Research Article

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Analysis of Red-Lipstick using Attenuated Total Reflectance Fourier -Transform Infrared Spectroscopy

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Abstract

In the context of criminal investigations, specifically those involving crimes against women, it is common to find cosmetics such as lipstick, eyeliner, eye shadow, nail polish, and vermilion as potential evidence. These cosmetic items are frequently used in everyday life and can be easily transferred onto clothing, drinking cups, handkerchiefs, tissue papers, cigarette butts, and various surfaces through contact during the commission of a crime.

This paper presents the application of Attenuated Total Reflectance Fourier-Transform Infrared Spectroscopy (ATR-FTIR) as a powerful technique for investigating the chemical composition of red lipstick. By employing ATR-FTIR spectroscopy, the researchers have analyzed the compounds present in the red lipstick. This spectral analysis provides valuable chemical information that can aid in criminal investigations and forensic analysis. The result demonstrates that ATR-FTIR spectroscopy is a highly effective tool for examining the chemical composition of cosmetics. The technique enables the identification of key compounds and functional groups present in the samples, allowing for differentiation and characterization of various cosmetic products. Overall, this paper highlights the significance of ATR-FTIR spectroscopy as a valuable tool in forensic analysis and criminal investigations involving cosmetic product (red lipstick). The chemical information obtained through this technique provides crucial evidence that can contribute to the understanding and resolution of cosmetic-related crimes.

Keywords: ATR-FTIR, spectroscopy, cosmetics, crimes against women, Lipstick

Introduction

Lipstick is frequently utilized as a part of daily routines, and as a result of its widespread usage, it may be discovered as trace transmitted evidence at a murder scene. Examinations of these displays can furnish supporting evidence to establish a connection between the perpetrator and the victim or the location of the crime. In the context of criminal investigations, specifically those involving crimes against women, it is common to find cosmetics such as lipstick, eyeliner, eye shadow, nail polish, and vermilion as potential evidence. These cosmetic items are frequently utilized in everyday life and can be easily transferred onto various surfaces, including clothing, drinking cups, handkerchiefs, tissue paper, and cigarette butts, due to contact during the commission of the crime [1]. The term "Cosmetic" is officially defined in Section 201 (i) of the 1938 FOOD, DRUG, AND COSMETIC

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ACT (FD&C Act). According to this definition, cosmetics are articles that are intended to be applied to the human body or any part of it through rubbing, pouring, sprinkling, or spraying. These articles are used for purposes such as cleansing, beautifying, promoting attractiveness, or altering appearance. Additionally, the term includes articles that are meant to be used as a component of such cosmetic products. However, it is important to note that soap is specifically excluded from this definition[2]. One category within the realm of cosmetics, sometimes referred to as "makeup," encompasses products that largely consist of color pigments and are designed to alter the visual appearance of individuals. Additional examples of commonly used cosmetics include body lotion, shampoo, skin cleanser, and conditioner, among others. The use of cosmetic goods has experienced a significant surge, with lipstick being a prevalent choice among ladies. According to the provisions outlined in the Cosmetic Act, a total of 420 drugs are deemed illegal, while an additional 67 substances are permitted but subject to limitations[3].

Red Lipstick, lip balm, lip liner, lip stain, lip conditioner, lip primer, lip boosters, and lip butters are common lip cosmetics. Lipsticks are intentional to add color and texture to the lips and are even come in a wide range of colors, as well as finishes such as matte, gloss or shine. Lipstick applied on lips with a dye which is temporary. It is waterproof. The product of lipstick may come with a brush in the form of roller ball, stick or even can apply with finger.

Lip prints have been employed, akin to fingerprints, in the resolution of criminal cases. Through the comparison of the makeup of a lipstick smear found at a crime scene with that of the victim, forensic scientists are able to provide an indirect demonstration of touch or a potential relationship between the victim and the suspect. Various analytical techniques are employed in the examination of lipstick and its constituent substances. These techniques encompass chromatographic methods such as liquid chromatography, gas chromatography, and thin layer chromatography, as well as calorimetric analysis, acid-base titration, UV-VIS spectrophotometry, refractometry, and mass spectrometry. The aforementioned procedures are commonly linked to a particular, frequently arduous, process of preparing samples and employing many measuring instruments[4].

One of the most recent advancements in the realm of cosmetics is to the emergence of active cosmetics. Presently, cosmetics serve a dual purpose by not only enhancing the aesthetic appeal and fragrance for consumers, but also providing targeted benefits to various areas such as the skin, hair, mucous membrane, or teeth. Through the use of a functional approach, products have undergone diversification and have begun to assert a myriad of effects on the human body. Following this, the cosmetic industry experienced significant growth, leading to its widespread availability to millions of people throughout the globe.

