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STUDY OF PAPER UNDER DIFFERENT LIGHT SOURCES AND ITS FORENSIC RELEVANCE

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ABSTRACT:

Forensic document examination has count four decades but is still new and beginning so the literatures are being collected to provide base for development. Documents are integral parts of our lives so it is important to check whether the papers of same brands are same or different under the impact of different light sources and how the paper is differentiated from each other within same brand or in different brands. Light sources help us to examine the authenticity of paper whether it is the same paper or substituted later to mislead the others. Many questions on authentication of document arise in front of forensic document examiner. So, it is important to examine the paper whether the papers of a document are same or different from each other. The purpose of this study is to analyse the impact of the different light sources in authentication of documents and its forensic relevance. The different types of registers were taken to perform the examination. Since documents are integral part of our lives, it is very easy to generate fraudulent documents by tampering.

KEYWORDS: Light source; FTIR analysis; Paper analysis; Invasive Method

INTRODUCTION

ISSN: 0971-1260

Vol-22-Issue-17-September-2019

Paper is a thin material derived from wood, grasses or rags, by pressing the moist cellulose pulp fibres together and drying these fibres into flexible sheets. Paper being a versatile material has many uses such as for writing, packaging, printing, cleaning and for construction and industrial processes. The uses and knowledge of paper spread from China in the 13th Century. The first water powered paper mill was built in China. Paper was first called bagdatikos because it was introduced to the West through Baghdad. The cost of manufacturing paper was reduced greatly by the industrialization in the 19th Century.

The German inventor F. G. Keller and Charles Fenerty from Canada independently developed processes for pulping wood fibres in 1844.

Classification of paper:

There are seven categories:

- Wide variety of printing papers.
- Wax and kraft papers for the protection and wrapping of goods and merchandise.
- Bond paper, bank and ledger paper as Stationary needs and writing material.
- Blotting papers.
- Rough surfaced Cartridge paper used for drawings
- Handmade papers including decorative papers and Ingres papers.
- Specialty papers.

ISSN: 0971-1260

Vol-22-Issue-17-September-2019

Bond paper: It is made up of high-grade rag pulp which is more durable and stronger than average paper. It is used for typed reports, letterheads and envelopes.

Gloss coated paper: It is highly shiny in nature and used for brochures and flyers.

Matt coated paper: It is opposite of gloss paper matt paper and has matt finish. This paper is used for flyers, leaflets and reports and is not shiny and also prevent glare.

Recycled paper: Recycled paper is used mostly for documents which include forms, memo papers and reports. This paper is made from re-used paper products.

Silk coated paper: It is intermediate of gloss and matt. This paper has smooth silky coating which makes it smooth to the touch without the shine .

Uncoated paper: It is found in most office printers. This paper has no coating which makes it excellent for ink receptivity and absorbency.

Watermarked paper: It is a high-quality paper. An impression by attaching a wire pattern is pressed on the paper to create the desired watermark. It is used for essential documents such as exam certificates as a security feature.

Paper is made up of many components which includes Cellulose fiber, Sizing, Fillers and pigments. The manufacturing process of paper consists of four main steps which are making pulp, beating, conversion of pulp to paper and finishing.

ISSN: 0971-1260

Vol-22-Issue-17-September-2019

Paper & Ink Examination

FDS undertakes non-invasive forensic examination of papers as well as writing and printing inks. It is important in the matters where it is suspected that whether the document has been altered, when a document created or when the entry was written, the order of the entries written is correct, the document is counterfeit or genuine, recovering and bleached/ entries erased/ faded, whether the entries are reproduced or original, the method in which the document is produced, whether many documents have same source and so on.

Invasive paper or ink examination may be considered where non-invasive examination cannot provide required information to address the questions aroused. Samples are taken from the documents in invasive examination techniques. In order to prevent loss of potential evidence, it is necessary to compare all the non-invasive forensic examinations before invasive examinations.

A number of analytical tools ranging from standard optical magnification, to exquisitely sophisticated molecular spectroscopy are there with investigators at their disposal. To identify the paper properties these tools are used in many ways in combinations or alone.

For example, materials in paper like fibre and ink are shown by a qualitative analysis; the quantities in which are present are measured by quantitative analysis. Composition and pH is evaluated by chemical analysis; strength, gloss and color are measured by physical analysis. Carbon-based traces of plants and organisms are detected by organic analysis; while mineral evidences in ink and pigment are identified by inorganic analysis.

ISSN: 0971-1260

Vol-22-Issue-17-September-2019

The method of choice is determined by several factors for any given situation, including the investigator's objectives, the relative value of the paper and whether the information we get from destructive testing will outweigh the loss of the samples.

Solved by organic analysis**:**

Authenticity of mysterious Vinland Map was questioned for ages. In 2002 a scrap of map parchment was analyzed by destructive organic method (radiocarbon dating). It proved that the map of the New World was made in 1434 AD (+/-11) 60 years before Columbus got there.

Destructive and non-destructive methods:

To record each and everything documents are required, starting from birth certificate to end with death certificate so forensic examination of documents is an important part of our society. During litigation question arises on the validity of these documents. This paper focuses on the use of nondestructive analysis of paper such as Fourier transform infrared spectroscopy using an attenuated total reflectance (ATR) technique, Raman spectroscopy and destructive analysis of paper which includes microscopic analysis of fibers, FTIR analysis of paper ash, inductively coupled plasma–mass spectrometry.

Destructive Testing (DT)

To determine the strength, hardness and toughness the material is broken down in destructive testing (DT). When we compare non-destructive methods with destructive methods then we find destructive tests best as they give the best information on materials and welds.

Non-destructive Analysis of Paper

ISSN: 0971-1260

Vol-22-Issue-17-September-2019

Paper is made through different steps of drying and straining from pulp of organic fibers and water. To improve the required characteristics of a product other additives can be added.

For example printing and writing paper includes bleached softwood (75%) and bleached hardwood (25%) as fibers.

FTIR Analysis: For non-destructive analysis of paper, infrared spectroscopy has been used to study coating composition. Advantage of this technique is that there is no preliminary preparation of sample required and it is relatively simple and rapid.

Different light sources:

Forensic Light Source: A light source designed for use in Forensic Applications which is bulb based with multiple wavelength and high intensity. Forensic Light Sources are extremely versatile with a moderate price and high power.

Different types of light sources:

- Natural sources like sun, moon
- Artificial sources like Incandescent Sources, Luminescent Sources and Gas Discharge Sources

The band of significant radiation power can be categorized into five different regions of wavelengths:

- Ultraviolet C which spans a range of 100 to 280 nm.
- Ultraviolet B which spans a range of 280 to 315 nm.
- Ultraviolet A which spans a range of 315 to 400 nm.
- Visible range or light spans 380 to 780 nm.

ISSN: 0971-1260

Vol-22-Issue-17-September-2019

- Infrared light spans 700 nm to 1,000,000 nm.
- Transmitted Light: The process of shining light through a semi-opaque body, the light source being on the opposite side of the object from the observer, used in the examination of art works to reveals aspects such as differences in thickness or density.

