

THE HIDDEN SIGNATURE: EXPLORING THE FORENSIC SCIENCE OF LIPS IMPRESSIONS

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ABSTRACT

Lipstick stains are one of the trace evidences which can be found at a crime scene. They are easily transferable and, like other forms of evidence, can provide a link between a suspect and a victim. Although even the unambiguous results of the lipstick stains examination do not constitute conclusive evidence of a crime, the information obtained may be useful as an aid to an investigation or as corroborative evidence. The biological phenomenon of systems of furrows on the red part of human lips was first noted by anthropologists. R. Fischer was the first to describe it in 1902. The shape of creases on the lips has distinct features like fingerprints. Cheiloscropy is a forensic investigation method that deals with identification of humans depending upon the on lips traces. According to the Federal Bureau of Investigation, lip prints, which are similar to fingerprints, palm prints, and footprints, can be used as a positive means of identification. The lip prints can also give other details such as cosmetics used, habits, occupational qualities and the pathological changes of lips. OBJECTIVES: This article's main goal is to describe the role that lipstick stains play in forensic science and how they can be used to identify a person. Different forms of expected and well-known sophisticated analyzing methods include gas chromatography mass spectrometry, thin layer chromatography (TLC), and high-performance liquid chromatography (HPLC). Raw lipstick and stains have been examined using spectrometric techniques such as neutron activation analysis (NAA), Raman spectroscopy (RS), and ATR-FTIR. Raman spectroscopy has been shown to be a useful tool for distinguishing and identifying lipstick samples. FTIR spectroscopy is another extensively used technique for examining lipstick stains. It is a non-destructive technique that yields rapid, precise examination of a small sample size. Using the proper methodology and analytical procedures is crucial for producing reliable results. Lipstick stains may be a useful evidence for identifying criminals. Identity can be established by a combination of methods which makes the identification procedure relatively flawless.

Keywords: Lipstick stain, TLC, HPLC, Raman spectroscopy (RS), Control sample.

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INTRODUCTION

Criminal investigations today are so sophisticated that they now include experts from many different fields in order to solve a crime. Every discipline adds a piece to the puzzle until it is finished. The keystone of a death inquiry is typically the coroner or medical examiner, who consults with other professionals until enough data is gathered to identify the cause and manner of death. The prosecutor and police investigators are then given access to this material. This necessitates the greatest degree of cooperation and communication between everyone engaged [1]. Trace is short for tiny or tiny. A forensic scientist might define trace evidence as information

transferred from one person to another or place and cannot be seen with the naked eye. i.e., hairs, fingerprints, fibers, lipstick stains, gunshot residue, wood and pollen etc. Lipsticks are considered important trace evidence in forensics because they help link the perpetrator to the crime [2]. Lipstick is a type of material evidence usually found in the cases of sexual assault, homicide, larceny, home invasion etc. It is originated on the scene of incidents on clothes', papers, tissue-papers, cigarette-buts, skin or any other surface or material [3]. Lip prints are normal lines and crevices in the form of wrinkles and grooves present in the section of human lip,

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between the inner labial mucosa and outer skin, and the exploration is known as cheiloscropy. This is unique for particulars, as finger prints [4]. Modern day criminal investigation has reached the point of sophistication requiring the involvement of many different disciplines to solve a crime for the ease of investigation, a forensic investigation technique used to identify a person depends on a specific array of lines that become apparent on the red parts of lips. Every human has different grooves on the red part of lips by the lip prints of these grooves we can identify the human like fingerprints, human lip prints are also unique. This article aims to provide the readers a brief and summarize study of all the analyzing techniques used for the analysis of lip prints and lip stain patterns.

