

Erasable Inks and Writings: Review with Forensic Examination Perspective

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Abstract - In general, alteration such as addition, obliteration and deletion etc., is stand out amongst the most widely recognized kind of fraudulent cases encountered. Mainly, examination of questioned documents might be divided into non-destructive and destructive examination. Under most conditions, non-destructive visual microscopic examination and comparison against respective concerned samples are preferred to avoid any damage on the disputed documents, which have to be presented as exhibits in the court of law. Document Experts are frequently facing the problem of vanished writings including erasable or disappearing writings. To demonstrate such vanished writings, either non-destructive methods (using magnifying hand lenses, electronic microscopes, different types of light, infrared illumination) or the destructive methods by the aid of chemicals are used. Using others writing equipment in trust instead of own one, create cases of erasable ink writings. In such cases writings written through special erasable inks are erased by using a rubber and further, the writing text is changed to desired content by fraudsters. This review study explains about erasable inks as well as tools and techniques used in their examination.

Key Words: Erasable ink, Erasable writing, Disappearing ink, VSC, Document Expert.

INTRODUCTION:

Many ink compositions are available on the market and might differ significantly depending on the type of writing instrument (e.g. fountain, felt tip, roller ball or gel pens) or printer used (e.g. inkjet, toner or security printers). Inks are mainly composed of the following ingredients with some exceptions (e.g. toner printers do not require a solvent):

- dyes and/or pigments (to colour the ink),
- vehicles (to solubilize the dye and apply it smoothly on the paper),
- resins and additives (to adjust the different ink properties).

Numerous types of documents can be produced and /or personalized using impermanent inks, such as, an erasable ink (an erasable ink is defined as ink removed easily by using certain rubbers incorporated in each pen

or any rubber or by scratching using any solid substance). [4]

Thermal ink is a type of erasable ink which is removed easily by the friction produced by rubbers incorporated in each pen. It has different colors like red, blue, green and black. Such inks can be removed from the paper surface mechanically through erasure or by exposure to heat and cooling simultaneously. It is a type of viscous ink that depends largely on the heat generated during erasure which affects the solvent of ink. For the ink to disappear or fade the ink requires an external heat such as friction through eraser or through direct exposure to temperature. [10]

Thermochromic inks are known for their poor stability against UV light, appearing differently in leuco dye-based and liquid crystal-based ink types. The leuco dye-based inks lose the colour contrast between the coloured and discoloured states but the temperature at which the colour changes stays the same. These inks retain thermochromic functionality, i.e. the relation between colour and temperature, as long as the colour contrast between both states remains visible. [8]

Other types of inks are now available which can be erased simply by swiping by a special rubber incorporated in each pen over the original text. These inks have been used for fraudulent purposes. Forensic scientists especially in the examination of questioned documents have long been familiar with the erasable ball-pen sold in the UK under the product name "Replay" and manufactured by Paper Mate. The long-established Paper Mate "Replay" erasable ball-pens have been rebranded in the UK as "Eraser. Max": a recent addition to this class of writing instruments is the pilot "Fraxion" erasable roller ball pen. [2]

In 2006, Pilot Pens, Inc. released the FriXion erasable ball pen, a new type of erasable pen. Previous erasable pens, such as Papermate's Erasermate, erased ink by using a conventional rubber eraser that physically lifted ink and some paper away from paper surfaces. The ink from the FriXion pens is "erased" by a completely different phenomenon; the heat caused by friction between its hard, smooth plastic "eraser" and the paper

containing the ink causes the thermochromic ink to turn colourless. This colour change has also been found to be reversible. [1]

An erasable ink pens from the Ballpoint ink pens category but differ in stability on papers or documents, where an erasable ink strokes or ink-lines erased easily by eraser or heat, so, value documents grafted with some polymeric compound such as poly vinyl pyrrolidone (PVP) and poly vinyl alcohol (PVA) to stabilize strokes of an erasable ink on papers or value documents. [4]

Methods which used to check or examine documents that were wrote by using an erasable ink are very important in forensic examination such the indented writing on a document from the writing process or a pressure caused by writing, so we can obtain the physical evidence to prove (fraud) forgery. [4]

Techniques used for decipherment/examination of ink:

The optical examinations of documents are considered superior at the first examination of the documents. In 2013 Braz et. al, published a review article on using of Raman spectroscopy for the analysis of inks on questioned documents, where this technique is very important for inks and paper analysis. Infrared spectroscopy is a common technique in the analysis of inks from questioned documents which can be useful to solve crimes. FT-IR spectrometer has been used in combination with Scanning Electron Microscopy/Energy Dispersive X-Ray Spectroscopy (SEM-EDXS) mapping to successfully determine the sequence of intersecting lines of ink. Ink analysis involved the examination of documents using the naked eye, oblique lighting conditions with special optical filters. It can be performed using optical, spectroscopic and chromatographic methods. Diffuse Reflectance Infrared Fourier Transform Spectroscopy (DRIFTS) was utilized for the analysis of ink samples using KBr as a background. This analysis was found to give discrimination between the ink spectra. Also, Micro-Attenuated total reflection with infrared spectroscopy (Micro-ATR-IR) was found to be a simpler technique for acquiring and getting on the spectra of ink samples but it is more easy. FTIR was used to analyze different historical writing ink samples and revealed the possibilities to identify the historical ink based on their chemical composition, and the nature of ingredients in different types of inks. However, only KBr pellet and ZnSe cell methods were successful. On multivariate chemometrics for the forensic discrimination of inks based on their visible spectra showed that the results of Ultraviolet-visible spectra of ink were difficult to compare but, the used ink sample seized or confiscated was very important to overcome this problem. Each of the spectra represents the average of the absorption from the same batch. Chemometrics application such as, discriminate analysis (DA), principal component

analysis (PCA) and cluster analysis (CA) were successively used to calculate the discriminate model. UV-VIS examination may indicate that the document has been stained by chemicals or other materials that may affect the ink analysis. [5]

