Formulation and evaluation of fingerprint powder to aid forensic investigation in a depressed economy

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Abstract

This study was designed to produce an effective, locally produced fingerprint powder for identifying latent prints on various surfaces. Fingerprint identification uses the impressions of unique ridge patterns on the fingertip, visualized through powder application [1, 2]. Three research questions were used to guide the study on how the particle size and retention ability affect the visualization of the powder. The objective is to evaluate a crime scene effectively using locally-produced fingerprint powder. Our materials and methods combine comparison analysis, sieve analysis (#100 mesh, #150mesh (µm), and infrared (IR) spectroscopy using florescent, lycopodium-based powder. Equipment includes: thermal /electric driers (oven), ultraviolet scanning devices, and Optical and Electronic Microscopes. Fourier Transform Infrared Spectroscopy (FTIR), was used to determine the molecular structure and group of the element used; Scanning Electron Microscopy (SEM) determined the particle arrangement, others are X-ray diffraction (XRD) was used for crystal structures, and energy dispersive X-ray (EDX) for elemental composition. Results proved that finer powder particles adhere better to surfaces, while IR spectroscopy enables rapid powder constituent detection. The study demonstrates the importance of particle size and color for optimal latent print visualization on diverse surfaces [3]. Production of local powder will reduce the crime rate in our society, and lower the cost of crime investigation.

Introduction

Fingerprint patterns and characteristics are formed before birth. They are unique to everyone, including identical twins, and have been used for identification and crime-solving purposes [4] in the *Commonwealth of Virginia*.

Forensic science is the application of scientific principles and methods to investigate crime through legal proceedings and evidence. It is a multidisciplinary profession with several fields of study, including digital forensics, forensic chemistry and drug analysis, forensic toxicology, forensic and legal medicine, and others [5].

Fingerprint analysis is a crucial tool in forensic criminal investigations. It is extremely useful in providing reliable physical evidence that can associate suspects with crime scenes. They can be used to identify individuals, validate or invalidate their presence at a crime scene, and track their criminal records.

The fingerprint powder produced in this study can be used to develop the fingerprint of individuals who might have touched surfaces or items made up of materials such as paper, glass, wood, or metals at a crime scene. When matched with a suspect's fingerprint, the developed print becomes a useful scientific tool for proving the culpability or otherwise of the suspect [6].

This study will create room for crime scene investigators and analysts to identify management and vendors or boards, to have access to an efficient universally accepted, and locally produced fingerprint powder, which can effectively make the same correct result as that of the foreign /imported fingerprint powders from other countries like United States of American. It will lead to a reduction in the crime rate in our society as a whole.

Research Questions:

1. Can Infrared (IR) Spectroscopy be used to determine the molecular structures of the materials used to produce black/colored fingerprint powder?
2. Can the particle sizes of the materials used to formulate a sample fingerprint powder affect its efficiency and retention on a surface?
3. Will improperly seasoned (complete removal of moisture content) fingerprint powder lead to coagulation and affect the durability of a powder?

Objectives of the Study:

1. Characterize the locally produced fingerprint powder using Fourier Transform Infrared spectroscopy (FTIR) and Scanning Electron Microscopy (SEM).
2. Modify the formulation operating procedures (protocol) to conform to CGMPs-current good manufacturing practices (Regulation).
3. Evaluate a crime scene effectively using the locally formulated fingerprint powder, to visualize prints discovered in the crime scene, under UV light and IR spectra, and matching it with Automated Fingerprint Identification System (AFIS).

Materials and methods

Study design

According to Jaffer A. *et al* (7), Methods are the specific techniques and tools employed by researchers to collect data, analyze information, and conduct investigations as part of a research study. These methods are practical steps taken to address the research questions and objectives of the study. They include: Infrared (IR) Spectroscopy, FTIR-Spectroscopy, Sieve Analysis (gradation test), Comparison Analysis, and Pictorial Representation Analysis.

***Laboratory Procedure*:**

***Step1*: lycopodium powder**, 100g was used as a base (major) component powder of the formulation;

***Step2*: Metal Salt (zinc)**, 10g, in the ratio 1:10, was added to the 100g of lycopodium, both powders were mixed and sieved into a fine, uniform particle size mechanically;

***Step3*: Organic Compound (Fluorescent dye),** 2g,in the ratio of 1:100,was added and mixed thoroughly with the aid of mechanical mortar and pestle into a fine, uniform particle size;

***Step4*: Identifier compound (Ninhydrin crystal),** 2.5g, in the ratio of 1:100, was added and mixed vigorously into a fine, uniform particle size;

***Step5*: Binder (Gum Acacia**), 3g, in the ratio 1:100, was added and mixed into a fine, uniform particle size*;*

Step6: **50c**l of **Ethanol Solvent** was generally added to the powder mixture and was stirred until a uniform paste was formed;

Step7: The paste formed was dried in a controlled environment, using electric oven and preserved in a desiccator containing silica gel or calcium oxide (SiO_2 or CaO2). The dried paste powder was subsequently

milled/ground into a fine, uniform particle size.

