text of "A" except for the questioned entry—line 8—which is missing.

The ink in the documents was examined with the microspectrophotometer, but no conclusive difference between the questioned entries and the rest of the writings was observed.

The questioned entries were tested using thin layer chromatography with two different solvent systems, and compared with chromatograms from samples taken from the rest of the text (4), but no conclusive difference between these inks was found. The paper controls developed purple and pink bands at the solvent front in addition to the brightener. These bands did not fluoresce under UV radiation, but did show infrared luminescence which led us to search for additives in the paper such as leucodyes as found in carbonless copy paper. Dilute HCl, silica gel and a special pen provided by "Nirotek," (an Israeli company that manufactures carbonless copy paper), all of which react as weak acids, gave coloration of the back of the documents that is characteristic of a coated-back (CB) carbonless copy paper.

In order to verify further that documents "A" and "B" were indeed written on a carbonless copy-like paper, they were examined with the SEM. The reverse side of the documents show two main features in addition to the papers fibres; numerous "small" spheres ( $d \approx 3\text{--}8 \mu\text{m}$ ) and a few "large" rounded particles ( $d \approx 20\text{--}30 \mu\text{m}$ ), (Fig. 4).

The "large" rounded particles contained starch, as was found

<sup>2</sup>Polilight® is a multiwavelength xenon light source ranging from 350 to 1000 nm which was initially developed to enhance the fluorescence of latent fingerprints. However, it can also be used successfully for other applications, including document examination.

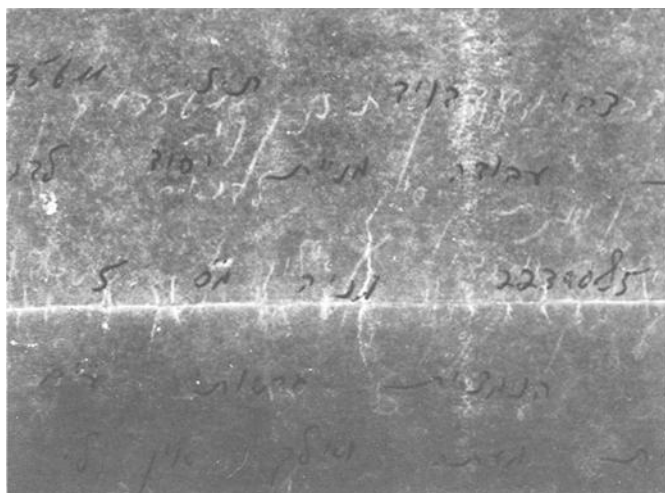


FIG. 2—A section of document “B.” The visible writing appears in black, whereas the indented impressions luminesce. Photographic conditions are given in Table 1, Set 1.

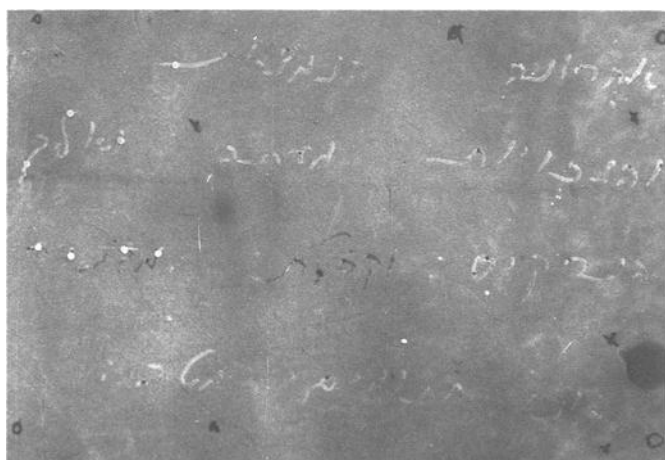


FIG. 3—A different section of document “B.” The visible writing shows weak luminescence whereas the questioned entry mostly absorbs. Photographic conditions are given in Table 1, Set 2.

when treated with a solution of iodine. These particles are a spacer which protect the dye-filled microcapsules in the coated back of carbonless copy paper from bursting under random pressure. The “small” spheres are the microcapsules themselves, and the paper as a whole is similar to the CB sheet in carbonless copy papers.

