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LATENT FINGERPRINTS TECHNIQUES AND THE USE OF STARCH TO IDENTIFY THE PRINTS: A MINI-REVIEW

(Teknik Cap Jari Tidak Kelihatan dan Penggunaan Kanji Sebagai Bahan Asas untuk Mengenal Pasti Cap Jari: Ulasan Ringkas)

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Abstract

Early techniques to develop latent fingerprints have shown many drawbacks such as being costly, time-consuming, less stable, highly toxic, low selectivity, low sensitivity, and low contrast. Numerous studies have been introduced to improve the identification of latent fingerprint techniques. The application of starch as a based material or binding agent offers advantages since this biomaterial is nontoxic, easily available, abundant, and cost-saving. Studies show that starch-based materials have good potential in the detection of latent fingerprints. However, studies related to the use of starch-based material in the development of latent fingerprints are still limited. Therefore, this mini-review highlights the techniques used in the detection of latent fingerprints and the potential alternative in detecting latent fingerprints using starch particularly as coating and coated materials.

Keywords: latent fingerprints, powder dusting, quantum dots, carbon nanoparticles, starch

Abstrak

Kajian terdahulu berkaitan kaedah untuk mengesan cap jari tidak kelihatan mempunyai banyak kelemahan seperti mahal, kurang stabil, bertoksid, tahap selektiviti yang rendah, kepekaan yang rendah, serta kontras yang juga rendah. Terdapat banyak penyelidikan yang telah dilakukan bagi mengkaji pelbagai kaedah untuk meningkatkan pengenalpastian cap jari tidak kelihatan. Penggunaan kanji sebagai bahan asas menawarkan beberapa kelebihan seperti tidak bertoksid, mudah didapati, banyak, dan dapat menjimatkan kos. Kajian menunjukkan penggunaan kanji adalah berpotensi dalam pengesanan cap jari tidak kelihatan. Walaubagaimanapun, kajian berkenaan penggunaan kanji sebagai bahan asas dalam teknik pengesanan cap jari tidak kelihatan masih terhad. Sehubungan itu, ulasan ringkas ini memfokuskan kepada kaedah-kaedah yang digunakan dalam mengesan cap jari tidak kelihatan dan kaedah alternatif yang berpotensi dengan menggunakan kanji dalam pengesanan cap jari tidak kelihatan terutamanya sebagai bahan salutan atau bahan bersalut.

Kata kunci: cap jari tidak kelihatan, debu serbuk, titik kuantum, nanopartikel karbon, kanji

Introduction

In forensic analysis, the primary physical evidence that may link to the criminal is fingerprints. This forensic evidence is an imperative method for identifying criminals through examinations at crime scenes. It is also a useful approach for collecting reliable records of evidence against the accused. In the world of law enforcement, fingerprints are regarded as the gold standard for depicting biometric and scientific evidence [1]. Fingerprints are distinctive and easier to verify due to the capillary tube-shaped channels at the fingertips that are connected to the sweat glands and they are unique for each individual, remain permanent, and do not change [2–6]. When a finger contacts a solid object, its secretion leaves a distinctive ridge pattern on the surface. Due to their weak optical contrast with the substrates, these patterns are sometimes referred to as latent fingerprints, which are undetectable to the naked eye [7].

Cyanoacrylate fuming, ninhydrin, 1,8-diazafluoren-9-one method, powder dusting, silver nitrate, silver nanoparticles, and small particle reagent method are among the techniques used to identify latent fingerprints [3, 8, 9] since they are straightforward, effective, and simple to apply [9]. However, these techniques are costly, time-consuming, less stable, high toxicity of the developing reagents, have a low selectivity of the specificity of emerging materials, low sensitivity of the clarity and visibility of the ridge detail due to enormous and irregular particle size, and low contrast due to the non-fluorescence of most powders [3, 8, 9]. Recently, improved latent fingerprint formation has been achieved using novel techniques including nanotechnology such as quantum dots and fluorescent carbon nanoparticles [1]. The latent fingerprints produced by quantum dots have several advantages such as enhanced sensitivity, contrast, and selectivity. However, there are rising concerns about their intrinsic toxicity thus limiting their long-term usage since quantum dots contain heavy metal cores [1].