CHEILOSCOPY

A Greek word “cheilos” means lips). A forensic investigation technique used to identify a person depends on the distinct pattern of lines that appear on the red area of the lips. In 1902, The grooves on the red portion of human lips were initially depicted by Fischer, an anthropologist [5, 6]. Cheiloscropy is significant since each person's lip print is distinct from another's, with the exception of identical twins. Lip prints are permanent, just like fingerprints and palatal wrinkles. As early as the sixth week of intrauterine life, it is possible to evaluate lip patterns. At that time, lip groove patterns, which rarely alter, fight a variety of illnesses, including fever blisters. Lip print identification is comparable to finger print identification in the forensic sciences as a method of establishing a person's identity. Wax (approximately 20%), oils (40–70%), and colorants (dyes or pigments 2- 10%), when applied in the proper amounts, provide the desired product in lipsticks. When lipstick is applied to lips, it gives lips soft and smooth appearance. Castor oil, jojoba oil, and lanolin derivatives are among the oils that are frequently used to aid in the uniform dispersion of pigments. The final key elements are colorants, both natural and synthetic (such as tartrazine, erythrosine, eosin, and phloxine B) (e.g. carmine). The colorants group also contains mineral pigments (e.g. iron yellow) and are employed in tiny quantities as they are a source of heavy metals. In addition to the primary ingredients, they also contain smaller amounts of other substances like gloss agents, moisturizers, and scents (they suppress the odor of other chemicals and increases the attractiveness of the Product). furthermore contain UV radiation shields, vitamins (A, B6, C, and E), and other minerals that enhance the characteristics [7].

The biochemical interaction of chemical agents with lip residues (deposited on surfaces) is the basis for the advancement of chemical lipstick procedures. Lysochrome and fluorescent dyes are the most commonly employed substances with lipid soluble characteristics for lipstick enhancement (Nile red). Lysochrome is a general name for chemical

substances that stain fatty acids by causing one component (Lyso) to dissolve upon contact with fat and create a color that reveals the print patterns. The biochemical interaction of chemical agents and lip residues (deposited on surfaces) is what drives the development of chemical lipstick procedures [8]. Lysochrome and fluorescent dyes are the most commonly employed substances with lipid soluble characteristics for lipstick enhancement (Nile red). Lysochrome is a general term for chemical substances that stain fatty acids by causing one component (Lyso) to dissolve upon contact with fat and produce a color that reveals the patterns in the prints [9]. The waxes determine the lipstick's structure, hardness, and stability. Wax smooths and softens its characteristics. Wax from plants (such as carnauba and candelilla), animals (such as beeswax), and minerals (such as polyethylene) are all used in varying amounts to make lipsticks [10].

When the pattern of all the lip compartments was examined, Type II (branching) was found to be the most common, occurring in 59 cases (39.5%), with 27 males and 32 females (a ratio of 35.5% and 42.5%, respectively). The Type V (reticular) pattern, which only occurred in 21 cases (14%) with 8 males (10.0%) and 13 females (16.5%), was the least common. Men had more Type I and Type I' cases, totaling 29 (38%); Type I (full vertical) is the dominant pattern across all quadrants. In males, Type V (reticular) is uncommon. The most prevalent pattern in females was Type II (branching), which accounted for 32 cases (42.5%), and it was found that Type II in the fourth quadrant is typically present in all females. The majority of observations in females have similar patterns in all four quadrants. Type I (full vertical) occurrence is rare [11]. The asymmetrical lines on the lips create a recognizable pattern on the sulci labiorum, which are regarded as unique fingerprints. The labial mucosa's sulci labiorum, or wrinkles and grooves, create a distinctive pattern. Cheiloscropy is the study of lips and the patterns left by their lips [12]. Numerous researches have examined the likelihood that lip prints may be recognized, much like fingerprints, the presence of gender and species differences. These investigations noted that if this uniqueness and specificity were confirmed, the lip prints might be an important tool for identification [13]. Trace amounts (<1 mg) of transfer stains must be examined by forensic chemists without causing significant harm to the display. In principle, Also, being able to distinguish between the various lipstick brands that are available is ideal (probably several hundred brands). We are aware of seven articles that have discussed the forensic examination of lipstick stains. Many methods, such as UV spectrophotometry [14].

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ease of investigation, a forensic investigation technique used to identify a person depends on a specific array of lines that become apparent on the red parts of lips. Every human has different grooves on the red part of lips by the lip prints of these grooves we can identify the human like fingerprints, human lip prints are also unique.

