Using an erasable ink to forge documents, medico-legal study on evaluating them in detection and prevention the forgery

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Abstract: The examined inks in forensic chemistry suffer some problems due to using an erasable ink pens in writing documents. (An erasable ink is a type of an ink which could be used to forge documents and easily removed by certain rubbers incorporated in each pen) For an erasable ink, the written strokes were manipulated manually using the incorporated eraser. The examined of an erasable ink pens and its strokes by the aid of the document apparatus such as video spectral comparator, Projectina Docucenter, magnifiers, microscopes and electrostatic apparatus. Therefore we can be prevented from used in the forgery operations (fraud). An erasable ink pens from the Ballpoint ink pens category but differ in stability on papers or documents, where an erasable ink strokes erased easily by eraser or heat, so, the value documents grafted with some polymeric compound such as polyvinyl pyrrolidone (pvp) and polyvinyl alcohol (pva) to stabilize strokes of an erasable ink on papers or documents.
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Keywords: Erasable ink pen, forgery, fraud (fraudulent), document, forensic examination, mechanical eraser, rubbers and grafting copolymerization.

1. Introduction:

Analysis of permanent ink may be important in forensic science, i.e. establishing whether a document is authentic or fraudulent or whether written entries come from a common source (same ink formula). This may require identification of the manufacture and the specific formula of the ink **[1].**

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) **[2].** Where, an erasable ink pen used to forge documents causing problems for people. These problems may be solved by using different methods to prevent lying people in these cases.

These methods are applied for ink using different types of papers to decipher and stand on nature of this erasable ink and we can know the nature of these ink-lines or ink strokes of an erasable ink, strokes erased demonstrated and reappearing by cooling or freezing in some cases, consequently, we can demonstrated the faded writing. Problem of erasable inks, some people have badness faith used these inks in writing documents then erase this writing by using a rubber and changing the writing text to what they want without leaving any impact to see by the naked eye in order to achieve that gain to them.

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. **[3]** or a pressure caused by writing, so we can obtain the physical evidence to prove (fraud) forgery.

Currently, the inks used in modern pens contain many confusing substances to improve their properties. Generally, the most important component is the colouring material, which consists of dyes and pigments or a combination of them. Dyes are compounds that are solubilized in the ink vehicle. On the other hand, pigments are multimolecular granules insoluble in the vehicle. The vehicle composition affects the fluidity and the characteristics of the ink. It is usually composed of oils, solvents and resins. Other substances may be used to adjust the characteristics of the ink, such as driers, plasticizers, waxes, greases and surfactants (soaps and detergents) **[4,5]**.

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 the most investigations. The techniques regarding the analysis of inks can be divided into non-destructive and destructive approaches. **[6].**

In forensic work, analysis of ballpoint pen inks on questioned documents is often required in the field of forensic analysis to know the writing implement used in the carrying out a crime. It is thus necessary to identify the manufacturer of the pen or the specific ink product.

The existence of various ballpoint ink types can lead to a serious problem with selection of the most efficient extracting agent for colouring matter. When choosing an extracting agent, the forensic examiner should take into account the composition, polarity, density, and viscosity of selected reagents. In addition, the most important factors are boiling point, resistance, and purity of solvents, as well as the disadvantageous influence of the extracting mixture on analyzed inks (oxidation and disintegration) and paper (physical damage). Organic solvents in which such kinds of undesired self-activating processes occur should be definitely rejected. All the above-mentioned features may have serious impact on the sample preparation process and subsequent analysis**. [7]**.

Removal of a small section of the ink line or strokes followed by solvent extraction of the ink opens up more avenues of analysis.

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. **[8-17]**.

Paper as a carrier material for written information was introduced in Europe in twelfth century. It is a multi-component material, and because of its complex and varied nature, research findings in paper chemistry can be difficult to interpret, needing both chemical and physical methods to understand its characteristics. The overall behaviors of paper (chemical, mechanical properties, stability, degradation. etc) are strongly dependent upon the nature, origin, and characteristics of component as well as upon their interaction. Paper chemical and its properties will also be dependent upon manufacturing processes. The paper component can be classified according to their origin, chemical structure, and function, such as fiber (composed mainly of cellulose, but also of lignin, hemicelluloses and other minor components), mineral particles, (talc, kaolin calcium carbonate, etc) natural sizing agents (as starch or rosin) or synthetic ones as { alkyl ketene dimer (AKD) and alkenyl succinic anhydride (ASA)} colorants, and other substance. **[18]**.

Forensic document examiners are mainly interested in the identification of signatures and handwriting, but they are also interested in writing materials and printing equipment. The composition of inks, papers and the materials from which documents are produced can be of great significance in a case. With respect to the identification and interpretation of alterations, deletions and additions to documents, a study of the chemical composition of the ink used on documents may confirm whether or not two documents were written using by the same pen **[19, 20]**.

And in finally for this introduction what is a Forensic Document Examiner? The American Board of Forensic Document Examiners (FDEs) defines forensic document examination as follows:

"Forensic document examination is the practice of the application of document examination to the purposes of the law. Forensic document examination relates to the identification of handwriting, typewriting, the authenticity of signatures, alterations in documents, the significance of inks and papers, photocopying processes, writing instruments, sequence of writings and other elements of a document in relation to its authenticity or counterfeits". **[21]** But with Revolution of information, digital Technology, multimedia crimes, and the newly composition of inks, the Forensic Document Examiners (FDEs) have hard effort to keep up with developments and confronts to these crimes.

2. Aim of the study

To know if the documents that were written by Erasable ink pen, we can be erased using erasers and then converted the original data for the documents to a new text, where frauds are illegal operation, as well as studying the shape and the nature of erasable ink pen and its strokes or ink- lines, and how can be stabilized strokes or ink-line of an erasable ink on papers or value documents, therefore we can be prevented from used it in the forgery operations (fraud) by grafting process as possible.

3. Materials

3. I pens

Different type from Ballpoint pens containing blue colored erasable inks and with a small eraser incorporated within the pen, which are made in china or Japan as:

3.1.1 blue colored Erasable ball point pens inks and with a small eraser incorporated within the pen typed is(XZB 0.8 mm), made in china (pen code E1)**.**

3.1.2 Blue colored erasable ball point pens inks and with a small eraser incorporated within the pen typed is (SCM v1259, 0.5mm), made in china**.** (Pen code E2)**.**

3.1.3 Blue colored erasable ball point pens inks and with a small eraser incorporated within the pen typed is (the pilot ‘‘Frixion’’), made in Japan (pen code E3)**.**

3.2. Paper Specimens (different papers).

3.2.1 Papers

Different types of local **(**commercial) papers sheets were used in this study. These paper sheets were kindly delivered from **Rakta, Quena and Edfu** Paper Mills, and were made of:

3.2.1.1 Local writing-photocopy and printing paper (80 grammage) made of 80% rice straw Kraft pulp +15% bleached soft wood pulp+5%machine broke locally produced at **Rakta** mill, Alexandria, Egypt (Paper Code, P1).

3.2.1.2 Local writing-photocopy and printing paper (80 grammage) which is made of 80% bleached bagasse Kraft pulp+15%bleached soft wood + 5% calcium carbonate which is locally produced at the Distilling Company and Egyptian sugar at **quena** Egypt (Paper Code, P2).

3.2.1.3 Local writing-photocopy and printing paper (80 grammage) which is made of 70% bleached bagasse Kraft pulp +25% bleached soft wood + 5% calcium carbonate which is locally produced at the Distilling Company and Egyptian sugar at **Edfu** Egypt (Paper Code, P3).

3.2.1.4 Notebook trust receipts, which are number ten receipts with a white background, locally made with laser printing (Paper Code, P4)**.**

3.2.1.5 Notebook trust receipts, which are number ten receipts with a blue background, locally made with laser printing (Paper Code, P5)**.**

3.3 Tools and Instruments

3.3.1 Magnifying glasses.

3.3.2 Microscopes.

3.3.3 Video Spectral Comparator 6000 (VSC6000).

3.3.4 Ultraviolet lamp.

3.3.5 Projectina Docucenter (4500).

3.3.6 Electrostatic Detection Apparatus (ESDA).

3.3.7 Oven, WTB Binder 1505, Germany.

3.4 Chemicals

H_2O_2 as initiator**,** poly vinyl pyrrolidone (pvp), and poly vinyl alcohol (pva) for grafting copolymerization.