Step 8: **Quality control**: The powder was tested for its ability to develop a fingerprint on various surfaces. Evaluation of the powder's stability, Shelf life, and performance were also conducted using some of the analytical methods as represented in the data analysis page.

Data collection

Lycopodium powder, (100g); Metal Salt (zinc, (250g); Organic Compounds (fluorescent dyes or pigments), (25g); Identifier (Ninhydrin), (10g); Binders/gum acacia (starchy or silica), 500g); Solvent (ethanol), (200ml); Grinder/ crusher, Mixer(mechanical), Sieve device #100 and #150 (µm) mesh, Electric oven/drier110^{o}C, Desiccators (with silica gel-SiO_2 and calcium chloride-$CaCl_2$), FTIR device, Airtight plastic container (5- 10 ml), Powder-free adhesive hand glove, IR device, and UV scanner.

Data analysis

The data collected was analyzed using: a UV Scan to determine the absorbance rate of the powder; SEM/XRD was also used to determine the particle's morphology/physical arrangement; FTIR was used to analyze the molecular structures of the compounds/elements used.

Results

Findings

The results showed that the particle size of metals/ingredients in the sample powder influenced how elements were ionized and absorbed. Moreover, it was proved that IR spectroscopy is a more rapid/simpler/easier method of detecting ingredients used.

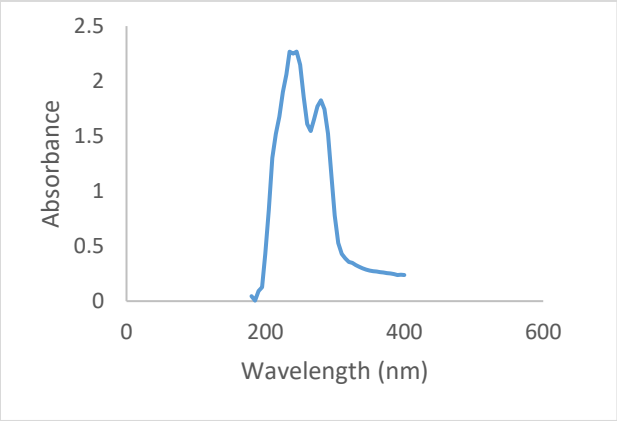
From the findings during UV scanning, it was also discovered that the UV absorbance rate was at the short UV wavelength range of 235 and 245. The graph also showed direct proportionality between the two axes of the elements or compounds' structures that were ionized, using FTIR spectroscopy.

From our results, it was discovered that the more the amount of powder in the mixture of ethanol, the higher the absorbance rate, meaning, directly proportional to each other. This showed the same on wavelength versus concentration as it is directly proportional to each other, as shown below.

Tables and Figures

Table 1: UV Standard Calibration. Showing that concentration is proportional to its absorbance.

Concentration	Absorbance
0.2	0.779
0.4	1.364
0.6	1.905
0.8	2.237
1	2.336



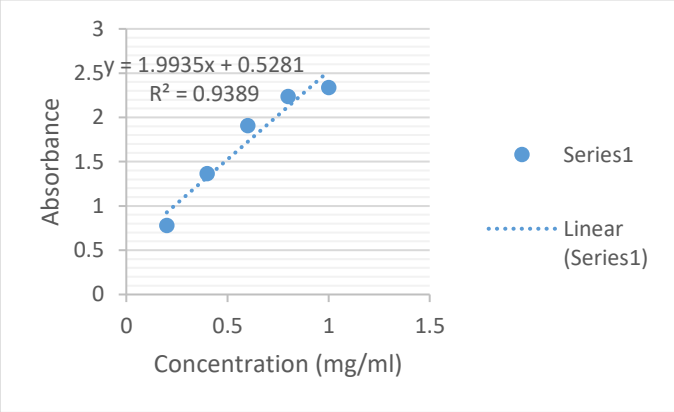


Figure 1: UV Scan result, showing the rate of absorbance in relation to wavelength of the IR-light.

Figure 2**: UV Scan result**, showing Absorbance in relation to concentration of the powder.