Figure 1: Red lipstick collected for the examination

Fourier-Transform Infrared Spectroscopy(Ftir)

The Fourier-transform infrared spectroscopy (FTIR) technique is employed to acquire an infrared spectrum that captures the absorption and emission characteristics of a solid, liquid, or gas sample. The FTIR spectrometer is capable of acquiring data with excellent spectral resolution across a wide range of wavelengths. This provides a notable benefit compared to a dispersive spectrometer, which assesses intensity within a limited range of wavelengths sequentially.

The phrase Fourier-transform infrared spectroscopy denotes the necessity of employing a Fourier-transform algorithm to turn raw data into a discernible spectrum.

Fourier-transform infrared spectroscopy (FTIR) is a measurement technique that is utilized in conjunction with infrared spectra. An interferometer is utilized to transmit infra-red light through both an interferometer and a gas cuvette sample. The presence of a mobile mirror within the interferometer alters the light distribution throughout the system. The raw signal, known as an interferogram, is a representation of the intensity of light. The raw data is subsequently transformed into the spectrum using a mathematical process known as Fourier Transform. The spectral characteristics of the optical signal are contingent upon the composition of the gas components that are present. Subsequently, the quantification of the diverse gas constituents is established by analyzing the optical signal derived from the spectrum.

Non-destructive infrared spectroscopy has been employed for the examination of archaeological artifacts, encompassing the research of cosmetic materials utilized during prehistoric eras[5]. The composition of lipstick from previous centuries can be determined by the utilization of infrared spectroscopy. Nevertheless, the identification of minute quantities of the constituents in the sample proves to be exceedingly challenging, if not unattainable[6]. Consequently, it is recommended to employ supplementary techniques such as chromatography and Raman spectroscopy. Typically, the utilization of a dual approach including two methodologies, such as FT-IR and Raman spectroscopy, yields a more comprehensive and unambiguous understanding of the sample's composition. The presence of surfactants, emulsifiers, and alcohols can be determined using infrared spectroscopy.

Materials and Methodology

A selection of popular lipstick brands was procured from the North Western Indian market. Lipstick samples, weighing approximately 1.5 mg, were applied directly onto an ATR-FTIR crystal for subsequent analysis. The crystal and sample were effectively brought into contact by means of a securely fastened anvil, ensuring optimal surface interaction. Regarding the instrumental setup, the materials were analyzed using ATR-FTIR spectrophotometer that was equipped with a ZnSe crystal.

The instrument was employed to capture spectral data inside the mid-infrared region. The spectral range of interest lies between 4000 and 600 cm^{-1}. The optimization studies conducted determined that the ATR-FTIR spectrometer's scan duration and resolution should be set at 24 scans and 4 cm^{-1} respectively, as these parameters are considered significant. There is no significant evidence or findings to support the claim.

Observation Table

Table 1: Results from ATR-FTIR

Hit No.	Hit Quality	Compound Names
1	370	RUMITEN 250 CQ* LOW DENSITYPOLYETHYLENE,
2	369	PARVAN 3150, F.N. 3502* REFINED PARAFINWAX
3	369	RUMITEN HD 630 INJECTION MOLDING* HIGHDENSITY POLYETHYLENE
4	354	EPCAR 5875* ETHYLENE/ PROPYLENE/DIENE TERPOLYMER
5	312	POLY(ETHYLENE) LOW DENSITY

Result and Discussion

The technique of Attenuated Total Reflectance Fourier Transform Infrared Spectroscopy (ATR-FTIR) was employed to acquire spectra of lipstick samples in order to discern the changes in composition among different lipstick samples. Figure 1 displays a representative spectrum of lipstick.The spectral range spanning from 3700 cm−1 to 3100 cm−1 exhibited a wide spectrum, which can be attributed to the vibrations of O–H bonds in compounds such as water and alcohol. Within the spectral region of 3100 cm−1–2800 cm−1, there are observed peaks at. The wavenumbers 3007 cm−1, 2917 cm−1, and 2850 cm−1 have been assigned to the vibrational modes associated with the CH3 functional group. The stretching vibrations encompass the C–H asymmetric and C–H symmetric vibrations. In accordance with their respective positions or roles. The occurrence of peaks within the spectral ranges. The spectral regions centered around 1730–1740 cm−1, 1370–1560

cm−1, and 850–1270 cm−1 have been assigned. The C–O stretching vibration with a wavenumber of 1742 cm−1 corresponds to the propyl ester of hexanoic acid. The presence of acid, aromatic compounds (at a wavenumber of 1375 cm^{-1}), and the existence of silicates were observed.