4. Methods

4.1 Different types of papers mention previously [Rakta (P1) - quena (P2) - Edfu (P3) - Notebook white background (P4)-Notebook blue background (P5)] these are listed in **table1**.and some of Physical, Chemical, mechanical and optical properties of blank sample tabulated in **table 2**. These mention papers were used in writing by used Erasable pen ink, where sample[XZB 0,8 mm (E1) [sample] SCMv12590, 5mm (E2) are made in China, and Erasable ink pen is]The pilot ‘‘Frixion’’eraser.max (E3)] a recent addition to this class of writing instruments made in Japan **[22]**, also some of quantity of an erasable ink collected in bottle and marked these are listed in **table 3.**

4.2 According to the erasable ink, the ink-line or the ink strokes were manipulated using the eraser that is incorporated within the body of the pen **[23],** and also the other Erasers (Rubbers).

Table(1): Sample of Papers of different brands

No.	Paper Brand	No. of Paper	Code of Paper
1	Rakta	10	P1
2	Quena	10	P2
3	Edfu	10	P3
4	Notebook white background	10	P4
5	Notebook blue background	10	P5

Table (2): Physical, Chemical, mechanical and optical properties of blank sample (p1, p2, p3, p4 and p5)

Experiments \ Type of papers	P1	P2	P3	P4	P5
Basis weight(gm/m^2)	83.3	83	83.5	83	83
Tensile test(Kg/cm)	5.700	5.927	4.512	4.512	4.500
elongation test(cm)	0.50	0.50	0.53	0.44	0.46
Tearing test(Kg / m^2)	40	53	48	38	38
Bursting test(kg/ cm^2)	2.37	2.71	2.38	2.38	2.38
Sizing (seconds)	4	4	3	3	2.5
Roughness(kilo. gram / cm^2)	300	320	320	340	330
Thickness(μ m)	110	109	99	100	95
Opacity (%)	93	91.30	90.8	90.8	90
pH	7.5	7	6.5	6.5	6.5
Whiteness (%)	89	95	95	95	91

Table (3): Sample of Blue Erasable pen inks of different brands

No.	Ink Brand	No. of Pens	Pen code	manufactured
1	XZB 0,8 mm	10	E1	China
2	SCMv12590,5mm	10	E2	China
3	Frixion'' eraser.max	10	E3	Japan

5. Experimental

5.1 Shape examination erasable pens

Shape examination of erasable ink pens occurred by naked eyes, **Fig. (1).**

Fig. (1) Shape of erasable ink pens

5.2 Optical examination of strokes of an erasable ink pens

5.2.1 Magnifiers and Microscopes

5.2.1.1 Examination with magnifying lenses

The surface of the paper deliberately examined by magnifying lenses, as well as, the emergence of fiber paper erasure is important to also show some of the lingering effects of a tool such as itchiness small parts of rubber or glass powder and also strokes or ink-lines of writing of an erasable ink pens will be examined **[24].**

The magnifying lenses such as, a hand magnifiers, illuminated magnifiers and binocular magnifiers with different **X. [25].** In a different light sources (direct and oblique light). **[24], [26[**

5.2.1.2 Microscopic examination

5.2.1.2.1 Episcopic illumination

Under this illumination an erasable ink are examined, the shapes and the Specifications of these Strokes.**[27,28]**

5.2.2 Examination with different Lights

5.2.2.1 Transmitted Light

In cases of severe abrasion or itchiness, when exposing the paper to light, the scraped part seems more transparency and enforcement of the light from the rest of the parts of the paper, which handed than any of them because of the impact on the thickness of the sheet in place erasure.

5.2.2.2 Side Light

When exposing the paper to light from one side of the fiber paper, which liberated after the erasure and grabbed the polishing surface layer, confer a shadow over part of the surface of the paper, which was wiped showing them other than the rest of the parts of the surface of the paper, which maintains original refinement.

5.2.2.3 Oblique Light

Under oblique illumination at different X, different Strokes of an erasable ink can be observed.

5.2.3 Examination with VSC®60000

This is device contain filters in the visible, Ultraviolet and infra red rays, this device photoed and scanned the documents **[29].** Applications of Questioned Document are Examination of security features, Detection of alterations or forgeries, Revealing concealed or obliterated information, Visualization of TLC plates**,** penetration of ink on paper, mechanical and chemical erasing.

5.2.4 Examination with Projectina Docucenter4500

Examination with Projectina Docucenter occurred for Photoed and scanned the documents which have the same job of VSC®60000.

5.3. Inks Removal (process of erasure)

5.3.1 Percentage of the process of erasure of inks

Evaluation of the process of erasure was the naked eye because the erasure or when it is happening in the document, which is in the possession of the ordinary citizen does not have them tools can be sure of the process of erasure though but if he own some of the tools she does not have the ability to accurately detect erasures like experts or anyone working in the field of discovery of forgery **[30].** And the Percentage of The rest inks from papers are illustrated in **Table (4)** and **Fig. (2).**

Table (4). Percentage of the rest inks

No.	Pen code	% of The rest inks
1	E1	1
2	E2	1
3	E3	1

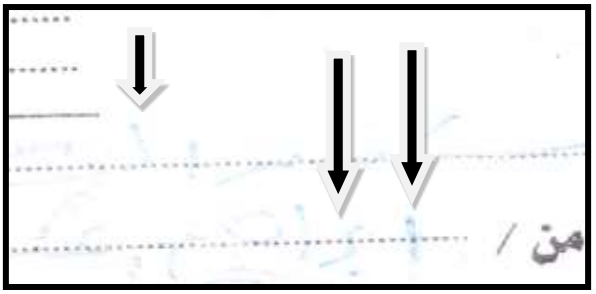

Fig. (2): Shape of erasable ink strokes erased of erasable ink pens at 40 X

6. Physical properties for paper

6.1 Thickness measurements (thickness examination)

The paper thicknesses obtained before erasing process by using erasers differ than paper thickness after erasing process that the coating layer surface of the paper is removed and consequently thickness decrease, cellulosic substrate surface of paper affected, Several Thickness measurements were taken at various position on each specimen and the average values were recorded**. [31-33].**

6.2 Roughness and Texture

The roughness is measured by a device present in Semo Company and the machine used in this work is Bendil Apper. the process of mechanical erasing extracted exterior of paper containing smooth matting thus appear fiber paper and acquires its surface texture rough in the place subjected to the process of erasing other than the parts that smelt of which it retains finger natural most softness.

7. Chemical composition of erasable Ink

In general, an erasable ink consists of elastomeric polymer, volatile solvent, nonvolatile solvent, pigments, dyes, and lubricants**. [34].**

8. Using Chemicals

8.1 The use of organic solvents

When a few drops of an organic solvent placed, that has a feature spread like gasoline or chlorine form or carbon tetrachloride on the surface of the paper, the part of this surface, which was wiped and still polished be more and faster scalability to drink the liquid and spread clearly distinct and that Unlike other parts of the paper, which handed over the process of erasing the spread of the liquid which is slow and limited.

8.2 Iodine

Iodine material which has a feature direct transition from solid-state to a gaseous state without passing through the situation of liquidity; When exposed surface of the paper to the fumes of iodine, the portion of the surface of the paper, which was wiped mechanical erase appeared fibers absorb the amount of iodine vapor is greater than the rest of the parts of the paper, which delivered from the process of erasure.