Challenges in paper examination:

Forensic document examination has count four decades but is still new and beginning so the literatures are being collected to provide base for development. The information sources were examiners of Forensic document, investigative officers of police, Attorneys, bank and insurance workers were sources of information. The data analysis suggested that awareness about the investigation of documents which are suspected was lacking because legal justice bodies has not given the proper attention, the persons who were operating the instruments and performing procedures were not skilled and certified. Due to lack of salaries the laboratories do not have stable examiners.

Forensic significance:

The examination of the paper can give the important information as the documents are written on the paper. This information which is derived from the examination of paper can help in fraud detection of documents or linking documents, materials and/ or other samples of paper which are associated with particular suspects under investigation of crime with particular criminal suspects.

This paper discusses different paper properties, standard paper test methods and analysis of fiber for paper as a means for differentiating one paper from the other.

ISSN: 0971-1260

Vol-22-Issue-17-September-2019

Materials and Methods

Sampling

A set of registers consists of 5 brands were purchased from markets in Kangra/ Dharamshala, Himachal Pradesh. All registers were given a reference number during this study, as shown in Table 1. Three different individual register were sampled for each variety of paper. Investigational work was carried out by examining different register under different light sources.

serial no.	brand name	type of register	reference number
1	**classmate**	**long register**	**a-1**
		medium register	**a-2**
		small register	**a-3**
2	**saathi**	**long register**	**b-1**
		medium register	**b-2**

ISSN: 0971-1260

Vol-22-Issue-17-September-2019

		small register	**b-3**
3	**evergreen**	**long register**	**c-1**
		medium register	**c-2**
		small register	**c-3**
4	**schoolmate**	**long register**	**d-4**
		medium register	**d-2**
		small register	**d-3**
5	**today**	**long register**	**e-1**
		medium register	**e-2**
		small register	**e-3**

Table No 1- Reference number of all brands of register samples

Techniques

Different light sources are used for examination of paper samples, which are as follows

1) Transmitted Illumination

ISSN: 0971-1260

Vol-22-Issue-17-September-2019

2) Ultraviolet Fluorescence

3) Infrared Illumination

4) Incident Illumination

Methodology

The methods adopted for the analysis of paper samples are according to guidelines mentioned as follow**:**

1) **SWGDOC** standard for examination of paper in non- destructive way.
2) **ASTM** standards for examination of paper in non-destructive way.

In this study three different types (long register, medium register and small register) of same brand were examined to know the physical difference between the papers without the use of any destructive method.

In this study the paper was examined under different light sources. Paper examined under transmitted light using Reprovit system and projectina. Paper was examined under far ultraviolet fluorescence and near ultraviolet fluorescence using projectina and Digital video spectrograph. The stereo microscope is used for the spectroscopic examination. Forensic xp 4010 D is used for the examination of paper samples under infrared illumination**.** The results for each register were arranged in a tabular manner and comparison is done within the different register of each brand. The results of one brand (for all register) were compared with the other brands taken for examination and compared to each other for similarities and dissimilarities.

ISSN: 0971-1260

Vol-22-Issue-17-September-2019

This study is based on the fact that to find the similarities or dissimilarities in paper without destroying it or by using non – destructive method. It is to find out the substitution or insertion of any paper to set of documents or not.

RESULT

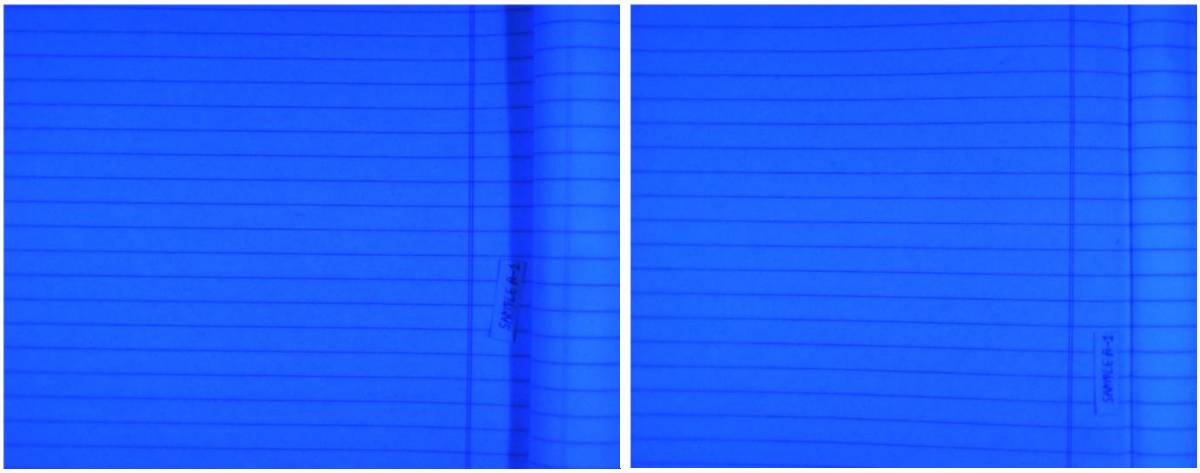
In this study the samples of different brands of register commonly used in district Kangra, Himachal Pradesh were collected from the month of January to March, 2018 for the examination of the brightness of paper to check the authenticity of the paper under different light sources. The result shows difference in some brands of register within and in different brands of the registers while some shows no difference.

Table 2: This table shows the difference within the pages of same register of same brand "A" under different light sources. In this sample no difference is found under any light source.

Sample		**Infrared light**	**Ultraviolet light 256**	**Ultraviolet light 365**	**Transmitted light**
A	1	Not defined	Not defined	Not defined	Not defined
	2	Not defined	Not defined	Not defined	Not defined
	3	Not defined	Not defined	Not defined	Not defined

ISSN: 0971-1260

Vol-22-Issue-17-September-2019



Sample A-1 under UV 256 **Sample A-1 under UV 256**

Fig 1: Sample A-1 under UV 256

Table 3: This table shows the difference between the pages of different registers of same brand “A” under different light sources. This sample shows no difference under any light source.

