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Unit-2: Development of Fingerprints

[Latent prints. Constituents of sweat residue. Latent fingerprints' detection by physical and chemical techniques. Mechanism of detection of fingerprints by different developing reagents. Application of light sources in fingerprint detection. Preservation of developed fingerprints.]

Among the most common items of evidence collected at a crime scene are fingerprints. The ridged-skin patterns at the end of our fingers contain individual characteristics that make them highly unique. When perspiration on the hands and fingers combines with oils, dirt, or other substances, these fingertip ridges can leave an impression on surfaces that are touched. Fingerprints are useful in investigations because an individual's fingerprints are consistent over time, and no two fingerprints have ever been found that are exactly alike.

Role of fingerprints in personal identification

1) A fingerprint is an individual characteristic. No two fingers have identical ridge characteristics. So far no two fingers have been observed to possess identical ridge characteristics.

2) A fingerprint will remain unchanged during an individual's lifetime as they appear in intra-uterine life and remain till the time skin is damaged permanently or disintegrated after death. Certain diseases also may cause damage to the friction skin.

3) Fingerprints have general ridge patterns which make it possible to systematically classify. This advantage allow us to classify fingerprints of large number of individuals systematically just like books are classified and arranged in the library to retrieve them easily to save time.

Various Types of Fingerprint Patterns

The dermal ridges tend to make specific patterns on the distal phalanges of the fingers, representing the following types of patterns and are of immediate concern.

The main types of the patterns are as follows: Arch; Loops; Whorls.

Constituents of sweat residue: The components are composed primarily of water but also small amounts of minerals (such as sodium, potassium, calcium, and magnesium), amino acids, metabolites (such as lactate, ammonia, and urea), and unmetabolized pharmaceutical drugs.

Scene of Crime Fingerprints

Fingerprints found at the crime scene may be of three types: 1) Visible fingerprints, 2) Plastic fingerprints, and 3) Latent fingerprints.

Visible fingerprints (or **negative fingerrints**) as the term suggests, are visible by naked eyes without any aid. The fingerprint is visible as long as there is sufficient contrast between the print and its support. They do not require any treatment for their enhancement and can be photographed directly for record and further analysis purpose

Plastic fingerprints are those prints which are formulated on soft, greasy or plastic surfaces. These are visible and thus can be photographed and sent for comparison purpose.

Latent fingerprint is the most common form of fingerprint. These prints are produced by touching a surface and leaving behind fingerprint residue (oils, dirt, perspiration) in the pattern of the ridges. Because the prints are invisible to the naked eye, investigators must use development techniques to find them

Development techniques use the chemical and physical properties of the fingerprint residue to produce contrast so the hidden prints can be observed. To develop a latent fingerprint, investigators must understand the potential composition of the residue. The development of fingerprints depends upon the type of surface on which they exist, the temperature of the surface, and the surface texture. All surfaces bearing latent fingerprints can be divided into three main groups: 1) porous (e.g., paper), 2) semi porous (e.g., polymer bank note), and 3) nonporous (e.g., polythene). Different type of the surfaces may need different set of treatments.

Several fingerprint development techniques will be discussed in the following sections. The properties of the components allowing for development and the surfaces on which the techniques work best will be identified.

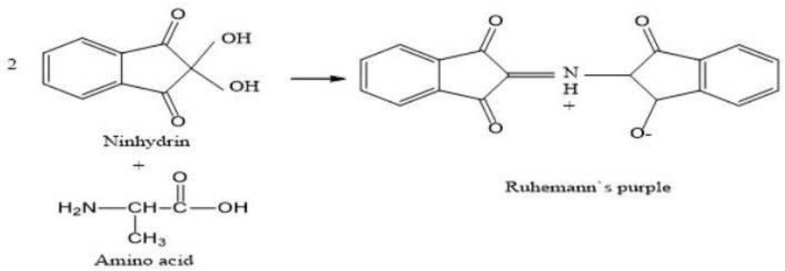
Powder Dusting

Powder dusting involves the use of fine powders to visualize latent fingerprints. It works well on smooth nonporous surfaces such as glass, certain plastics, and ceramics but is less effective on porous surfaces such as paper or cardboard (the residue tends to absorb into the fibers over time) or on wet or sticky surfaces. Among the many components of fingerprint residue, sebum and perspiration tend to adhere to powder particles. This physical property of fingerprint residue, in conjunction with the fact that many smooth, nonporous surfaces do not adhere well to powder particles, allows for fingerprint development. The contrast developed between the adhered powder and the surface allows for visualization.