8.3 Powders colored

If splashed some powder colored soft on the surface of the paper to be tested regular spraying The parts that had been wiped take these powders in amount greater than the rest of the parts of the paper and take into account in this process - in order to achieve her success - to be the color of the powder is different from the color of the paper surface markedly and that the distribution of the powder along the surface of the paper equitably completely **[24].**

9. Electrostatic detection apparatus ESDA®

Since the Electrostatic Detection Apparatus (ESDA) was first commercially produced in the late 1970s by Foster and Freeman, (is oldest technique). Document Examiners have been greatly aided in their search for and decipherment of indented writing impressions or a pressure caused by writing, The EDSA is a non-destructive technique.**[35].**

Indented handwriting or a pressure caused by writing developed by an ESDA machine can be examined to determine the identity of the writer; however, results are limited by the quality of the text recovered. One limiting factor always present is the lack of ink (hence pen striations reflected in the ink).

10. Effect of heat

Some erasable ink strokes disappear by the effect of heat or sunlight**,** this test is carried out in case of the effect of heat by using oven) Oven, WTB Binder 1505 (or exposed erasable ink strokes to fire directly **[34]**.but these strokes reappear by freezing process.

11. The grafting copolymerization

Grafting preparation by treatment with poly vinyl pyrrolidone (pvp) and poly vinyl alcohol (pva). The grafting copolymerization is the process used in treatment materials to improve its properties and also used in preservation the ink which was written on papers and value documents.

11.1 Chemical activation of paper sheet

In the starting of reaction, the chemical activation of paper surface carried out in a flask where dipping the paper sheet in H_2O_2 solution, then paper sheet washed by using Distilled water, after drying the paper sheet, they dipped in poly (vinyl pyrrolidone) (pvp) and poly vinyl alcohol (pva) and mixture from pvp and pva at different concentration, at 10 minutes and then Leaved until to dry **Table (5)** show concentrations of the mixtures.

Table (5): show grafted polymeric compound concentrations.

Chemical Compounds	poly vinyl alcohol			poly (vinyl pyrrolidone			poly (vinyl pyrrolidone +poly vinyl alcohol		
conc.	0.5%	1%	1.5%	0.5%	1%	1.5%	0.5%+0.5%	1%+1%	1.5%+1.5%

12. Fading of Inks

Fading of Inks or fastness of inks on paper are measured by two a ways, the colour strength (K/S) and total colours difference (ΔE) for blue erasable ink different brands on paper sheet samples at different time, different brands amount of ink putted on surface paper sheet samples and allow to dry at room temperature at two year which Fading measure at one day, one year and two years. The change in value of the colour strength (K/S) and total colours (ΔE) measurements give information and the indication for fading of inks. Where each colour measured at wave length 70 nm**. Tables (6,7)** show the results **[36].**

12.1 Colour strength measurements (K/S)

The colour strength values of strokes erasable ink pen ungrafting and grafting samples as **Fig (3)** were measured using a Data Colour SF 600+ Relative colour strengths (K/S values) were determined at room temperatures degree between 20-25^{c} using the Kubelka- Munk equation. **[37, 38].**

K/S = (1-R) ^{2} /2R

Where, K is molar absorption coefficient,

S is the scattering coefficient.

R is the absolute reflectance of the ink on paper.

12.2 Total colours difference (ΔE)

The colour of all inks samples are examined by the naked eye in daylight and under ultraviolet lamp . The total color difference (ΔE) of defined area of ink between two specimens is measured using a Hunter lab colorimeter. The color between two specimens is usually designated by the use of A (L, a, b) and the total colour difference is the length vector sum of the individual, as in the following equation (the Berger-Schunn equation) **[39].**

$$\Delta E = [(\Delta L)^2 + (\Delta a)^2 + (\Delta b)^2]^{1/2}$$

Where (Δ**E**) is the total Color difference

L, a and b coordinated named by CIE L, a, b colour space values.

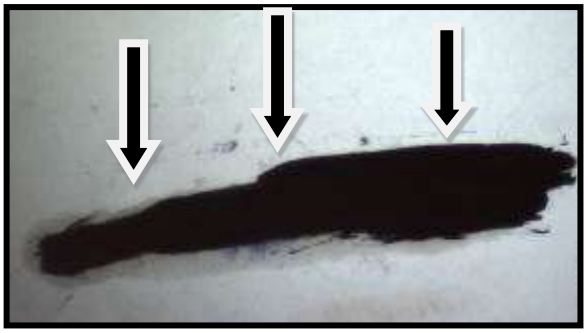

Fig (3) large stroke for erasable ink

Table (6): Colour strength measurements at different time for ungrafting samples

Pen Code	Paper Code														
	P1			P2			P3			P4			P5		
time	1 day	1 year	2 years	1 day	1 year	2 years	1 day	1 year	2 years	1 day	1 year	2 years	1 day	1 year	2 years
E1	5	3.1	1.1	5	3.1	1.1	5	3.0	1.1	5	3.1	1.1	5	3.1	1.1
E2	5	3.1	1.1	5	3.1	1.1	5	3.0	1.1	5	3.1	1.1	5	3.1	1.1
E3	5	3.1	1.1	5	3.1	1.1	5	3.0	1.1	5	3.1	1.1	5	3.1	1.1

Table (7): Colour strength measurements at different time for grafting samples

Pen Code	Paper Code														
	P1			P2			P3			P4			P5		
time	1 day	1 year	2 years	1 day	1 year	2 years	1 day	1 year	2 years	1 day	1 year	2 years	1 day	1 year	2 years
E1	5	3.3	1.5	5	3.5	1.5	5	3.7	2.1	5	3.6	2.1	5	4.1	3
E2	5	3.6	2	5	3.5	1.4	5	3.5	2.1	5	3.7	1.6	5	4	3.7
E3	5	4.1	2.1	5	3.6	1.9	5	3.9	3	5	3.8	2.3	5	4.5	2.9

Table (8) :Total colours difference at different time for ungrafting samples

Pen Code	Paper Code														
	P1			P2			P3			P4			P5		
Time	1 day	1 year	2 years	1 day	1 year	2 years	1 day	1 year	2 years	1 day	1 year	2 years	1 day	1 year	2 years
E1	1.5	1.3	0.1	1.5	1.3	0.1	1.5	1.3	0.1	1.5	1.3	0.1	1.5	1.3	0.1
E2	1.5	1.3	0.1	1.5	1.3	0.1	1.5	1.3	0.1	1.5	1.3	0.1	1.5	1.3	0.1
E3	1.5	1.3	0.1	1.5	1.3	0.1	1.5	1.3	0.1	1.5	1.3	0.1	1.5	1.3	0.1

Table (9): Total colours difference at different time for grafting samples

Pen Code	Paper Code														
	P1			P2			P3			P4			P5		
Time	1 day	1 year	2 years	1 day	1 year	2 years	1 day	1 year	2 years	1 day	1 year	2 years	1 day	1 year	2 years
E1	1.5	1.4	1.2	1.5	1.4	1.2	1.5	1.4	1.2	1.5	1.4	1.2	1.5	1.4	1.2
E2	1.5	1.4	1.2	1.5	1.4	1.2	1.5	1.4	1.2	1.5	1.4	1.2	1.5	1.4	1.2
E3	1.5	1.4	1.2	1.5	1.4	1.2	1.5	1.4	1.2	1.5	1.4	1.2	1.5	1.4	1.2

13. Mechanical properties (tensile, elongation, bursting and tearing tests)

In all mechanical properties (strength test, tearing resistance test, bursting test and elongation test) were

measured by 5500, R Universal Testing Machine (Instron, USA). According to the ASTM Standard method D882-91, **[40].** This type of machine has a self-calibration, zero adjusting and automatic balance, which are done daily before testing or during testing

alcohol) at 1.5%+1.5% respectively because these concentrations gave the best results. **[41].**

14. Scanning electron microscopy and EDAX

The scanning electron microscope was used to examine the surface of the blank (untreated) ungrafted and (treated) grafted paper in order to compare between them the surface of the fiber surface paper. Where this analysis allowed us to obtain high magnification images a as can be seen in the photograph, as well as

Table (10): mechanical properties of grafting ample (p1, p2, p3, p4 and p5)

Type of papers / Experiments	P1	P2	P3	P4	P5
Tensile test(Kg/cm)	6.00	6.. 27	5.51	5. 12	5. 00
elongation test(cm)	0.55	0.55	0.57	0.50	0.51
Tearing test(Kg / m^2)	44	55	52	43	44
Bursting test(kg/ cm^2)	3.30	3.70	3.30	3.30	3.30

This testing instrument is accompanied by a highly reliable system for evaluating the mechanical properties. Measuring drum of sensitivity ± 0.01 mm was used for dimensions evaluation. The tests specimens were conditioned at 25°C with a humidity of 60 %. For, tensile, elongation bursting and tearing, each sample was measured three times for in case grafting by using poly (vinyl pyrrolidone + poly vinyl

perform elemental analyses present in samples and spectra were recorded. Samples are cut Small squares nearly 4 mm × 4 mm, the photographs are illustrated in **Figs. (4-8)** and spectra in **figs (9-13)**. The paper samples were performed by tool is called Quanta FEG (field emission gun) 250-EDAX TEAM, Netherlands Industry. **[42]** And this is destructive technique.

