e-ISSN: 2582-5208
International Research Journal of Modernization in Engineering Technology and Science
(Peer-Reviewed, Open Access, Fully Refereed International Journal)
Volume:06/Issue:04/April-2024 Impact Factor- 7.868 www.irjmets.com

A REVIEW PAPER ON METHODS AND APPROACHES OF INK DATING

Sayali Godase*1, Pratima Salunkhe*2

*1B.Sc.Lll Forensic Science Student, Yashvantrao Chavan Institute Of Science, Satara, Maharashtra, India.

*2Assistant Professor Of Department Of Forensic Science, Yashvantrao Chavan Institute Of Science, Satara, Maharashtra, India.

ABSTRACT

Ink dating is important part of Questioned document. It analyses different questioned document in which ink as important component. Ink dating is defining the age of ink which improves when highly informative and discriminating analytical methods are used. Main approaches of ink dating are static and dynamic. Static involves identification of component and comparing it with known source. Dynamic involves the detraining the changes it undergoes or the environmental factors which effects the ink. Ink dating is analyzed by two methods. First is Non-destructive which includes the examination without disturbing the sample. Destructive which involves the examination by performing chemical process which causes the irreversible and permanent changes. Three main principles which helps to analyses the ink are dye degradation, solvent evaporation, resin polymerization.

Keywords: Ink Dating, Static, Dynamic, Destructive, Non-Destructive, Solvent Evaporation.

I. INTRODUCTION

The chemical analysis of inks, as well as paper, can be is most important when trying to prove whether a document is original or altered. Ink dating is a highly specialized forensic examination and considered to be one of the most accurate method which reliable for examination [1]. It helps to analyses the evidences in serving better result to justice system and also help to provide clues to investigation. Ink dating is the examination of ink then it may be various types of ink. According to many researchers' inks is can be examined by different methods and approaches. Ink dating improves when highly information and discriminating analytical methods are used for examination [2]. A document dating examination includes the chemical, and physical examination of ink which includes its composition. Ink dating analysis can be instrumental in those instances, it is a challenging task for forensic examiner due to the various factors. [2]. Partial least squares regression (PLSR) was used to generate dating models for these inks aged with exposure to light [3].

Researchers have been investigating these dating procedures from very earlier years due to the very confusing nature of ink, which can include components such as dyes, pigments, solvents, resins, lubricants, biocides, surfactants, corrosion inhibitors, sequestrates, shear-thinning agents and other chemicals to enhance the quality of ink [4]. 2-Phenoxyethanol (PE) is present in the composition, it is a volatile compound of inks. When ink deposited on paper it start to evaporate and degradation with respect of time. This ageing process allow to determine the date of an ink in a questioned document [5]. Based on the evaporation of 2-phenoxyethanol (PE) over time, that can contribute to ink age estimation [6].

Forensic research dating ballpoint pen inks on paper is among the most difficult and hardest problems [7]. The increasing complexity of ink formulations can also be attributed to the following: (I) the continuous development of new ink products, with similar chemical properties [4], by manufacturers to reduce cost; (ii) the use of the same ink formulation or in some instances, the addition or replacement of particular components to improve the cost-effectiveness of the product [4]; and (iii) the use of the same dye in different colors of ballpoint pen inks [4]. Using the solvent volatility ratio was an effective method of determining the rate of degradation and time since deposition of the ballpoint pen ink [8]. Ink analysis is important part of Questioned Document Forensic Science. All blue and black inks look same but chemical composition are different hence it is analyzed through different ways [4].

II. METHODOLOGY

There are different approaches of analysis and examination of ink according many scientists. The two main challenges are to determine when the ink was manufactured and to determine time since deposition (TSD) of

e-ISSN: 2582-5208
International Research Journal of Modernization in Engineering Technology and Science
(Peer-Reviewed, Open Access, Fully Refereed International Journal)
Volume:06/Issue:04/April-2024 Impact Factor- 7.868 www.irjmets.com

the ink on a handwriting document [7]. Ink´s time since deposition depends on internal and external factors of ink. For example environmental conditions. Once a document has been handwritten the ink deposited starts the aging process, which involves solvent evaporation, dye degradation, polymerization and hardening of the resins [7]. The analysis of physical changes or chemical changes of solvents present in ink on a given set of environmental conditions can provide a measure of chronological age of ink. To obtain a chemical fingerprint of ink changes, chromatographic methods have been explored [7]. Evaluating the potential of three interpretation models to date ink entries in a legal perspective:

(1) the threshold model comparing analytical results to tabulated values in order to determine the maximal possible age of an ink entry,

(2) the most accurate and reliable tests which focuses on the "ageing status" of an ink entry, and

(3) the likelihood ratio calculation comparing the probabilities to observe the results under at least two alternative hypotheses [10]. The likelihood ratio calculation introduced a degree of certainty to the ink dating conclusion in comparison to the threshold approach [10].