Sample		Infrared light	Ultraviolet light 256	Ultraviolet light 365	Transmitted light
A	1	No difference	No difference	No difference	No difference
	2	No difference	No difference	No difference	No difference
	3	No difference	No difference	No difference	No difference

ISSN: 0971-1260

Vol-22-Issue-17-September-2019

Sample A-1 under UV 365

Sample A-1 under UV 365

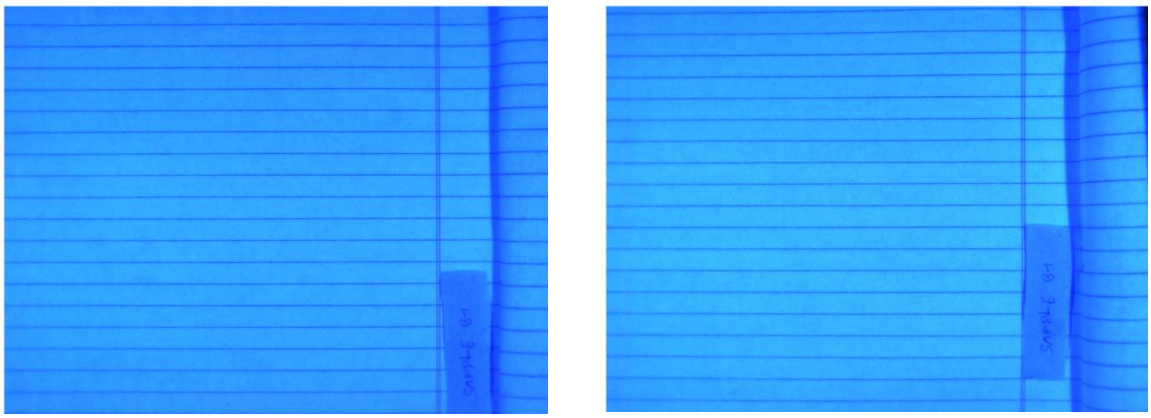
Fig 2: Sample A-1 under UV 365

Table 4: This table shows the difference within the pages of same register of same brand "B" under different light sources. In this sample no difference is found under any light source.

Sample		Infrared light	Ultraviolet light 256	Ultraviolet light 365	Transmitted light
B	1	No difference	No difference	No difference	No difference
	2	No difference	No difference	No difference	No difference
	3	No difference	No difference	No difference	No difference

ISSN: 0971-1260

Vol-22-Issue-17-September-2019



Sample B-1 under UV 256 Sample B-1 under UV 256

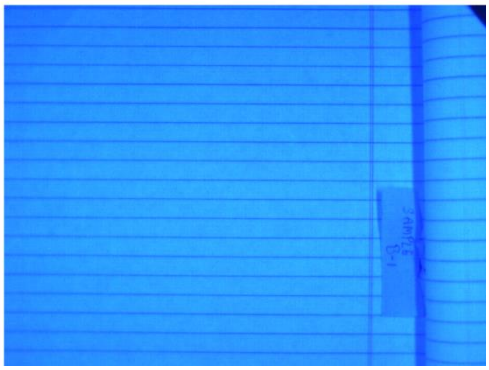
Fig 3: Sample B-1 under UV 256

Table 5: This table shows the difference between the pages of different registers of same brand “B” under different light sources. This sample shows no difference under any light source.

Sample		Infrared light	Ultraviolet light 256	Ultraviolet light 365	Transmitted light
B	1	Not defined	Not defined	Not defined	Not defined
	2	Not defined	Not defined	Not defined	Not defined
	3	Not defined	Not defined	Not defined	Not defined

ISSN: 0971-1260

Vol-22-Issue-17-September-2019



Sample B-1 under UV 365

Sample B-1 under UV 365

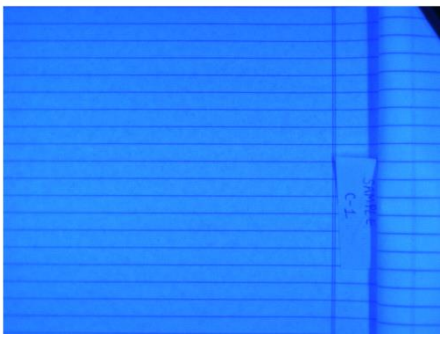
Fig 4: Sample B-1 under UV 365

Table 6: This table shows the difference within the pages of same register of same brand "C" under different light sources. In this sample no difference is found under any light source.

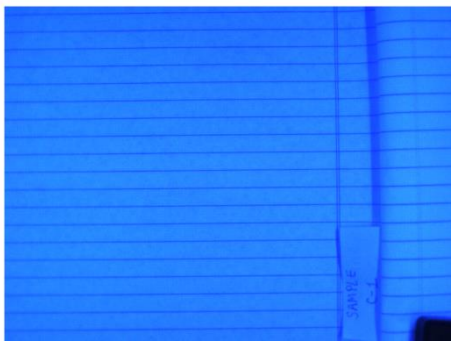
Sample		Infrared light	Ultraviolet light 256	Ultraviolet light 365	Transmitted light
C	1	Shows difference	Shows difference	Shows difference	Shows difference
	2	Shows difference	Shows difference	Shows difference	Shows difference
	3	Shows difference	Shows difference	Shows difference	Shows difference

ISSN: 0971-1260

Vol-22-Issue-17-September-2019



Sample C-1 under UV 256



Sample C-1 under UV 256

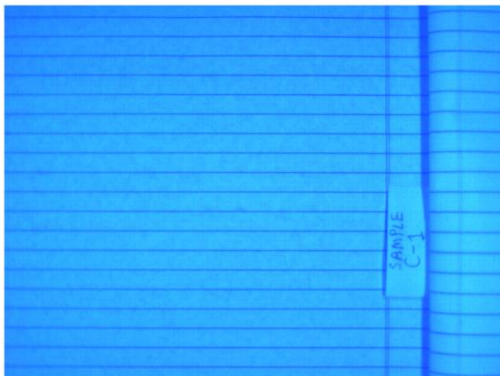
Fig 5: Sample C-1 under UV 256

Table 7: This table shows the difference between the pages of different registers of same brand "C" under different light sources. This sample shows no difference under any light source.

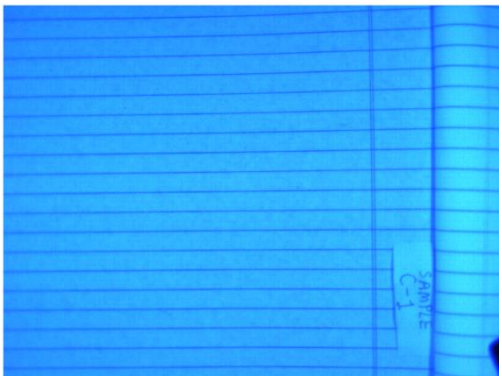
Sample		Infrared light	Ultraviolet light 256	Ultraviolet light 365	Transmitted light
C	1	Shows difference	Shows difference	Shows difference	Shows difference
	2	Shows difference	Shows difference	Shows difference	Shows difference
	3	Shows difference	Shows difference	Shows difference	Shows difference

ISSN: 0971-1260

Vol-22-Issue-17-September-2019



Sample C-1 under UV 365



Sample C-1 under UV 365

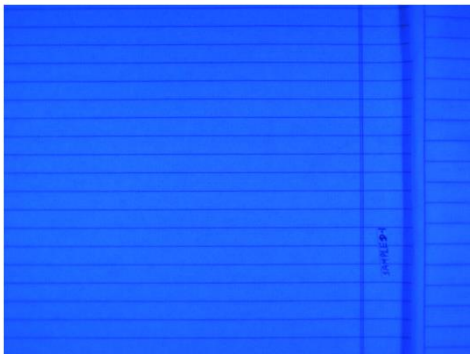
Fig 6: Sample C-1 under UV 365

Table 8: This table shows the difference within the pages of same register of same brand "D" under different light sources. In this sample no difference is found under any light source.