Investigators use many different types of powders. Most black powders are made from fine carbon or iron. Light-colored gray or white powders can be made of any number of substances, such as finely divided aluminum. There are also fluorescent powders in red, green, yellow, or orange, some of which may also contain iron particles. Once the powder has been applied and contrast can be seen, the fingerprint can be lifted and preserved using fingerprint tape, a high-quality transparent tape typically at least an inch wide. The lifted fingerprint can then be placed onto a fingerprint lift card that offers the greatest contrast (black for white-powder lifts and white for black-powder lifts).

Ninhydrin Reaction

For years, biochemists have used the ninhydrin reaction for both qualitative and quantitative determination of -amino acids. There are approximately 20 α amino acids that comprise proteins. Proteins are natural polymers (molecules composed of repeating monomer units) containing α amino acid monomers. Ninhydrin is known to react with α amino acids and produce a purple-coloured product called Ruhemann's purple, named after Siegfried Ruhemann who discovered the reaction in 1910. The reaction is sensitive enough to be used to develop small amounts of α amino acids found in fingerprint residue.



1: Development of Ruhemann's purple from ninhydrin and amino acid

Special ninhydrin chambers, which provide a hot and humid environment, allow for ninhydrin development in 20 minutes or less. When used for fingerprint development, the reaction works best on porous surfaces such as paper, and because amino acids are relatively stable, ninhydrin development works considerably well on old fingerprints.

Silver Nitrate Reaction

Chloride salts like sodium and potassium comprise a significant percentage of perspiration, and thus fingerprint residue. When silver nitrate ($AgNO_3$) reacts with any soluble chloride salt, the insoluble salt silver chloride is produced. The reaction occurs almost immediately. The silver chloride produced is a white solid that does not offer much contrast for fingerprint development. However, as the silver chloride remains exposed to ultraviolet light, it decomposes producing silver and chlorine gas. This produces a purple-black product that offers contrast for fingerprint development. $AgNO_3$ development works best on porous surfaces like paper.

Iodine Fuming

Iodine (I_2) undergoes a phase transition from solid to gas, skipping the liquid phase. This phenomenon is known as sublimation. Iodine is a purple solid under ambient temperature and pressure. When iodine crystals are heated, they will sublime, producing I_2 vapours. These vapours are absorbed by the fingerprint residue so that they produce a transient amber-coloured product. Over time, the amber colour will fade. Techniques have been devised to fix the developed print. One technique employs the reaction of iodine with starch to produce a stable dark purple product. Iodine fuming is one of the oldest fingerprint development techniques; it works well on porous surfaces.

(a) (b)

Fingerprints (a) during iodine fuming and (b) after being treated with a starch fixative.

Superglue Fuming

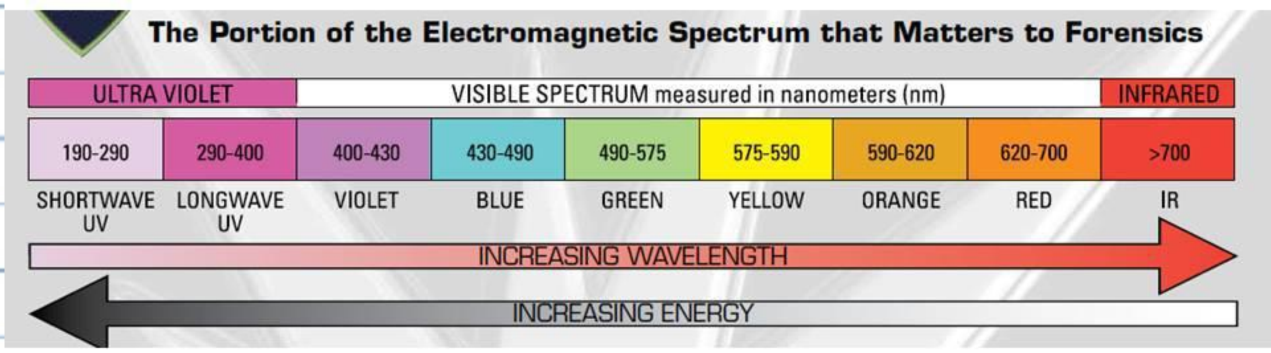
Superglue fumes composed of cyanoacrylate monomers, would selectively polymerize (form polymers) on fingerprint residue found on smooth nonporous surfaces. It is presently one of the most popular fingerprint development techniques. The polymerization of superglue monomers results in adhesion, and cyanoacrylates are commonly used for bonding purposes. The polymerization process is typically initiated by negatively charged water-soluble species (anions), which are found in fingerprint residue and are thought to preferentially initiate polymerization on their surface. This preferential initiation allows for the white-gray superglue polymer to form first on the fingerprint residue. The polymer not only offers modest contrast for fingerprint development but also aids in fingerprint preservation. Typically, analysts use fingerprint powders or dyes to enhance the contrast on the developed fingerprints. Most of the dyes used after superglue fuming are fluorescent dyes, which require the use of ultraviolet light for visualization.