LIP PRINT COLLECTION AS A TRACE EVIDENCE

At crime scene there are number of ways involved for gathering lip prints. To start, the investigator has to put on gloves to protect the data. The suspicious object or surface should then be checked for any lip prints that may be seen. Various methods, such as fingerprint powder, Ninhydrin, or silver nitrate, can be used to enhance the lip print. Once the lip prints have been located, they need to be photographed or copied in order to be preserved. To document the pattern and specifics of the lip prints, the investigator should take both wide-angle and up-close pictures of them. The crime scene drawing should also include the placement of the lip prints.

Control sample

By asking the suspect to apply a well-known lipstick or lip gloss and then pressing their lips against a piece of clean, white paper, you may obtain the control sample from their lips. By rubbing the victim's lips against a piece of white paper that has not been touched, or by gathering any object that could have the victim's lip prints on it, such a cigarette butt, or glass the question sample can be taken from the scene of the crime [15].

Sample Preservation

The lip prints should be stored in a sealed container after collection in order to prevent contamination before being forwarded to the forensic laboratory for examination. Comparing the pattern and specifics of the test and control samples in the laboratory can be done using a variety of techniques, including visual examination, digital imaging, or software-based analysis [16].

Recording of lipstick stains

The questionable lips can be photographed on a nonporous, flat surface, such as a mirror, and then magnified and unduly grooved. Using a finger printer, particularly a roller finger printer, the individual presses his or her lips on a sheet of paper, cellophane tape, or another suitable surface after applying lipstick, rouge, or another suitable product to the lips [17]. In order to emphasize the contrast between the white and dark parts, the lips should be lit properly when being photographed. The final lip print image needs to be of normal size. You can do this by using a measurement tool, especially an ABFO scale no. 2. The core sections of the lips and the angles of the lips are never in the same plane, which makes it difficult to focus and sometimes results in blurry, unsharpened, or incomplete images of the lips while photographing lip prints. This typically involves taking a lip print recording, a

photo of the two, and a comparison of the two images. Therefore, despite being a reliable method in other forensics applications, it raises the cost without increasing clarity in a rising proportion when used to record photos of lip prints. Since the development of digital photography, there has been a trend towards directly recording digital images us. Used are the same as finger print development and the latent lipstick print must be dry.

Processing and developing of lipstick stains

When the lipstick stain is left on a suitable medium, it can be developed and photographed using a variety of various powders or cyanoacrylate. The powders used are same to those used for fingerprint development, and the latent lipstick must be dry. Many crime scene investigators utilize ordinary, nonmagnetic powder for more than half of their powders. It can be used on windows, counter tops, television sets, and many other items that have been moved or touched at domestic crime scenes. It can also be used on metal filing cabinets, painted doors, broken glass, and metal window frames. Regular powders are available in a variety of colors, including black, silver and grey, dichromatic, and white. If a clear photograph of the latent print must be taken, the appropriate color is chosen to create sufficient contrast with the surrounding surface [18].

ANALYSIS OF LIPSTICK STAINS

It is a challenging job to analyze the lipstick stains in forensic investigation. Different types of expected and well known sophisticated analytical techniques involving TLC(thin layer chromatography), HPLC (high performance liquid chromatography) [15], GC- MS (gas chromatography mass spectrometry). (NAA) Neutron Activation Analysis, Raman spectrometry (RS) [19] and ATR – FTIR spectrometry [20] used for the inspection of raw lipstick stains. Many approaches have been developed to detect the elemental makeup of lipstick that is destructive in nature, and some of them are ineffective for analyzing residues of lipstick stains. ICP-MS (Inductive Coupled Plasma Mass Spectrometry) and Graphite Furnace Atomic Absorption Spectrometry (GFAAS) demand special procedure to interject the specimen to the plasma or Furnace. NAA (Neutron Activation Analysis) is nondestructive in nature highly sensitive, expensive and time consuming are the conditions that are dependent with that technique. Likewise, thin layer chromatography (TLC) [21-24] and High performance liquid chromatography (HPLC) [25] used to observe the dyestuffs of lipsticks but can't be used separately to identifying them because these techniques demand long term sample preparation. By the way these techniques are unsatisfactory in nature. Gas chromatography-Mass Spectrometry (GC- MS) is destructive in nature and analyze the volatile components in lipstick and demand special column for Analysis. Recently, Vibrational spectroscopy techniques as Raman spectrometry

(RS) and infrared spectrophotometric techniques [26-28] are mostly used for the analysis of lipstick stains due to its nondestructive in nature.