The ATR-FTIR spectra of Red Lipstick reveal the presence of various components, namely RUMITEN 250 CQ* LOW DENSITY POLYETHYLENE, PARVAN 3150, F.N. 3502* REFINED PARAFIN WAX, RUMITEN HD 630 INJECTION MOLDING* HIGH DENSITY POLYETHYLENE, EPCAR 5875* ETHYLENE/PROPYLENE/DIENE TERPOLYMER, and POLY(ETHYLENE) LOW DENSITY. These components exhibit Hit Qualities of 370, 369, 369, 354, and 312, respectively.

Parvaneh 3150, F.N. 3502* is often known as Paraffin wax. It exhibits melting points across a spectrum of low, intermediate, and high temperatures. The Parvan company's goods are sourced from petroleum sources. EPCAR 5875* is a polymer composed of hydrocarbon molecules that incorporates an ethylene/propylene/diene terpolymer. Polyethylene low density (LDPE) exhibits favorable chemical resistance properties and demonstrates low levels of water absorption. The cost is relatively inexpensive. This material finds extensive application in high-frequency insulation, toys, tote bags, as well as gas and water pipes.

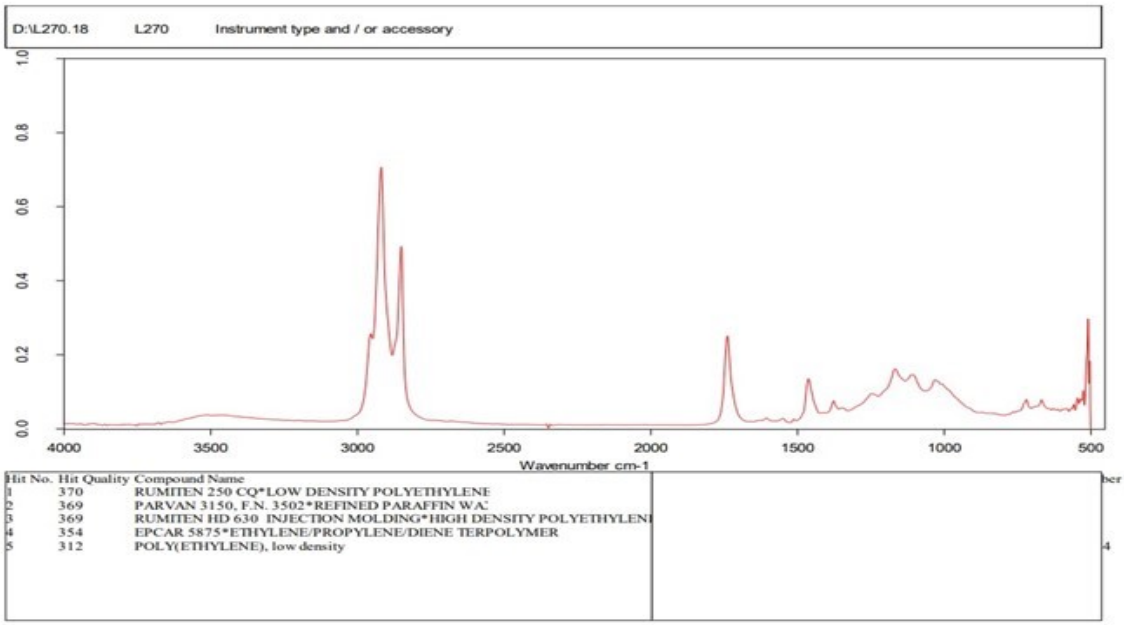

Figure 2: IR Spectra showing analysis of Lipsticks and related components

Conclusion

The comprehensive evaluation of Fourier-transform infrared spectroscopy (FTIR) in the context of cosmetics is challenging owing to the multitude of constituents included in these products. The ATR-FTIR spectroscopy technique is employed for the investigation of various substances. Cosmetic products, particularly lipstick, have the ability to serve as significant evidentiary material in crime investigations, offering vital insights into a suspect's actions or establishing a correlation with a specific crime scene. The examination of cosmetics can provide valuable insights by detecting minute traces of evidence, such as DNA or fingerprints, which can be essential in the process of identifying or establishing connections between individuals. Moreover, the existence of deleterious compounds or poisons in cosmetic products can play a significant role in instances related to assault, poisoning, or other illicit acts[7]. Thorough forensic analysis of beauty products can significantly contribute to the elucidation of factual evidence pertaining to a criminal investigation. The current investigation employed ATR-FTIR spectroscopy as an effective method for the analysis of lipstick samples. The samples were

subjected to non-destructive and expeditious analysis. The research approach employed in this study has the ability to facilitate a comparative analysis between questioned and known lipsticks by offering a statistical foundation upon which examiners can substantiate their results. Further investigation is necessary to validate the current research approach, and additional investigations should be conducted to establish a correlation between the lipsticks' smudges on substrates and their respective sources.

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