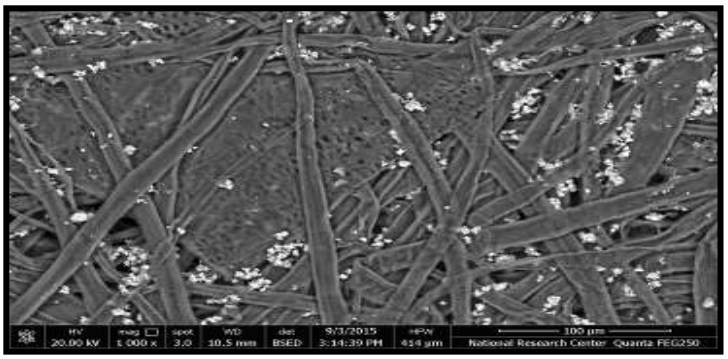

Fig. (4) The scanning electron microscopy of blank paper

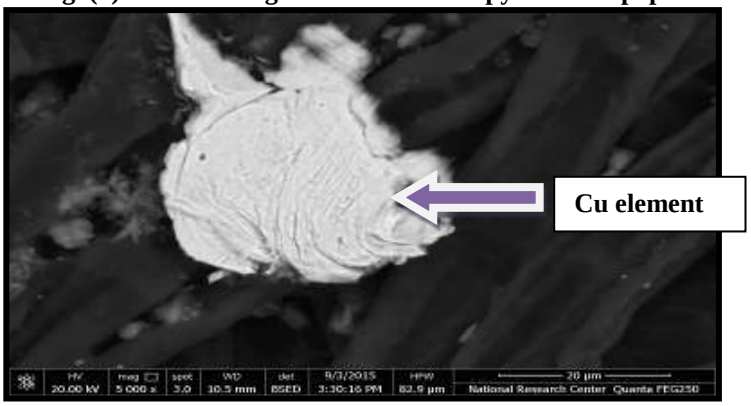

Fig. (5) The scanning electron microscopy of blue ballpoint on paper

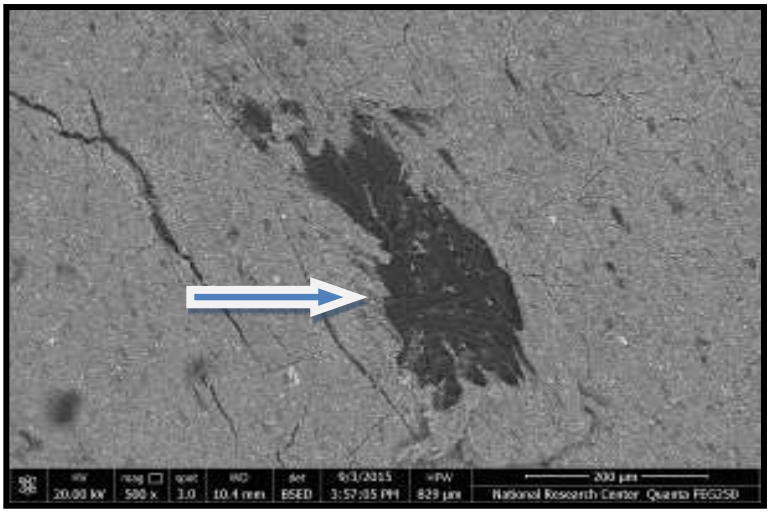

Fig. (6) The scanning electron microscopy of ungrafting paper written with erasable inks

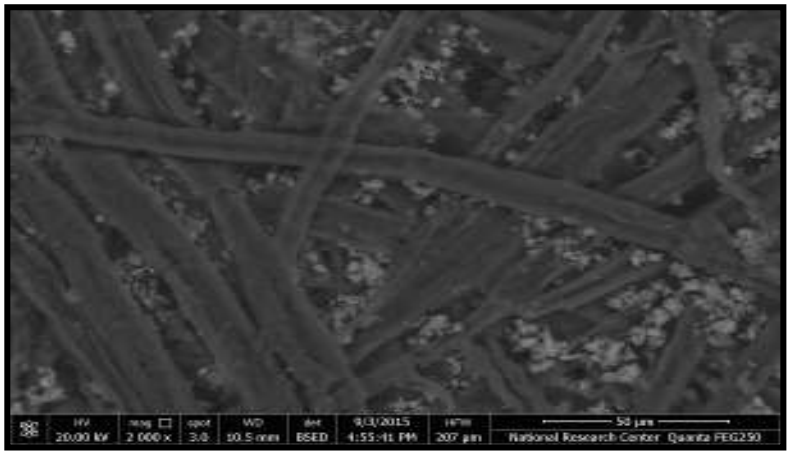

Fig. (7) The scanning electron microscopy of grafting paper only

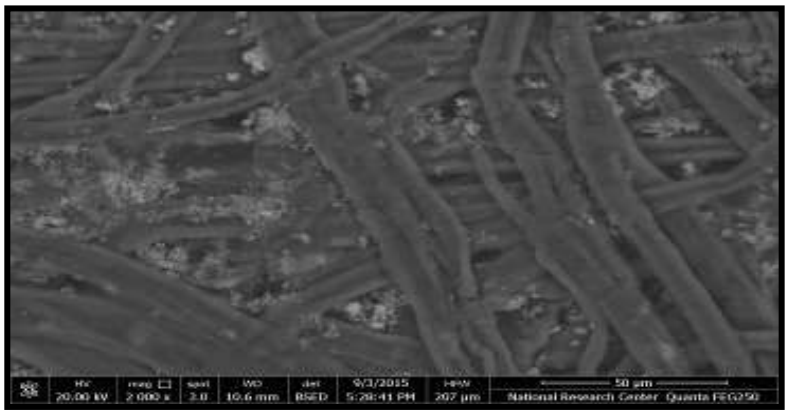

Fig. (8) The scanning electron microscopy of grafting paper written erasable inks then erased