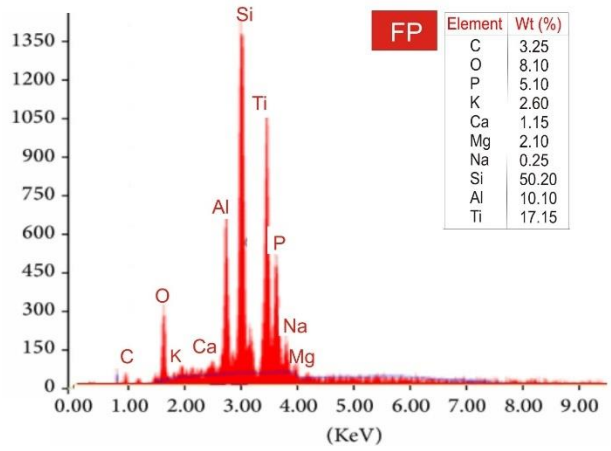


Figure3: Fourier Transform Infrared Spectroscopy (FTIR);
Showing components' molecular structures.

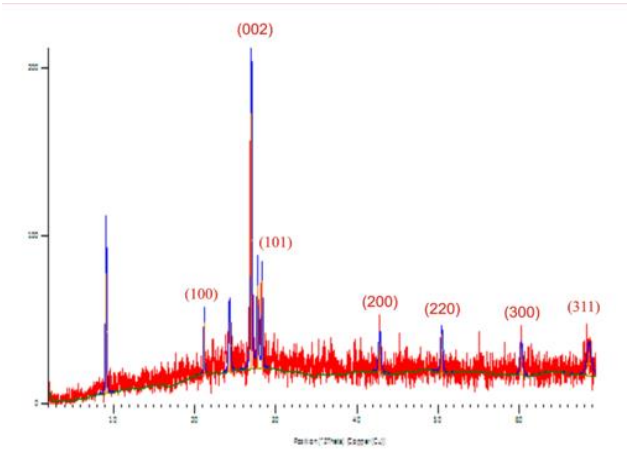


Figure 4: Showing results from Scanning Electron Microscopy (SEM),
Measuring particle sizes of the powders' Constituents.

Discussion

The results showed that the particle size of metals'/ ingredients' in the sample powder influences the rate at which elements were ionized. Moreover, it is indicated that IR spectroscopy is a more rapid/simpler/easier method of detecting the morphology of ingredients used. Similarly, Sy Fu (2008), on BBC News (2025) states that a decrease in particle size of reactants increases the surface area, thereby increasing the rate of reaction. The smaller the particle size, the faster the reaction/ionization energy.

From the result of our study, a short wavelength number was detected during UV Scan analysis at 245 UV scale, which was absorbed at 2.268 real absorbance, which implies that there was a smooth absorbance amongst the particles of the powder. In the same vein, Benedikt. *et al* (2022) proved that a shorter wavelength generally leads to higher powder absorptivity. He also added that powder tends to have higher absorption when exposed to shorter wavelengths. A shorter wavelength (higher wavenumber) is associated with higher frequency and higher energy (Agbom, 2025)

It also showed the functional groups that were detected in the fingerprint powder using IR at a wavelength range of 600nm to 4000nm. There was a strong absorption peak

at 3692.011 cm-1, which was caused by the -OH stretching vibration peak of the hydrogen-bond association and the absorption peak of water on the surface of the fingerprint powder. The functional groups identified in the FTIR spectra of the product are molecules from the materials used in the formulation, like lycopodium fluorescein powders. Similarly, Jennifer (2022), reported that the application of Infrared Radiation (IR) on the sample material (powder), gives the sample to have the ability to absorb the Infrared light's energy at various wavelengths, which is measured to determine the material's composition and structures.

The findings of the study also showed that an improperly seasoned (complete removal of moisture content) fingerprint powder leads to coagulation and affects the durability of the powder. This aligns with the research findings of Delft Solids Solution (2025), which proved that a high moisture content in a powder, generally reduces its durability by causing clumping, agglomeration, and poor flow ability, compressibility, reactivity, and stability.

The research discovered that the powders should always be stored in a controlled atmospheric environment like: "inside desiccator", with Silica gel (SiO_2) or Calcium Oxide (CaO_2) which can only be removed from there at the point of using the powder to identify a print.

Conclusion

From the research results, it was discovered that finer (smooth) particles adhere or stick more easily than coarse particle powder. Furthermore, for fingerprints to display on a light surface, rough, smooth, dark, and other surfaces, color has to be applied [3].

Suffice it to say that the production of local powder will reduce the crime rate in our societies at large. Now, the country can earn greater foreign exchange thereby commercializing the product to improve its economy.

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