Using an Olympus PX 60 microscope with a UV fluorescence light, (excitation at 360–370 nm, viewing at  $\lambda_{trans} > 420$  nm) in reflectance mode, magnification  $\times 200$ , large fluorescent irregularly-shaped particles of lengths 20–80  $\mu\text{m}$ , are seen (Fig. 5).<sup>3</sup> These particles are possibly a tag introduced by the manufacturer of part of the paper; their origin is not quite clear. Their presence probably explains the stronger fluorescence of the reverse sides of the papers.

<sup>3</sup>The Olympus PX 60 can also be used with a white light, where the microcapsules and starch spacers can be seen, albeit at a lower quality than that observed with the SEM.

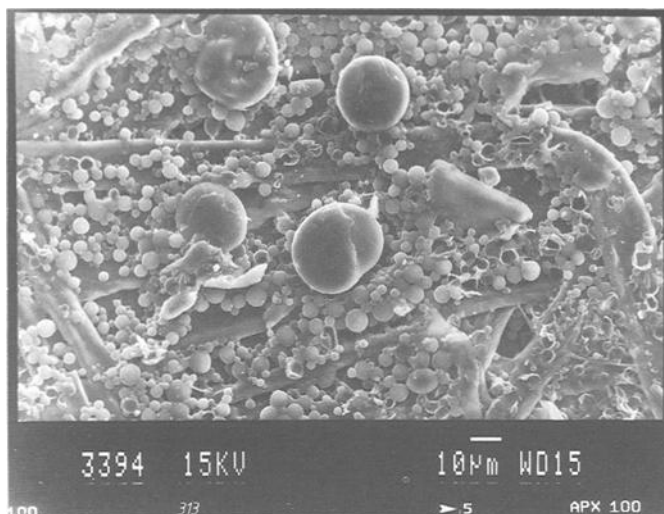


FIG. 4—A SEM photograph of the coated back of document “A” showing the paper’s fibers, spacers, and microcapsules of its coated back (CB) layer.

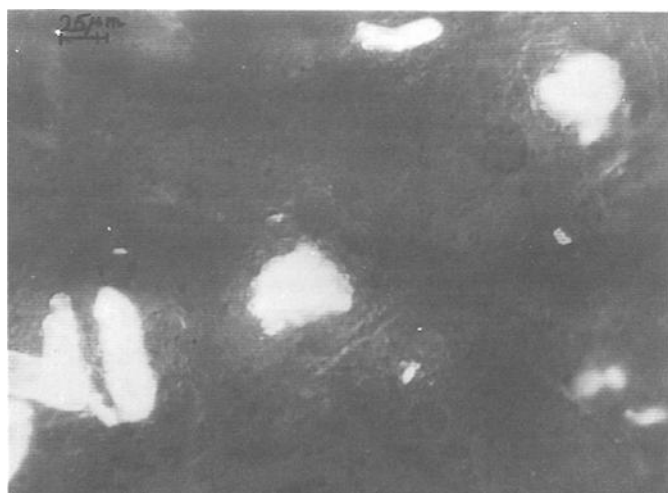


FIG. 5—A magnified section of the back of document “A” showing UV fluorescent particles; possibly a tagging system of the manufacturer.

## Discussion

The above findings imply that document “A” was written and signed while resting on the paper of document “B.” The questioned entry concerning the payment was not written at that stage. In document “B” the situation is reversed. The questioned entry on document “B” was written when it was resting on document “A,” but not the rest of its text, and therefore it can be concluded that it was not written concurrently with the rest of the text.<sup>4</sup> The paper of the notepad was possibly manufactured for intended use as a carbonless copy paper, but ended up, for one reason or another, as paper for notepads.

<sup>4</sup>A third document was submitted at a much later stage in the investigation. On this document the text of document “B” was found in indented impressions, except for the questioned entry and the signature of the suspect, which were found as indented impressions on document “A.”

The microcapsules containing the leucodye explain the infrared luminescence of the indented writings. Their presence enabled the determination of the sequence of the various entries, and therefore to conclude that the entries in question were made at a later stage with respect to the rest of the text.

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