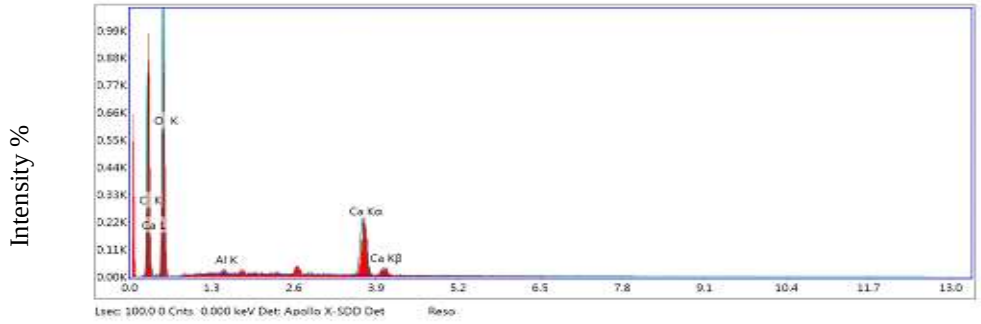

Fig. (9) EDAX spectra of blank paper

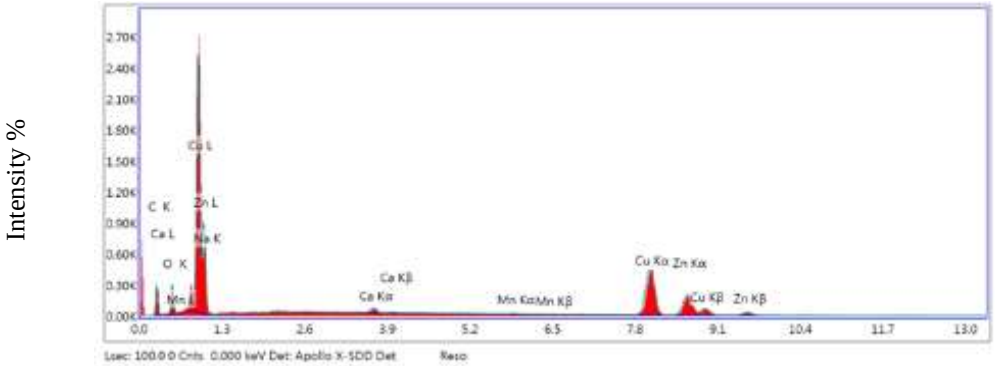

Fig. (10) EDAX spectra of blue ballpoint on paper

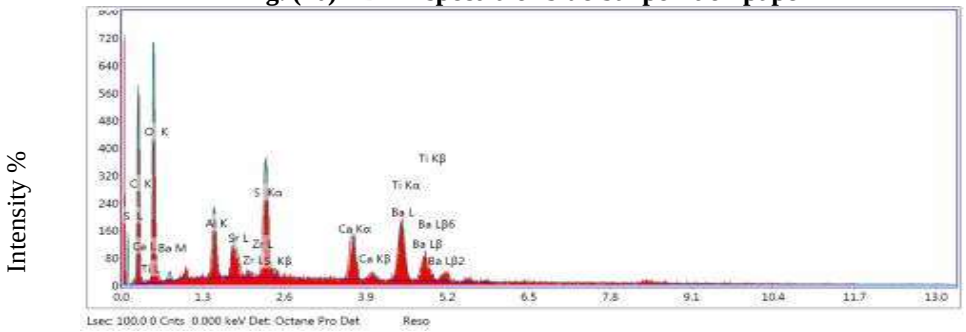

Fig. (11) EDAX spectra of ungrafting paper written with erasable inks

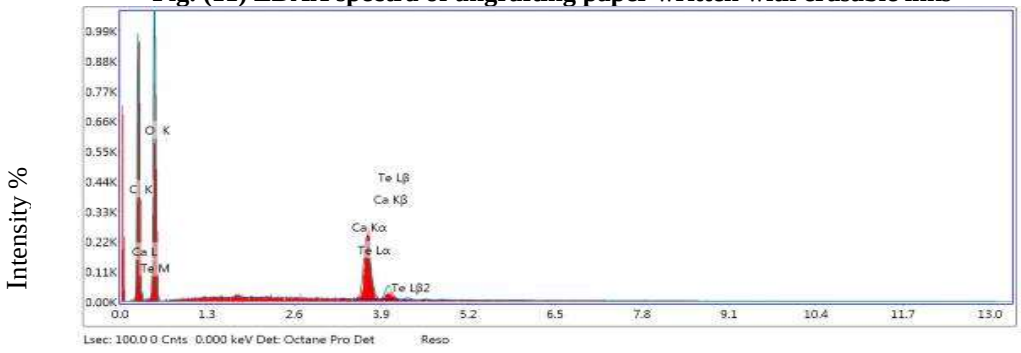

Fig. (12) EDAX spectra of grafting paper only

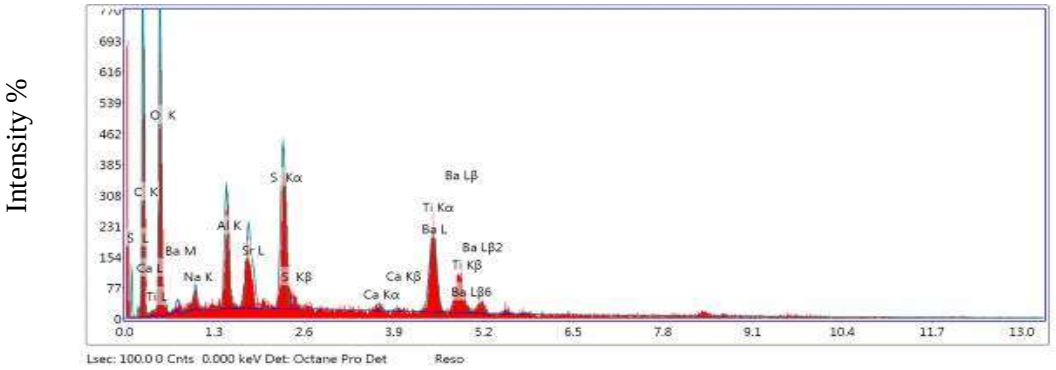

Fig. (13) EDAX spectra of grafting paper written erasable inks then erased

15. Results and discussion

15.1 Shape examination erasable pens

Ballpoint pens erasable inks are differ from the ordinary (Ballpoint pens) and anyone can identify them. Therefore, it is easy to distinguish and prevent any important documents be written using them, where in the field of forensic analysis required to identify the writing implement used in the commitment of a crime. **Fig. (1).**

15.2 Examination of erasable pen strokes or ink-line

The erasable pen has a small eraser fitted into the pen tip (behind of the tip) in use it removes the bulk of the written line-ink but a pale trace of it remains readily visible to the unaided eyes. The action of the eraser is not so much to abrade all the ink-line or strokes, but to generate heat through friction and decolorize the ink-line or strokes. **[43].**

15.3 Different examination of erasable pen strokes or ink-lines

For examination of questioned documents written with erasable ink pens. Several methods are employed by questioned document examiners to detect strokes or ink-line and erasure site. Some of the most frequently used methods are oblique, reflected and transmitted lighting measurements of paper thickness and variation of light transmission; ultraviolet and infrared light examination, photographic methods and techniques, various chemical examinations, including iodine fuming and detecting powders.

15.3.1 Examination with magnifying lenses and microscopic

Examination of ink-lines or strokes of erasable pen inks with magnifying lenses and microscopic at different magnifications (X) which began from 5X to 500X show that:

We have noticed that an erasable pen inks writings contain minute blank streaks or striations in their strokes which seemed to be individualized. These appeared to be distinct from the familiar grosser or other family, more obvious longitudinal blank streaks which occur in a greater number of an erasable pens writings as a class characteristic. The latter are caused by failure of the ink to fully cover the ball in its rotation in the housing of the erasable pens. The former however appear to be caused by some individualized mechanical condition of individual ballpoint erasable ink pens.

A project was undertaken to examine into the nature and possible utility of these minute striations. As a consequence it was concluded that it is possible in a certain percentage of cases to identify two different writings as having been written with the same in the category of all ballpoint pens or erasable pen by means of this feature.

A set of approximately of different types of paper samples tabulated in **table (1)** written with ballpoint erasable ink pens was examined microscopically. It was found that the writing possessed the type of distinctive striations described.

Ink strokes containing these striations consist of a pattern of successive inked and uninked or blank of a ballpoint erasable pen stroke. They can also occur at the turn of a stroke. Examination of ballpoint erasable pen tips shows that these patterns are also found in the ink covering the ball. They are apparently caused by something on or within the housing of the ball, **(figure 14).** Which appears to be minute burrs or projections of metal left by the machining process or irregularities on the machined surface of the housing holding the ball? These burrs or irregularities apparently scrape ink off the ball to an extent and in a manner matching their form **figure (14).**This condition is then transferred to the ink strokes on paper when the pen is used. A wide variety of patterns was found in the specimens examined.

Each section of the circumference of the housing holding the ballpoint erasable pen has its own characteristics, Thus it is possible to have different patterns produced by the same pen, all of which may possibly be of use in identifying strokes made by that

pen. A single writing may thus have more than one such pattern. The big problem of course is to find matching patterns.