Sample		Infrared light	Ultraviolet light 256	Ultraviolet light 365	Transmitted light
D	1	Shows difference	Shows difference	Shows difference	Shows difference
	2	Shows difference	Shows difference	Shows difference	Shows difference
	3	Shows difference	Shows difference	Shows difference	Shows difference

ISSN: 0971-1260

Vol-22-Issue-17-September-2019



Sample D-1 under UV 256

Sample D-1 under UV 256

Fig 7: Sample D-1 under UV 256

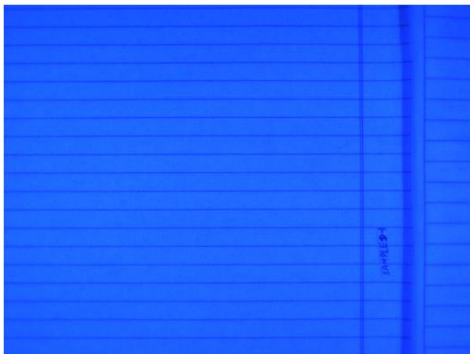
Table 9: This table shows the difference between the pages of different registers of same brand

"D" under different light sources. This sample shows no difference under any light source.

Sample		Infrared light	Ultraviolet light 256	Ultraviolet light 365	Transmitted light
D	1	Shows difference	Shows difference	Shows difference	Shows difference
	2	Shows difference	Shows difference	Shows difference	Shows difference
	3	Shows difference	Shows difference	Shows difference	Shows difference

ISSN: 0971-1260

Vol-22-Issue-17-September-2019



Sample D-1 under UV 256

Sample D-1 under UV 256

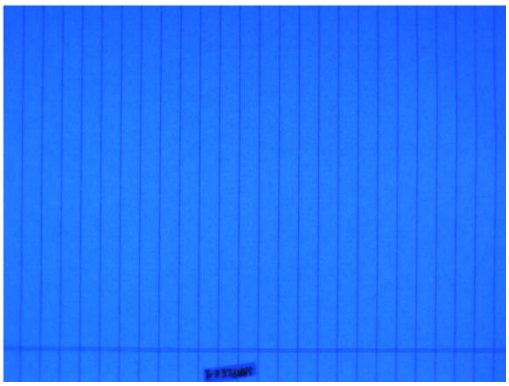
Fig 8: Sample D-1 under UV 256

Table 10: This table shows the difference within the pages of same register of same brand "E" under different light sources. In this sample no difference is found under any light source.

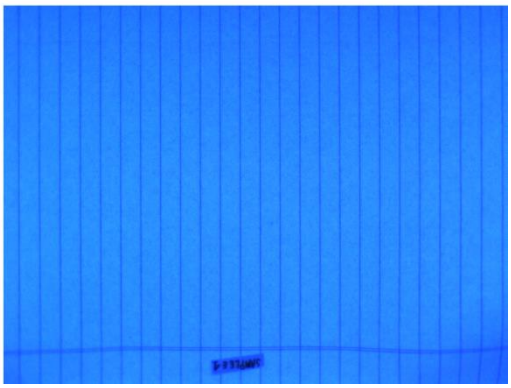
Sample		Infrared light	Ultraviolet light 256	Ultraviolet light 365	Transmitted light
E	1	Shows difference	Shows difference	Shows difference	Shows difference
	2	Shows difference	Shows difference	Shows difference	Shows difference
	3	Shows difference	Shows difference	Shows difference	Shows difference

ISSN: 0971-1260

Vol-22-Issue-17-September-2019



Sample E-1 under UV 256



Sample E-1 under UV 256

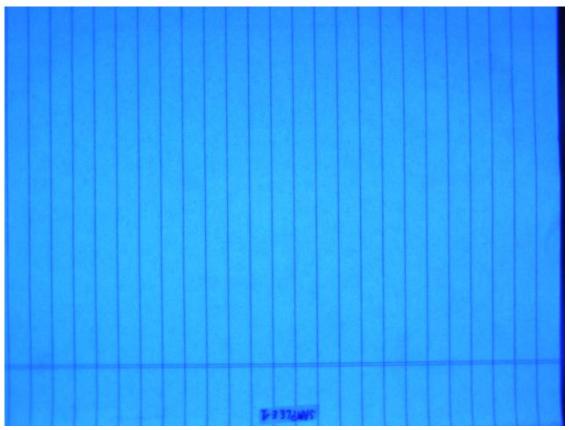
Fig 9: Sample E-1 under UV 256

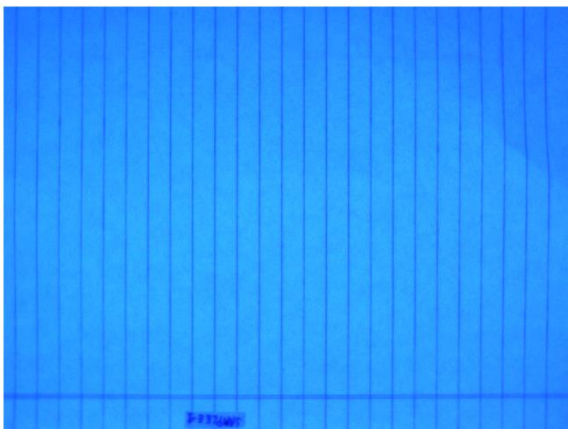
Table 11: This table shows the difference between the pages of different registers of same brand “E” under different light sources. This sample shows no difference under any light source.

Sample		Infrared light	Ultraviolet light 256	Ultraviolet light 365	Transmitted light
E	1	Shows difference	Shows difference	Shows difference	Shows difference
	2	Shows difference	Shows difference	Shows difference	Shows difference
	3	Shows difference	Shows difference	Shows difference	Shows difference