Two main approaches of ink dating are static and dynamic [2]. Static is based on characterization and identification of ink components, which is compared to other pen ink it is known as source. In it ink of known manufacturing history are identified by visual microscopic or chemical methods and then it compared to questioned sample. Standard sample with known manufacturing information and date of production helps in analysis. Static approach assumes that measured profiles of ink occur have not changed over time, it is critical that the comparison are representative and stable [2]. Dynamic involves the elucidation of inks processes and changes that occurs over time, as a result of ink interaction with environmental factors such as humidity and light. The dynamic ink dating examination works on the comparison between the inks present inside the pen or on recent application with the ink placed on paper for some time. Based on transformation it undergoes, it is possible to verify the how long the ink has been on the paper [2].

The ink also can be analyzed by two methods are destructive method and non-destructive method [11]. In nondestructive analysis it involves analyzing the physical properties of sample, it dints damages the sample. It is preferred first because it helps to maintain the integrity of sample. Mainly microscopes are used for non-destruction analysis. Non-destructive method is using the micro-spectrophotometry techniques for analysis. It uses the principle of absorption and emission of light [11]. It involves the scanning of ink with UV and IR light and it gives the spectrum. Spectrum is the light of different wavelength. Non-destructive methodology could assist document examiners in the relative ageing or approximate age determination of questioned documents, as well as the identification of document alterations [3].

Destructive method is opposite to non-destructive. Destructive analysis includes the irreversible and permanent changes to sample. Mostly used techniques are chromatographic techniques. Chromatographic techniques help to separate and individualize the components. It is used for identifying the composition of component [11].

Ink dating is done on the basis of three principle [2].

- Dye Degradation: Dye degradation is the changes ink undergoes like changing color (decolorization) or other chemical changes. Exposure to light effect the level of dye degradation of ink because it increases the rate of dye degradation [2].
- Solvent Evaporation: All pen ink contains volatile compounds and other chemicals to enhance the ink properties. After ink deposition on paper, those solvents begin to degrade and evaporate. Most of time 2-Phenoxyethanol is used as solvent in ink of ball point pen . Loss of 2-phenoxyethanol helps to investigate the age of ink. It can estimate the age of document up to 2 years approx.. [2].
- Resin Polymerization: Resin and polymers are used as binders in ink it. It helps to disperse and carry pigment of the ink. It provide ink's properties such as drying characteristics, ink transfer behavior.

III. CONCLUSION

Ink is considered as important evidence that comes under the branch questioned Document of Forensic Science. It analyzed by different informative and discriminating analytical methods. It includes different ways like Destructive or Non-destructive method. The destructive method includes analyzing the sample without

e-ISSN: 2582-5208
International Research Journal of Modernization in Engineering Technology and Science
(Peer-Reviewed, Open Access, Fully Refereed International Journal)
Volume:06/Issue:04/April-2024 Impact Factor- 7.868 www.irjmets.com

damaging it. The non-destructive methods are involving the chemical reactions with ink which causes the irreversible or permanent changes to sample. Another approach is first is static based on characterization ink components and comparing it with standard sample. Second is dynamic it involves the examination of changes occurs over time or due to environmental factors. There are three main principles of ink dating are 1. Dye degradation 2. Solvent evaporation 3. Resin polymerization.

IV. REFERENCES

[1] L. Gerald M, https://www.rileywelch.com/inkdating.Riley Welch LaPorte.
[2] C. B. R. Gorziza, "Blue and black ballpoint pen inks: a systematic review for ink characterization and dating analysis," Brazilian Journal of forensic science medical law and bioethics, January 2019.
[3] W. L. G. S. Simon, "A study into the ageing and dating of blue ball tip on paper using in situ visible spectroscopy with chemometrics," Research gate.
[4] M. B. T. A. D. Hoang, "combination of a green and a traditional method for estimating relative and absolute ink dating in vietnam," Journal of Analytical Methods in chemistry, 2021.
[5] A. Q. C. F. T. Leal, "2-Phenoxyethanol derivation in ink dating determination," Research Gate.
[6] A. R. C. F. T. Leal, "GC-MS Sialylation derivative method to characterize black BIC ballpoint 2-Phenoxyethanol ratio evaporation profile- a contribution to ink ageing estimation," PubMed central.
[7] C. F. A. Q. T. A. Leal, "Dating ink on paper through chromatographic analysis of volatile compound," Research Gate.
[8] D. E. O. El-Sabbah, "Dating the ballpoint pen inks using gas chromatography-mass spectrometry technique," Research Gate.
[9] D. V. N. Aginsky, "Ink Dating".Aginsky Forensic Document Dating Laboratory, Inc.
[10] C. W. A. Koenig, "Ink dating part 2: interpretation of results in a legal perspective," Research Gate.
[11] "Ink Dating," World of forensic science encyclopedia.com, 18 March, 2024.