As previously indicated, it is necessary to distinguish these individualized striations from the grosser longitudinal blank streaks which are a class characteristic of defectively operating ballpoint erasable pens and are not therefore individually identifying **(figure 15).** In the examinations conducted a small wedge or segment of paper bearing an ink stroke was cut from one area of paper and laid on top of or alongside another ink stroke on the paper, as shown in **figure (15**).

This method would of course not be permissible in actual cases. It would be necessary to make the examination using a comparison microscope or by means of photomicrographic comparison. In principle and demonstration the procedures are analogous to bullet striation comparisons and tool mark comparisons.

If one or more sufficiently distinctive matching patterns are found in the strokes in two portions of writing compared, and if the other pen operating characteristics are similar or consistent, and if the ink is identical, then in this practitioner's opinion a determination that the same ballpoint erasable pen was used is in order.

Factors to be considered in weighing the identification value of patterns found are the number of blank striations, their width, their location in respect to each other in the ink stroke, and the width of the inked portions between them. The greater the number of striations and the more distinctive its other features, the greater is the identification value of the pattern, of course.

The angle of the striation pattern relative to the base line of writing need not be the same, as this will change with the rotational position of the pen in the writer's hand and with the location of the pattern in the strokes of letters. The factors and techniques described in this research or herein provide the question document examiner with a means of individualizing and identifying certain ballpoint erasable ink pens.

Fig (14) Tip of the housing of erasable ink pens

15.3.2 The indented writing examination

Erasable inks are examined by using the microscopes and electrostatic detection apparatus ESDA®, Video Spectral Comparator 6000 (VSC®6000), Projectina Docucenter (4500), the shape and the weight of these Strokes at magnifying under microscopes has indented writing (grave or groove) shape**. (Figs, 16-21).** Consequently at examination of the behind of paper or document we are seen indented writing impressions or a pressure caused by writing at the position of the writing. **(Fig 22)**.

Many of the physical erasures that come to the attention of the question document examiner are the result of a rubber erasure. If utmost care has been taken with a rubber erasure, the location of the erasure site sometimes was difficult to be detected and even more difficult to demonstrate. It is also true that many of the above-mentioned methods employed by the question document examiner may not successfully locate the site of such an erasure [**44]**.

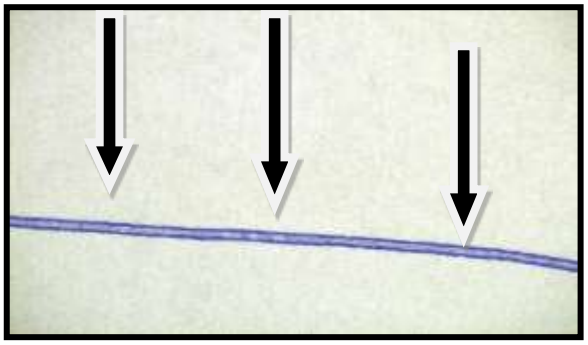

Fig (15) Striation of erasable pen strokes

16. Thickness and roughness examinations

The paper thickness of sample of papers of different brands mentioned in **Table (1).** No difference is observed between the thickness in the zones which have no erasable sites of the samples but in sites exposure for erasing process the thickness will be decreased due to coating layer on the surface of the paper removed. Roughness will be increased due to coating layer on the surface of the paper removed.

17. Permanence

17.1 Effect of flame

S**o**me erasable ink strokes disappear by the effect of heat**,** where appear in case E3 this is because contains volatile solvent has A less viscous colloidal and nonvolatile solvent has boiling point of less than $180^{c.}$ As well as, colored compound of ink may be contained crystalline water but discoloured if water evaporated.

17.2 Exposure to light

At room temperate and Darkness for all ballpoint erasable pen inks (E1, E2 and E3) the color slightly changed **Table (6).**

Deterioration of ballpoint erasable pen inks, by exposure to light, or sunlight may no longer, and the inks completely eliminated where appear in case E3. Three specimens of bulk of inks, from currently available ballpoint erasable ink pens, were exposed to an Ultraviolet lamp for two hours at a distance from 30 centimeters. To one meter, no fading was discernible.

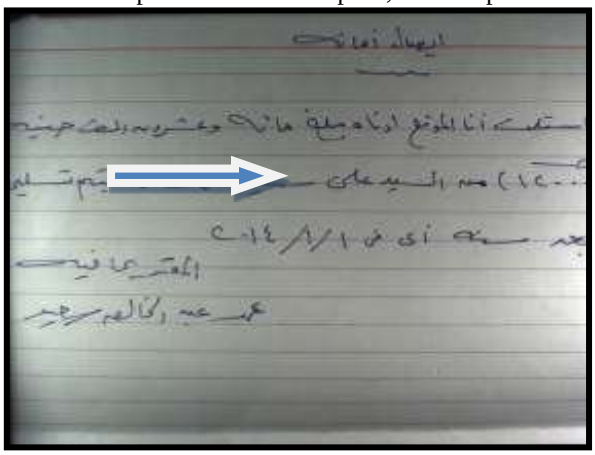

Fig. (16) Document has written by erasable ink

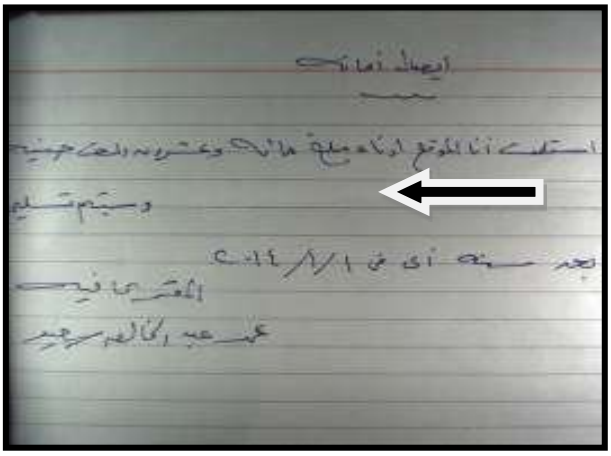

Fig. (17) the Document has written by erasable ink and occurs to it Erasing in value