ISSN: 0971-1260

Vol-22-Issue-17-September-2019

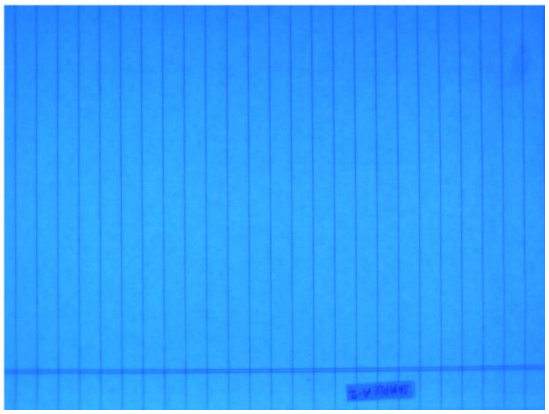


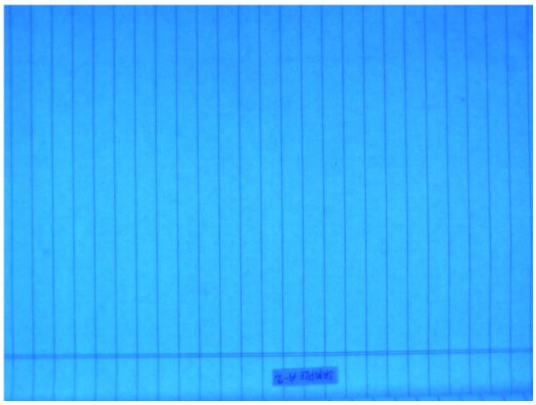


Sample E-1 under UV 365 **Sample E-1 under UV 365**

Fig 10: Sample E-1 under UV 365

Result Images





Sample A-2 under UV 256 **Sample A-2 under UV256**

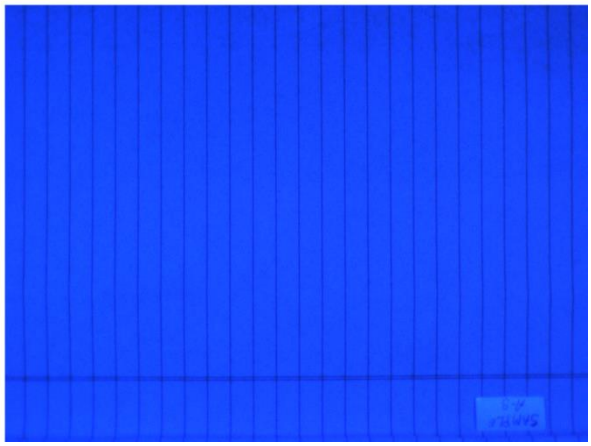
Sample A-2 under UV 365

Fig 11: Sample A-2 under UV 256 and 365

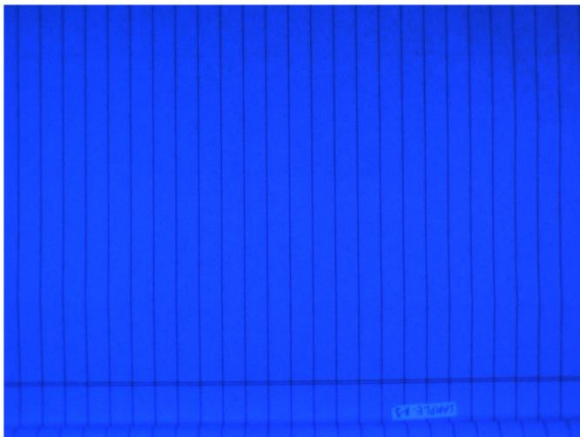
ISSN: 0971-1260

Vol-22-Issue-17-September-2019

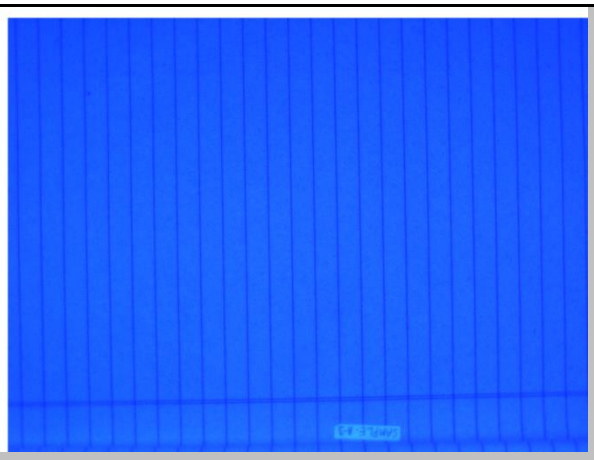
Sample A-2 showing no difference.



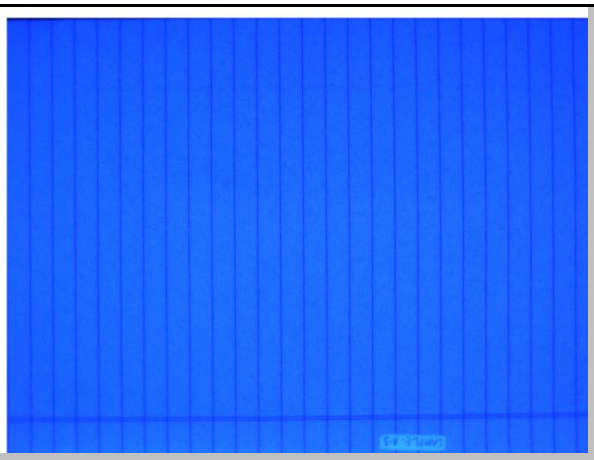
Sample A-3 under UV 256



Sample A-3 under UV 256



Sample A-3 under UV 365



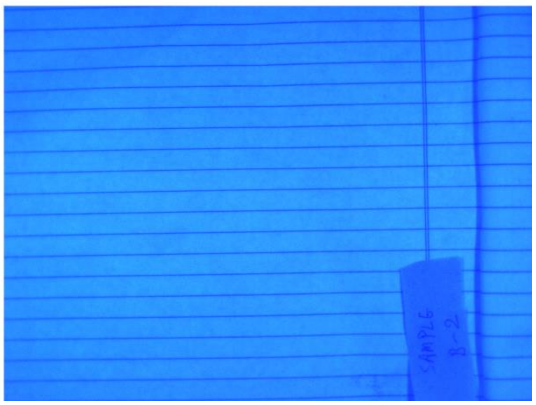
Sample A-3 under UV 365

Fig 12: Sample A-3 under UV 256 and 365

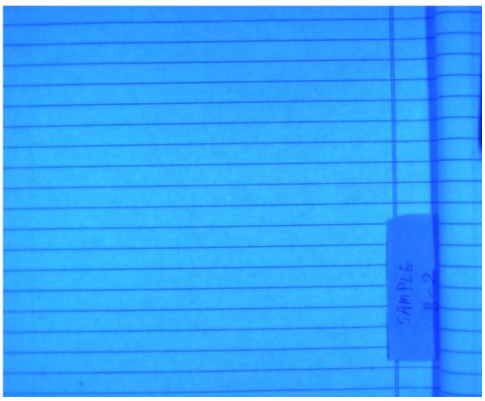
Sample A-3 showing no difference.