Thin Layer Chromatography (TLC)

Thin-layer (TLC) and high-performance liquid chromatography (HPLC) were employed to undertake selective analyses that were mostly focused on the colorants present in cosmetics (HPLC) [7]. Lipstick stains can be examined using the Thin Layer Chromatography (TLC) technique by scraping the stain off the target item and combining it with a solvent to create a solution. Drawing a line at the plate's base and dotting the solution along it at regular intervals prepares a TLC plate. The individual components of the lipstick stain are then allowed to separate and form distinct bands on the plate by placing it in a developing chamber with a solvent. The brand and color of the lipstick can be identified from the bands using a reference sample, which may help locate the criminal. Using a reference sample, which may help locate the criminal [29].

Many researchers have employed the TLC approach for the variate examination of lipsticks for its low running cost, rapidity, and clarity. To get the chromatogram, they used various iterations of the mobile phase combination, and their comparison [8]. Due to the poor sensitivity of TLC, false negative findings may occasionally occur. It necessitates a sizable sample size, which might be difficult if there is little accessible evidence. Using TLC, it is challenging to locate small components and contaminants in a sample. The analyst's skills are needed since the outcomes are arbitrary. The results' visual interpretation is arbitrary and open to mistakes or discrepancies. TLC involves precise control of experimental conditions, including temperature, humidity, and solvent content, and has poor repeatability [7].

High-performance liquid chromatography

By the use of HPLC process, components of a sample are separated according to their chemical makeup and how they collaborate with Stationary phase and Mobile phase. Lipstick samples are extracted using solvents and then introduced into an HPLC apparatus. Based on their polarity and retention duration, the components of the lipstick are separated, and they may be recognized by contrasting them to recognized criteria. When analyzing lipsticks, HPLC can offer useful insights, such as the brand's identity, the existence of certain ingredients, and comparison of several samples.

Vibrational Spectroscopy

Raman spectroscopy is a frequently used technique in Vibrational Spectrometry for the study of numerous forensic exhibits such as ink, paper, toner, and blood stains. P. Gardner and co. Use Raman spectroscopy to discriminate and characterize lipstick samples and you can bias 95% of them. F. Salahoglu and colleagues used a dispersive Raman

microscope with a 632.8nm laser beam to analyze lipstick stains. Raman spectroscopy also has fluorescence and high sensitivity difficulties. Many laser sources are too expensive and unavailable in laboratories. [30]. Raman spectroscopy is a non-contact, non-destructive technology that provides quick and meaningful information on the identity of a sample while needing little or no sample preparation. Confopy can obtain the Raman spectra of a specific substance by eliminating interference from the material around and under it. Because of the advantages of Raman spectroscopy for non-destructive study of lipstick stains, a few studies on the subject have been published [31].

ATR-FTIR

Attenuated total reflection-FTIR have major role while examining lipsticks. Infrared spectroscopy in non-destructive techniques is one of the extensive methods that yields fast consistent analysis of little amount of specimen [8]. Its principle is that spectroscopy was used to distinguish organic/inorganic compounds of the kohl's sample. It enables the collection of information on functional groups found in compounds containing the analyzed material. The chemical makeup of kohl samples includes hydroxyl group, aliphatic compounds, paraffin compounds, talc, mica, silica compounds, aromatic compounds, and-CH group. The FTIR technique was also utilized to analyze the organic and elemental content of any cosmetic product stain at a crime scene.

ATR-FTIR advantages is that it specifically used to analyze kohl samples. It is robust and nondestructive. It does not need preparation of specimen. It reserves the probity of sample for testing. It incorporates with other multivariate techniques for the examination of forensic material exhibits. It gives better clarification of results. It has greater accuracy and can immediately obtained results for criminal cases [31]. Disadvantages of ATR-FTIR is their destructive nature and require lengthy sample preparation step. Due to strong interference, it is difficult to obtain peak of a one.