A thermosensitive pen PILOT FriXion erasable ink pen (Figures 1 and 2 mentioned below) is easily available on the market and has ink that can be removed by heat produced due to friction of the eraser provided along with the pen as one of the factors. Due to the eraser, the surface of the document might get affected and its presence can be felt by a trained document expert. [9]

DISCUSSION:

To keep the FriXion erasable ink colourless at low temperatures, it must be cooled so quickly that it does not have sufficient energy to surmount any kinetic activation barriers, preventing the ink from converting from the thermodynamically most stable high-temperature colourless form to the thermodynamically most stable low-temperature coloured form. This is an example (Figures 1 and 2) of kinetic trapping, which manifests itself in other ways in chemistry. [1]

Disappearing ink is a substance that is made from a number of chemicals with the purpose of having the ink visible to the eye for only a certain period of time. This type of ink is made without the intention of becoming visible again once it has disappeared. It operates on the principle of acid/base chemistry. The ink is blue because a particular molecule in the solution, "thymolphthalein", turns blue in the solution that is basic. The same molecule is colourless under neutral conditions; not all disappearing inks are based on the described mechanism. The best example is the FriXion Ball pen. [12]

Disappearing inks have been used in different fields, but it may be abused in forgery and counterfeiting. The prepared auto-vanishing inks were applied to different types of handwriting papers. Deciphering the faded handwriting did not respond to different light sources. All the faded handwriting was visible when treated with alkaline solution. The fading time of disappearing ink in the current results varied between 2 to 40 h on the examined paper documents. [13]

The erasable pen has a small eraser fitted into the pen tip. It removes the bulk of the written line, but a pale trace of it remains readily visible to the unaided eyes. The action of the eraser is not so much to abrade the ink-line, but to generate heat through friction and decolorize the ink-line. Not coinciding with the recent findings, the decline of the ease of erasure with increasing time from writing is not a reported characteristic and methods of determining the erased words were also different. [14]

In contrast, the erasable ink could not be seen under ultraviolet light, but coinciding with the current results, the erased ink lines could be seen under infra-red luminescence, but it is not seen as its original blue line, a matter that could be referred to the differences in the wavelengths used and the camera used (the current study used VSC-6000 and VSC-2000). [15]

In spectroscopic methods, the inks were analyzed by means of Ultraviolet visible (UV-Vis) and infrared (IR), (Raman) spectroscopy, and thin layer Chromatography (TLC). UV-Vis analysis was successful in discriminating ballpoint pen inks and Blue an erasable Pen inks of different brands. IR, Raman analysis revealed that each brands for blue ballpoint pen ink and Blue an erasable Pen inks samples that are E1 (Reynolds Blue pin, E2 (PRIMA solo Blue pin), E3 (Blue an erasable Pen inks XZB 0,8 mm), E4 (Blue an erasable Pen inks SCMv12590,5mm) and E5 (Blue an erasable Pen inks Frixion" eraser.max) could be discriminated by looking the pattern of each spectra. the fingerprint regions for inks Infrared spectra at range $\approx 700 - 1800$ cm^{-1} in which many of inks constituents, as well as which using thin layer chromatography methods, we could be discriminated also depended on the retardation factor, (Rf). In case matching inks database if library inks present. Thus, the Raman Analysis spectra can differentiate between brands (E1, E2) of blue ballpoint pen ink and (E3, E4 and E5) for erasable Pen inks. [3]

The colour of erasable ink did not generally change by time at room temperature but changed on exposure to UV light. The polymer component of erasable ink is chemically bonded with polycarbonate polymer leading to ink stability. [5]

Detection of ghost strokes under VSC-6000/HS with different functions, like fluorescence spotlight and specific (300 to 365 nm) UV range will provide a new avenue by, which the forensic document scientist can identify the erased writing that might otherwise go undetected with other more frequently used methods. [6] As per Kaza et al. (2022) to tackle away problem of erasable ink/disappearing ink, always use a personal pen for writing/signing all important documents. Bank officials should be given training in dealing with such types of frauds in various forensic science laboratories or courses which may be organized for them by forensic scientists. As per the mode of operation in such frauds, the signature on the bank cheque was created with original non-disappearing ink, while the body writing – with the disappearing ink, so is manipulated. Hence, bank officials should take extra precautions while dealing with bank instruments which are written and signed with two different inks. [9]

CONCLUSIONS:

Auto-vanishing inks are available under the name of 'Magic' at most local fabric or sewing machine stores. They are designed to be used for making patterns in dressmaking and the ink will disappear within 2–40 h. When such inks are used in the writing process, they do not disappear from all the paper types at the same time. The ink when disappeared cannot be detected by UV light, infra-red illumination, or by the other conventional methods of examination. A weak solution of sodium hydroxide when sprayed lightly over the suspected writing will cause the ink to reappear for a brief period of time without inducing any harm to the remnant of the document. The introduction of erasable ball-point pens increased the likelihood of erased pre-decolorized writings in criminal activities. This article alerts the forensic science community to the existing erasable ball-point pens and describes a method in deciphering it. The strong luminescence displayed by traces of the erasable ink strokes under high wavelengths of infra-red light (VSC-6000) will provide a new avenue by which the forensic document examiner may detect the erasure that might otherwise go undetected with other more frequently used methods. This research paper alerts the forensic scientists as well as banking and insurance companies, law enforcement agencies, vigilance departments, bank customers, laymen etc. about the erasable ink pens and describes various method of deciphering it.

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