Phenolphthalin Reaction

Often fingerprints contain a trace amount of blood. Many reactions can be catalyzed by the heme portion of haemoglobin found in blood and have been used for the presumed identification of blood. When used for fingerprint development of blood-containing fingerprints, the reactant molecule is converted to a coloured product, resulting in contrast. Because these reactions require heme as a catalyst, blood is not consumed, and the reactions are extremely sensitive. They have been used to develop latent fingerprints containing the slightest amount of blood. Under ideal conditions, and in the presence of hydrogen peroxide and blood, colorless phenolphthalin will be converted to pink phenolphthalein. Reactions with chemicals other than phenolphthalin (leucomalachite green, tetramethylbenzidine, and ortho-tolidine) can also be catalyzed by heme and used to develop blood-containing fingerprints. All these chemicals produce a green-blue product in the presence of blood. The use of luminol is a popular test to locate trace amounts of blood, but it is not typically used for fingerprint development. It is a chemiluminescent reaction, producing light that can be seen in a dimmed room where blood is located.

Latent Fingerprint Detection

The primary application of a Forensic Light Source is for enhancing the detection of latent fingerprints. The use of fluorescent enhancement processes that compliment a light source greatly increases the types of surfaces from which a latent fingerprint can be detected. Consider the difficulties of dusting and lifting a print off of the following surfaces: thin plastic bags, rigid duct tape, thin aluminum foil, heavily grained wood, concrete wall, brick, printed glossy magazine pages, paper products, etc. Using traditional methods, fingerprint evidence on these and other types of surfaces may go undetected or even dismissed because they could not be detected with enough detail. Forensic Light Source techniques have been successfully utilized for revealing latent prints on these and many other types of textured surfaces, backgrounds which mask ridge detail, fragile surfaces, and contaminated surfaces. Different wavelengths are required for processing different types of surfaces making a Forensic Light Source with tunable or multiple wavelengths an important tool for any crime scene investigator. In many cases, the background surface will also glow under light source illumination. In these cases it is necessary to tune to a wavelength of light that causes the print to glow and not the background.



In general, Forensic and Alternate Light Sources (ALS) emit high-intensity ultraviolet, visible, and infrared light. Exposure to these types of radiation, even reflected or diffuse, can result in serious, and sometimes irreversible, eye and skin injuries.

Forensic Light Source (FLS)

A high intensity, multiple wavelength, bulb based, alternate light source (ALS) designed specifically for use in Forensic Applications. Forensic Light Sources are high power, moderately priced and are extremely versatile.

Lasers

Lasers are portable with higher powers, however they are still not versatile since they are only one wavelength. Background rejection is not possible and many fingerprints, body fluids, and trace samples will remain obscured on variously coloured backgrounds if you have only one wavelength available.

LED based ALS

LED's offer portability but require you to carry many parts to the crime scene. However, a single wavelength LED is for all intents and purposes an expensive blue light. They suffer from the same problems the blue lights and lasers encounter, lack of wavelengths. Again, this prevents adequate background subtraction. Additionally, LED units suffer from diffuse illumination spots. A large wide spot is nice for searching a room, but when it comes to photography, the diffuse spot wastes light.

Forensic Light Sources

FLS are the perfect mix of power, price, and versatility. An FLS can provide versatility unmatched by any other class of instrument. With multiple integrated wavelengths, an FLS provides the ability to change wavelengths to find the optimal wavelength for causing evidence to fluorescence and backgrounds to fade. This is background rejection.

Wavelength Availability by Class of Instrument

	UV	Blue	Green	Red	IR
Laser	–	–	✓	–	–
LED	–	✓	✓	✓	–
FLS	✓	✓	✓	✓	✓

UV = 300nm to 400nm