GC-MS

GC-MS is used for discriminant analysis. Despite the fact that rigorous visual examination and the relative strengths of specific peaks allowed differentiating all of the lipsticks tested. A capillary-MS is used to analyze a broad range of wax-based products. It gives reproducible results and Expose a defined outline of n-alkane peaks GC-MS is destructive method. It is suitable for trace from which amount of lipstick is adequate for extraction and additional analysis can be done.

This technique has the advantage of being the most sensitive. It has been used to analyze lipstick based on color and other components recovered from the sample [31]. It can analyze the volatile compound of lipstick stains. It is the most suitable method for PAH determination [32]. The typical disadvantage is

a lengthy sample preparation phase that damages the material. It necessitates a separate column for each lipstick sample, which is typically not available. Too small samples can vanish. It is the most susceptible to changes. Some low intensity peaks may disappear as a result of this [26].

Analysis of Reports

Forensic investigators must use a variety of scientific techniques to properly identify and characterize lipstick stains, which is a difficult undertaking. In this context, the examination of lipstick stains has frequently utilized vibrational spectroscopic methods as Raman spectroscopy, FTIR, and GC-MS. It has been demonstrated that Raman spectroscopy is an effective method for classifying and differentiating lipstick samples. It is a nondestructive, non-contact method which requires no need to prepare sample and gives immediate information on the identity of the sample. However, there are certain fluorescence and sensitivity concerns with Raman spectroscopy [19]. A lot of laser sources are also too expensive and unavailable in labs.

Another widely utilized method for analyzing lipstick stains is FTIR spectroscopy. It is a non-destructive method that produces quick, accurate analysis of a tiny sample size. For criminal cases, FTIR spectroscopy is useful since it doesn't need samples to be prepared, is reliable and non-destructive, and offers improved precision and quick findings. It does have certain drawbacks, though, such as its destructive nature and laborious sample preparation procedures. The most accurate method for analyzing lipstick stains is GC-MS. It can also analyze the volatile chemicals in lipstick stains. It was used to examine lipstick based on dye and other substances extracted from the sample. That's why, GC-MS is a destructive technique that necessitates a time-consuming step in sample preparation and is extremely sensitive to modifications. Furthermore, certain low-intensity peaks could vanish during the analysis, and the lipstick sample needs its own column, which is typically not accessible. For the examination of lipstick stains, vibrational spectroscopy methods including FTIR, GC-MS [32], and Raman spectroscopy are crucial analytical instruments. The less frequent methods used comparatively are TLC, HPLC and Neutron Activation Analysis (NAA) [33]. TLC mainly

focused on the colorants present in cosmetics. Lipstick stains can be examined using the TLC technique by scraping the stain off the target item and combining it with a solvent to create a solution. A TLC plate is prepared and the components of the lipstick separate and form distinct bands. The brand and color of the lipstick can be identified using a reference sample. In HPLC the components of a sample are separated according to their chemical makeup and how they interact with a stationary phase and a mobile phase. HPLC can tell the brand's identity, presence of certain ingredients and comparison of several samples. The best approach to use relies on the characteristics of the sample and the data needed for the analysis, as each technique has benefits and limits. In forensic investigations, the integration of several techniques can help with the identification and characterization of lipstick stains by allowing for a more thorough knowledge of the material.

CONCLUSION

In conclusion, forensic investigations involving lipstick stains need a variety of approaches that call for dexterity and experience. Lipstick stains may be a useful Evidence for identifying people who have committed crimes, and using the right methodology and analytical procedures is essential to getting accurate findings. The possibilities for using lipstick stains as trace evidence to identify a human being are more extensive than is often assumed. Only the point of actual, physical contact of a perpetrator's lips with an object at the crime scene can show this type of trace. Lip prints are being used in investigations to catch the culprit or to support evidence obtained in a specific investigation. As a result, the conclusion is that identity can be established through a variety of ways, making the identification process virtually perfect.

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