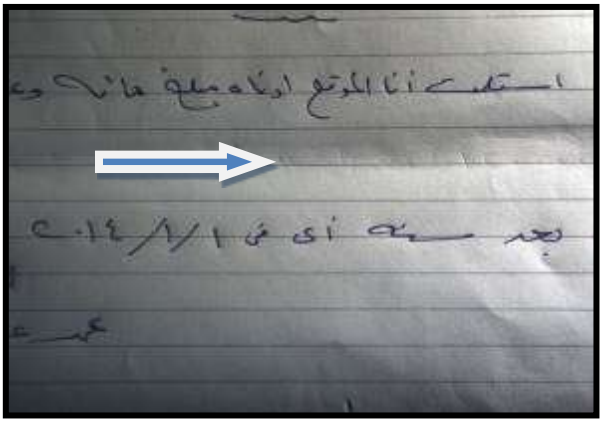

Fig. (18) the Document has written by erasable ink then erasing in value

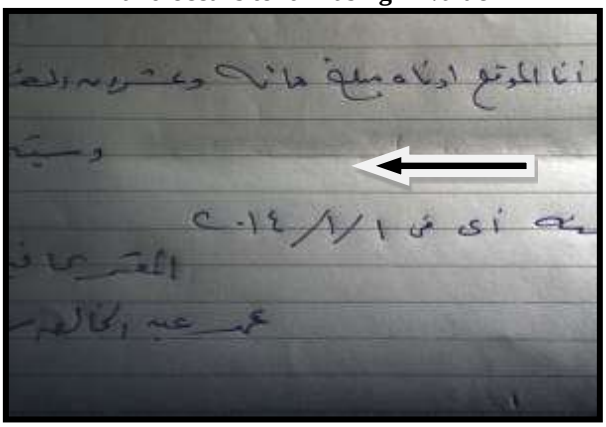

Fig. (19) the Document has written by erasable ink then erasing in value

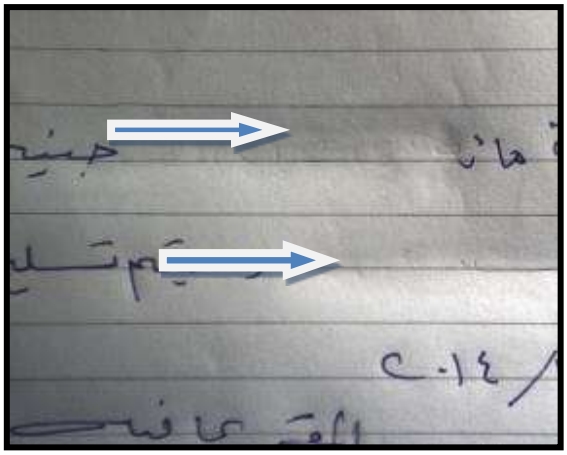

Fig. (20) the Document has written by erasable ink then erasing in value

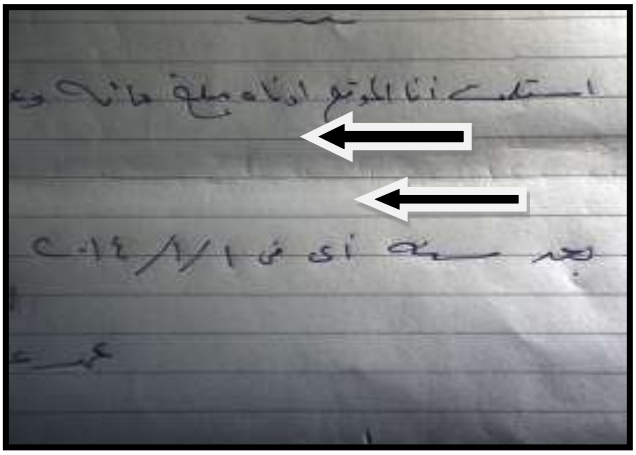

Fig. (21) the Document has written by erasable ink then erasing in value

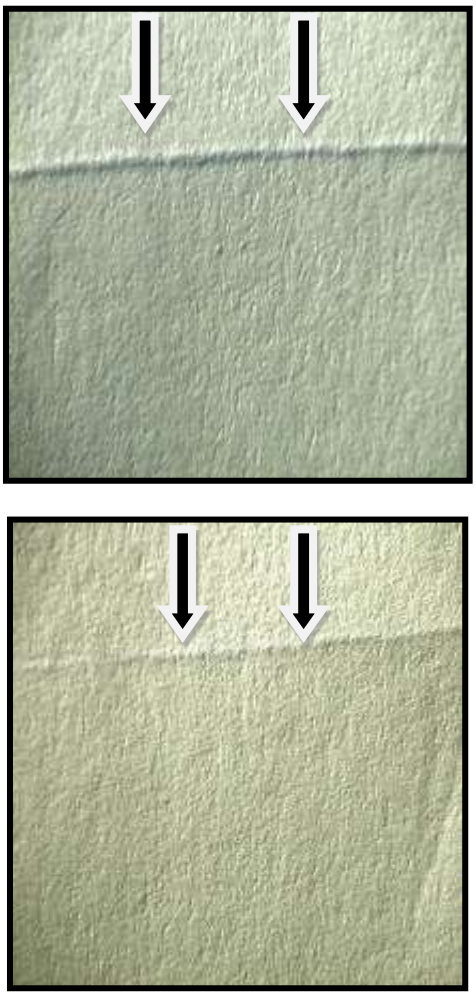

Fig. (22) Behind of paper samples written with erasable inks pen

18. The effect of graft copolymerization reaction as preservation methods for blue erasable ink written on paper against mechanical erasure by an eraser

The effect of graft copolymerization reaction as a preservation methods for blue ballpoint erasable ink written on paper by mechanical erasure by using an eraser was studied which A possible description for this phenomena that in fact these erasable inks are formulated by mixing a dye ("pigment", "colorant") and other terms of similar meaning with a variety of polymer and liquid carrier/solvent combinations consequently the flowing dye/polymer matrix. When the solvent of the ink component on paper evaporates where, these volatile solvents have boiling point of less than 180 ^{C}. the ink viscosity increases to the point where further penetration of the ink to the paper is minimized. The polymer component of the erasable ink is chosen for its film forming properties and its ability to be readily removed from the substrate to which it is applied e.g., cellulosic paper, through the abrasive action of an eraser easily.

In contrast, the results reveal a great improvement in the resistance of ink entries against mechanical erasure by a rubber eraser in case of different grafted papers **(45).**

Where a possible explanation and suggestion of these behavior may be attributed to the graft copolymerization reaction, Which this process decrease the viscosity of the ink dye/polymer matrix entries deposition on paper sheet surface, as a result, comparatively increasing in the penetration and diffusion of ink components from the surface into the voids and pores of inter-fiber spaces of the paper. Furthermore the maintaining of ink component with the formed graft chains during and after grafted reaction **(45)**.

The graft copolymerization reaction causes the ink spreading and penetration became more depth in the grafted paper than that of the ungarfted paper, consequently, the obtaining in final were the high resistance to abrasive action of an eraser. And from results in tables from **(6 to 9)** we found the Colour strength measurements and the Total colours difference (ΔE) increased in case the grafted paper than ungrafted paper **(45)**.

19. Evaluation of mechanical properties

19.1Tensile test

In order to show the experimental data obtained in an understandable form, we evaluated the mechanical characteristics caused by graft copolymerization procedure on five samples. Values of tensile strength reflect the detailed structure of the paper and the properties of its individual fibers, i.e., the dimension and strength of fibers, their arrangements, and inter fiber bonding. The results obtained for tensile strength of the paper graft copolymerization are presented in **Tables (2, 10).**

The results revealed little increasing on the obtained values of grafted paper for this test.

19.2 Elongation tests

Elongation at fracture or break shows the ability of a film to stretch or extension before it breaks. Elongation can be related to the papers ability to conform and maintain conformance to a particular contour, and is also regarded as one of the most important criteria for the satisfactory behavior of paper in applications. **Tables (2,10)** shows the elongation value ungrafed and grafted paper, the results revealed little increasing on the obtained values of grafted paper.

19.3 Bursting tests

The mechanical properties of paper determine its durability and resistance to environmental stress. To investigate the effect of graft copolymerization on paper samples, the bursting strength of ungraft and

graft paper is measured as shown in **Tables (2, 10)**. The bursting strength of grafted paper is increased slightly compared to the ungrafted paper,

19.4 Tearing tests

The strength properties (burst, tensile and tear) of paper are attributed to the fibre strength and the number of inter fibre bonds. From results listed in Table (2, 10). It is clear that the tearing load paper samples of grafted paper are higher than ungrafted paper or reference paper. This may be due to the graft copolymerization allow to a higher degree of polymerization (D.P.) leads to increasing the inter fibre bonds and cross linking between the fibres in the paper therefore. And from these results for the tensile test, Elongation test, bursting test and tearing test, we found improvement in The mechanical properties of grafted papers.

20. Evaluation of scanning electron microscopy and EDAX

Scanning electron microscopy (SEM) and EDAX is powerful analytical tool and has been proven to be a viable method for the destructive analysis of ink on paper. The observations from using this tool allowed the study at high magnifications of the film morphology of paper before ungrafted and grafted; more information was obtained from (EDAX) about the organic and inorganic elements. Where in **figs (4, 9)** for blank paper and Calcium element from the fillers materials such as Calcium carbonate and Calcium sulfate. In **figs (5, 10)** Copper element from phthalocyanine dyes such as copper phthalocyanine, Copper element is brightness in **figs (5)** due to this element have heavy atomic weight and gain more energy. In **figs (6, 11)** the ink in the surface on paper is break down not penetrate inside the paper. In **figs (7, 12**) the grafted of paper appear in the shape of the fibers, where the fibers enwrap and enfold with very thin film from polymer particles, as well as the grafted of paper appear have high percentage from carbon and oxygen elements. In **figs (8, 13)** the particles of inks are adhesive and embedded inside fibers of the paper.