ISSN: 0971-1260

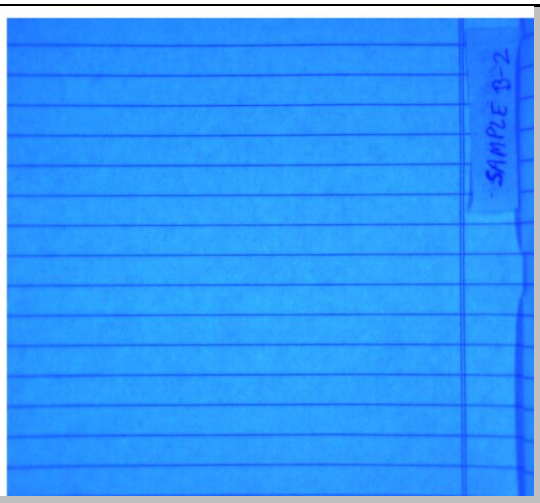
Vol-22-Issue-17-September-2019



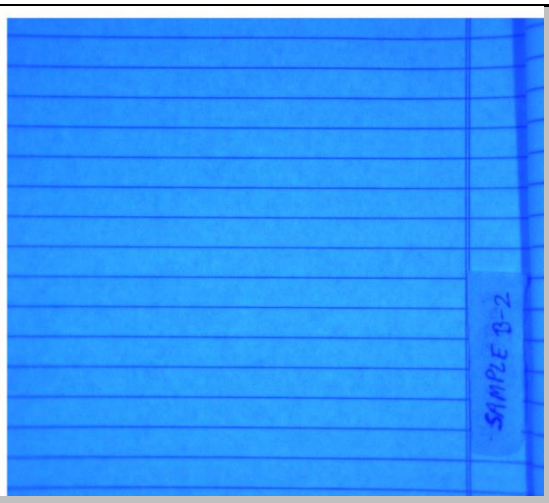
Sample B-2 under UV 256



Sample B-2 under UV 256



Sample B-2 under UV 365



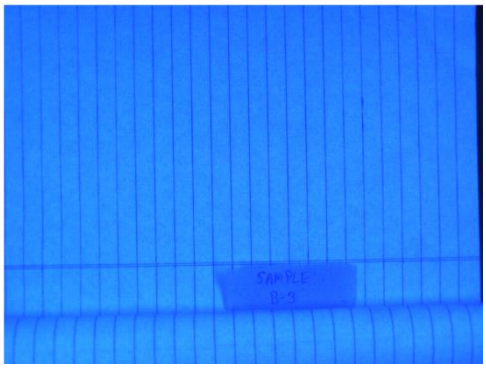
Sample B-2 under UV 365

Fig 13: Sample B-2 under UV 256 and 365

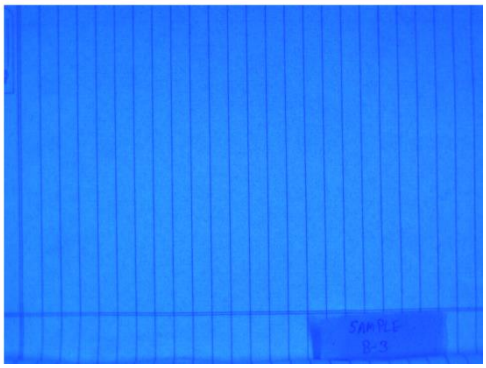
Sample B-2 Showing No Difference.