21. Replacing the original writing text

Exploitation or profiteering of blank of any document by erasing the original former writing if this text is written through pencil or erasable ink pens, when using eraser to erase or get rid of the original text writing, consequently, the Section highest signature being a blank after the erasure, **[46].** this may be the ink from the ink erasable so must be alert not to use this type of ink in writing the value documents and harsher penalties for those found to use this kind of these inks in writing value documents, so as to prevent and stop the crimes of forgery. **Figs. (23-26).**

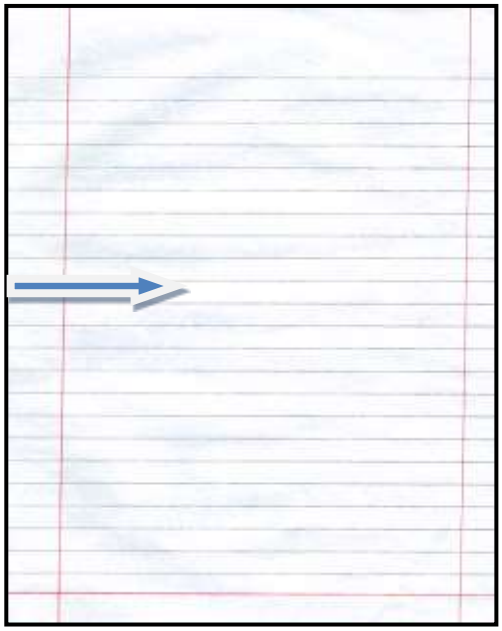

Fig. (23) paper has no writing

Fig. (24) paper has text writing by using erasable ink

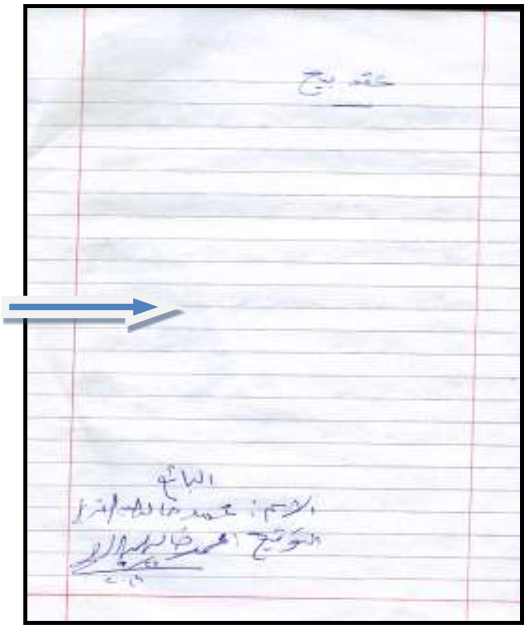

Fig. (25) Paper is erase of the writing

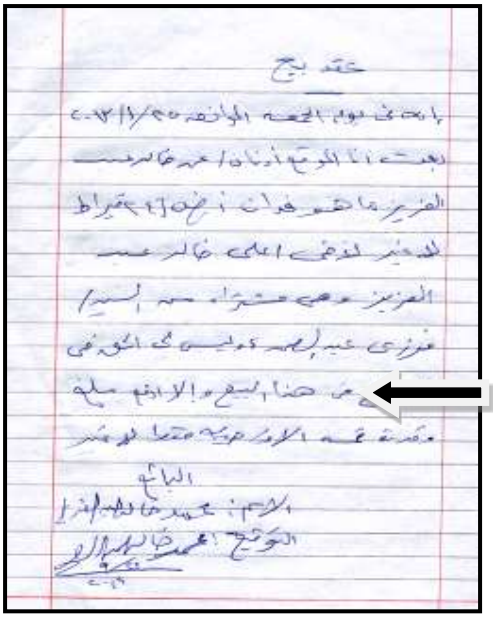

Fig. (26) Paper has new text writing with new ink

22. Conclusion

The introduction of erasable ballpoint pens increased the probability of erased of writings in criminal activities. This research alerts the forensic science community to the existing ballpoint erasable inks pen and describes a method in deciphering it. The strong luminescence displayed by traces of the ballpoint erasable inks pen strokes under high wavelengths of infrared light (VSC®60000) will provide a new pathway by which the forensic document examiner may detect the erasure, that might otherwise, go undetected with other expert more frequently used method. The factors and techniques described in this research or herein provide the question document examiner with a means of individualizing and identifying certain ballpoint erasable ink pens, and the justice activity of preventing and fighting against criminally requires the immediate and complete discovery of contravention, identification of offenders, determination without any doubt of their guilt and in relation to it, and it must be studied the people your mind conscience if your selves beckoned when used erasable ballpoint pens for harm and injury author people. Generally in this study the erasable ballpoint pens were be characterized and methods of examinations, and how to overcome what do the forgers, and does not exempt anyone from falling into the forgery of those pens.

23. Casework study

A number of real caseworks have been examined to evaluate the effectiveness of I.R, Raman, and UV. on an erasable ink strokes and this case is one of the lawsuits and sent from Agouza Court, number casework is 5127/ 2014 and registered in forensic Medicine by number 949/2014 where the use of expert proved then it was removed and the writing of this new text, we seen in **figures (27,28).**

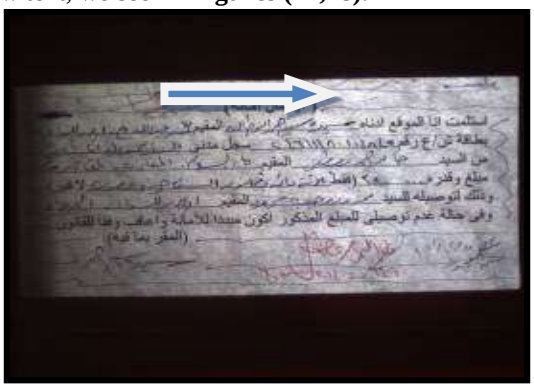

Fig. (27) The receipt through normal light

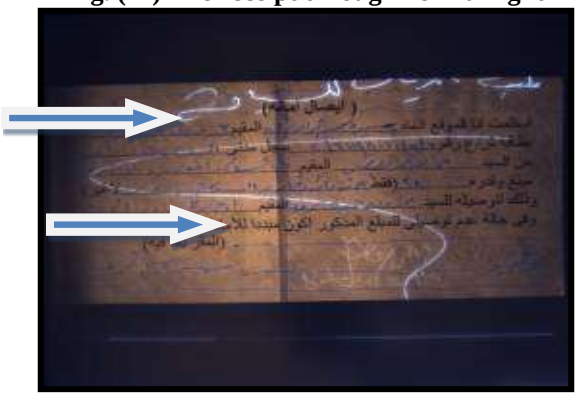

Fig. (28) The receipt through I. R.

24. Recommendations

24.1. We create fair competition between experts to Self-assertion and should be encouraged to conduct research and scientific studies in the fields of criminal sciences with the Faculties of Science, Medicine, Applied Arts and lows in different universities because of their association Criminal Sciences far from the basic of science which be educated in these colleges. With the need to differentiate according to these experts for the development of the scientific level of each of them to study and development in the world of crime.

24.2. The examination of any document in first by the naked eye, magnifying lenses, and lenses and binocular lenses with aid direct light "`incident - transmitted – italic(oblique)- spot" and note that parts of a document (face- behind) and the basic components. Then examination by using microscopes, comparison microscopes. Then record observations then testing by using infrared, ultraviolet radiation, recording any changes in writing inks, printing inks and illustrate some of the chemical, mechanical erase, obliteration, deletion, addition or reinstatement, any change can be seen or identified in the body of document and testing total study of the text of document taking into consideration the correlation between the text and written components of words, numbers, phrases, statements and signatures or fingerprints.

24.3. We use visible light in the following objectives:

24.3.1. Examination of minute written configurations, such as dots, numbers, ends of letters, with the microscopic imaging of minutes of these configurations.

24.3.2. Full technical examination of strokes using magnification devices appropriate to reflect and identify natural features of this writing or abnormal, In terms of speed, fluency, Vitality, solidity, slowness, stopping, stumbling, vibrations, and imaging of the necessary comparisons.

24.4. Check and detect chemical erasure and select the region that were expressed in the process of erasure and spread the chemicals used.

24.5. Check and reappear original writing erased by using eraser then Photography this writing.

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