ISSN: 0971-1260

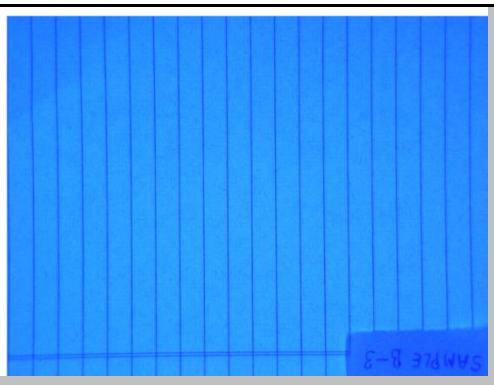
Vol-22-Issue-17-September-2019



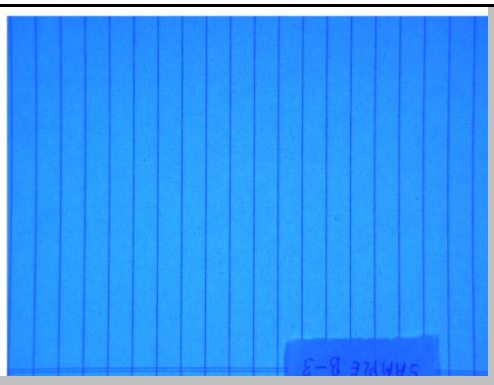
Sample B-3 under UV 256



Sample B-3 under UV 256



Sample B-3 under UV 365



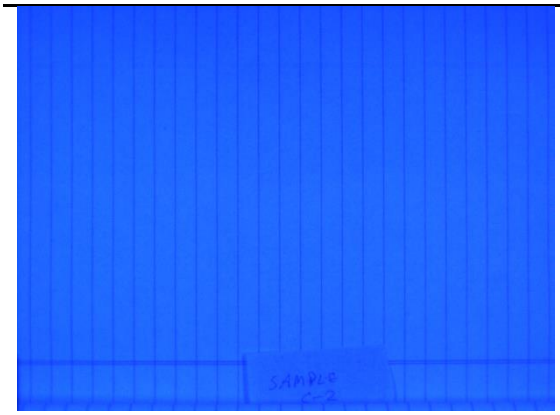
Sample B-3 under UV 365

Fig 14: Sample B-3 under UV 256 and 365

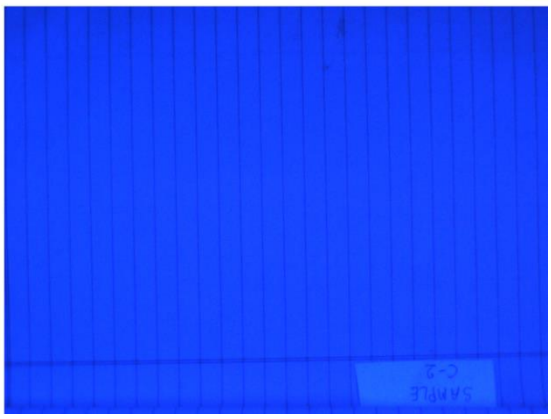
Sample B-3 showing No Difference

ISSN: 0971-1260

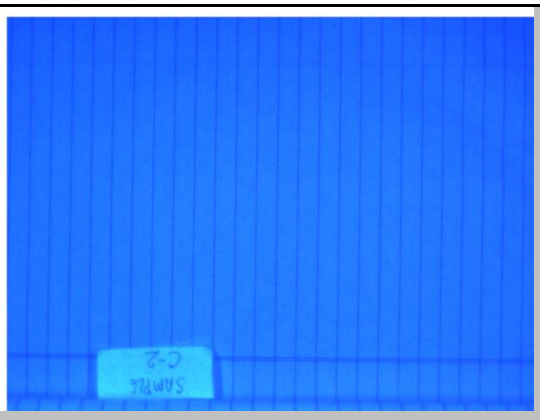
Vol-22-Issue-17-September-2019



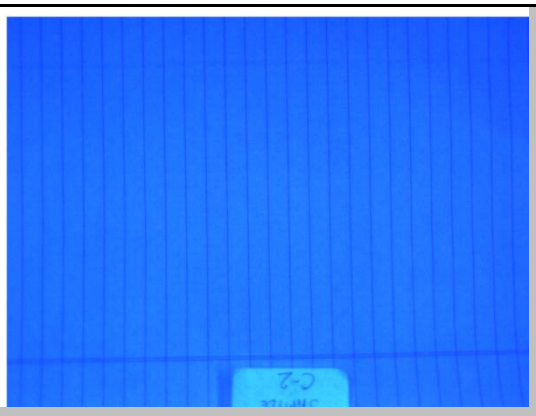
Sample C-2 under UV 256



Sample C-2 under UV 256



Sample C-2 under UV 365



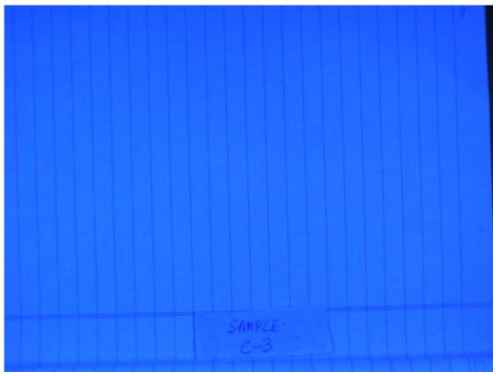
Sample C-2 under UV 365

Fig 15: Sample C-2 under UV 256 and 365

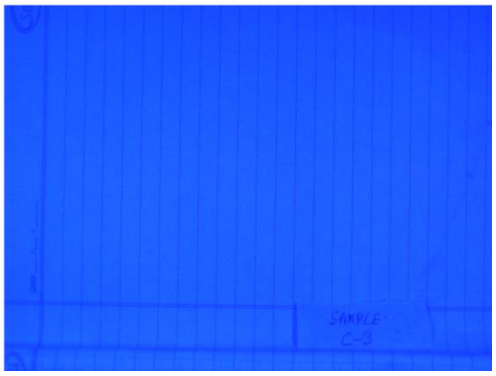
Sample C-2 showing Difference

ISSN: 0971-1260

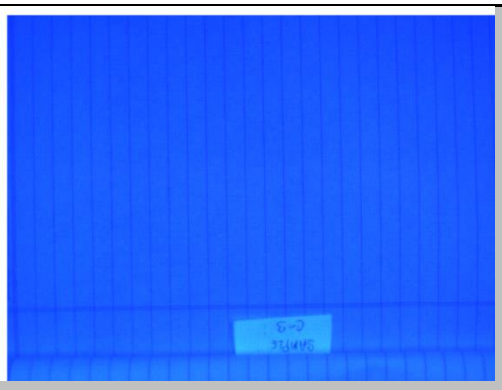
Vol-22-Issue-17-September-2019



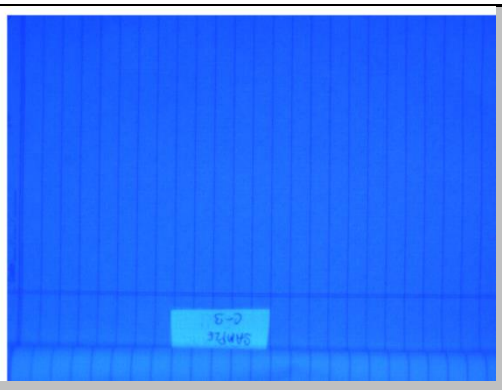
Sample C-3 under UV 256



Sample C-3 under UV 256



Sample C-3 under UV 365



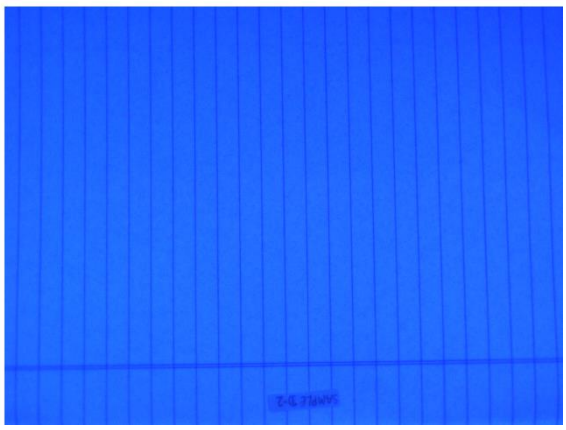
Sample C-3 under UV 365

Figure 16: Sample C-3 under UV 256 and 365

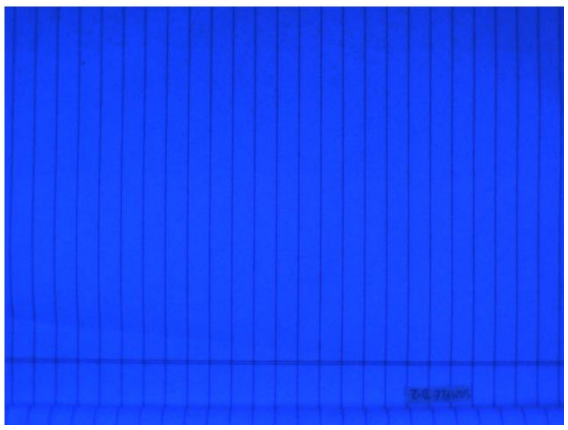
Sample C-3 Showing Difference

ISSN: 0971-1260

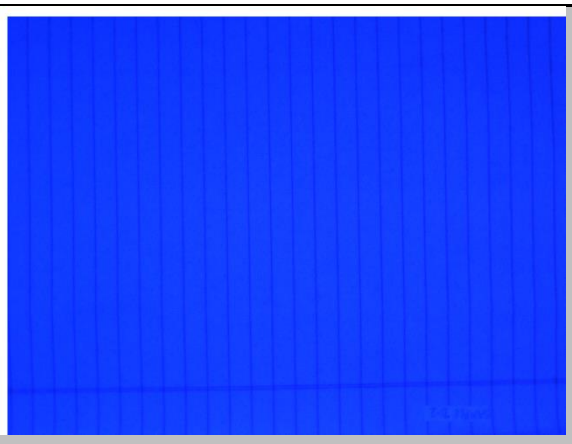
Vol-22-Issue-17-September-2019



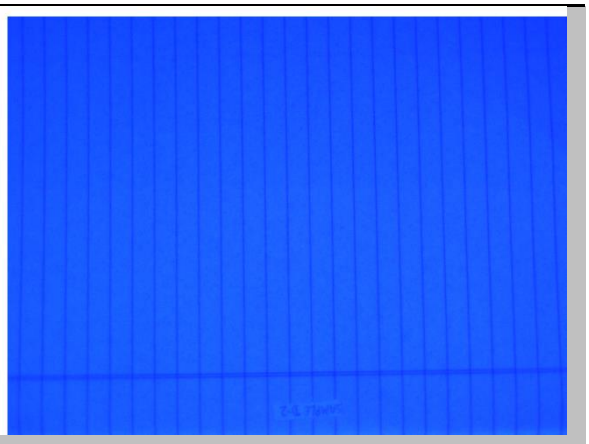
Sample D-2 under UV 256



Sample D-2 under UV 256



Sample D-2 under UV 365



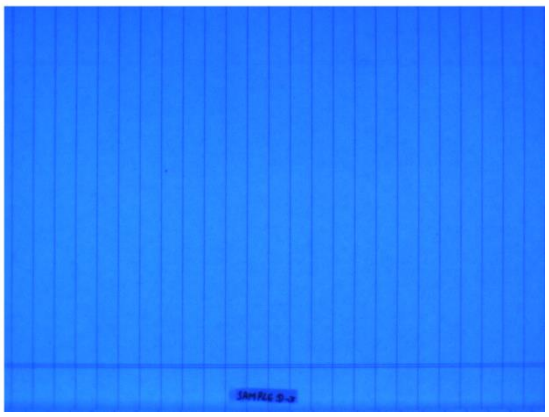
Sample D-2 under UV 365

Figure 17: Sample D-2 under UV 256 and 365

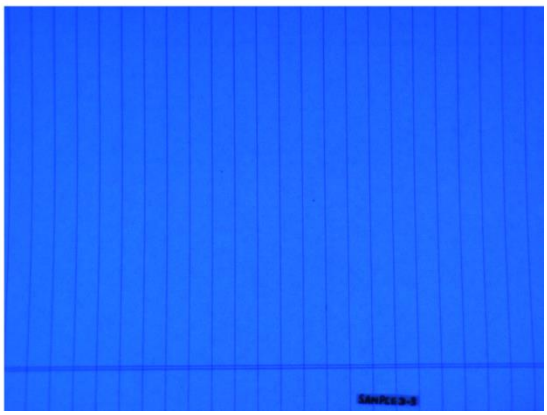
Sample D-2 Showing Difference

ISSN: 0971-1260

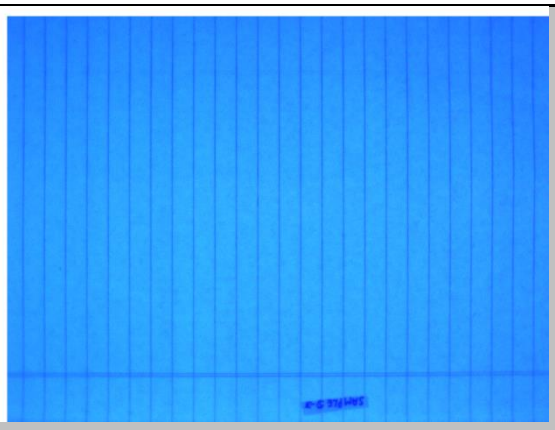
Vol-22-Issue-17-September-2019



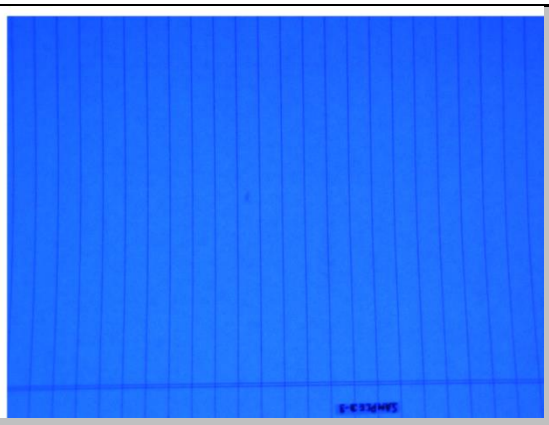
Sample D-3 under UV 256



Sample D-3 under UV 256



Sample D-3 under UV 365



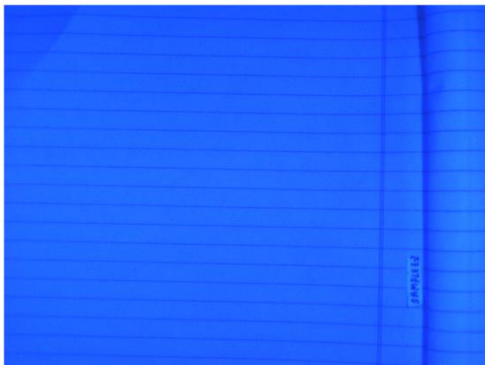
Sample D-3 under UV 365

Figure 18: Sample D-3 under UV 256 and 365

Sample D-3 Showing Difference

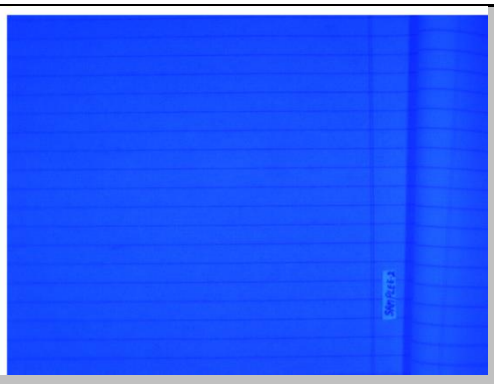
ISSN: 0971-1260

Vol-22-Issue-17-September-2019



Sample E-2 under UV 256

Sample E-2 under UV 256



Sample E-2 under UV 365

Sample E-2 under UV 365

Figure 19: Sample E-2 under UV 256 and 365

Sample E-2 Showing Difference

ISSN: 0971-1260

Vol-22-Issue-17-September-2019

ISSN: 0971-1260

Vol-22-Issue-17-September-2019

Discussion

Analysis of document is an important element of questioned document examination. There are different types of methods to examine documents. It includes:

1. Destructive method
2. Non-destructive method

In this research work non- destructive method was used to examine the different documents. Five common register brands Classmate, Evergreen, Schoolmate, Saathi and Today are taken as acquired sample. These are commonly used register brands in Kangra, Himachal Pradesh. Three registers were taken from each brand, i.e., small register, medium register and long register. From each register a bunch of papers were examined differently under Infra-Red light, far ultraviolet light, near ultraviolet radiations and transmitted light to check the similarities and dissimilarities of paper brightness and paper whiteness. Some brands of paper show similarities and some not.

All the papers were examined to check the brightness and whiteness of paper under different light. Out of all the lights used to examination of paper Ultraviolet light was found to be affordable and differentiating the brightness of paper. While the evaluation of brightness of paper considerations are on the storing manner of the registers.

Conclusion and Future Scope

As documents are the integral parts of our daily life. We use paper lifelong from the birth certificate to the death certificate. So to check the authenticity of the paper is must. From this study it is concluded that there are differences in a bunch of paper of same register of same brands and also in different brands. The light sources plays important role in differentiating the differences of the paper within and in different brands. The study helps in examination of

ISSN: 0971-1260

Vol-22-Issue-17-September-2019

the accurate authenticity of the brightness and whiteness of paper. This study proves that examination of paper can lead to reduce the frauds and misleads done by paper substitution and insertion. This study shows that UV 256 is better to examine the paper and Transmitted light is useful to check the opaqueness of the paper. This study is a pilot study to lead the future scope of authentication of paper in questioned documents.

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ISSN: 0971-1260

Vol-22-Issue-17-September-2019

ISSN: 0971-1260

Vol-22-Issue-17-September-2019