Fluorescent carbon nanoparticles have been created as an alternative method for the detection of latent fingerprints in substitution of quantum dots since it is biocompatible and non-toxic to nature, people, and the environment [10]. Even so, these fluorescent carbon nanoparticles can lose their luminous properties easily, making it difficult to convert them into brilliant powder. The addition of starch seems able to generate a strong blue fluorescence in its dry solid form and overcome the limitation. The fluorescent powder employed in this process produces distinct images of latent fingerprints on diverse surfaces, and a stain made from carbogenic fluorescent powder is used to disclose the latent fingerprints [1].

The present study aims to review the techniques used in the detection of latent fingerprints and the potential alternative in detecting latent fingerprints using starch particularly as coating and coated materials. Starch is a natural polymer stored in plants. Its major compounds are amylose and amylopectin. Starch is nontoxic, easily available, abundant, and cost savings [5]. Thus, the use of starch in the detection of latent fingerprints is more economical and safer.

An overview of latent fingerprints

Latent fingerprints are invisible to the naked eye. It is skin friction impressions of the fingers left accidentally on surfaces by eccrine sweat and greasy substances such as sebum. The volar pads transfer a small coating of translucent chemical residue [11] known as triglycerides which are composed of hummed, fatty acids, and amino acids in the shape of individual skin ridges, leaving behind latent fingerprints [12]. It can be used as evidence in criminal investigations and may help to identify suspects using three levels of fingerprint recognition.

The different levels of features in a latent fingerprint are divided into three namely Level 1, Level 2, and Level 3. The primary use of Level 1 features (macro-details) is to classify patterns but non-recognizable for fingerprint identification. The arch, tented arch, left loop, right loop, double loop, and whorl, are visible to the naked eye which assists in manual fingerprint matching and visual scrutiny [13]. Level 2 features (minutia points) are recognizable, consistent, and commonly used to verify a fingerprint's uniqueness. Their characteristics consist of hooks, bifurcations, and ridge ends. However, it may not be retrieved effectively due to the low quality of evidence caused by ridge smudging. The appropriate reconstruction and refinement are necessary to remove false features. The dimension parameters of the ridges known as Level 3 features (pores and ridge contours) provide more precise and reliable details for accurate fingerprint recognition, resulting in a significant performance improvement [14]. There are enduring characteristics that may be identified from a sample, such as pores, line patterns, and scars. Yet, it is difficult to extract such properties due to resolution restrictions. Thus, all of these level features are typically combined to attain the best possible matching results [13].

Latent fingerprints detection techniques

The initial stage of processing latent fingerprints known as latent fingerprint upliftment involves the process of detecting, enhancing, preserving, collecting, and matching the prints from a crime scene [13]. There are various approaches such as cyanoacrylate fuming, ninhydrin, 1,8-diazafluoren-9-one method, powder dusting method, and silver nitrate [3, 8, 9] that commonly used for rendering fingerprint visibility [13].

Cyanoacrylate fuming

Cyanoacrylate fuming which is known as super glue fuming is a chemical technique for detecting latent fingerprints on non-porous surfaces like glass and plastic [15, 16]. Alkyl 2-cyanoacrylate is an ester of the acrylate class that contains cyano or nitrile group. It produces vapours that react with certain of the eccrine elements of the latent finger mark residues, polymerised, and give them a white colour [15]. Tough this fuming technique provides a flexible and successful approach for identifying latent fingerprints on almost all non-porous substrates, particularly rough surfaces, nevertheless, it has a variety of health and safety concerns. Vapours and liquid cyanoacrylate esters are likely to damage mucous membranes, skin, and eyes severely. In addition, the cyanoacrylate fuming method tends to over-fume the fingerprints affecting the fine ridge features to be largely covered by the white polymers, thus reducing the growing sensitivity [9].

Ninhydrin method

Ninhydrin is an amino acid reagent used to develop latent fingerprints on porous surfaces such as paper and cardboard. This reagent exhibits Ruhemann's purple resulting from a reaction with the amino acid (eccrine) component of the finger mark deposit [17, 18]. The complete ninhydrin development may take 24 to 48 hours at room temperature and humidity [9]. Thus, to shorten the process, temperature and humidity shall be increased. A high-humidity environment of 50% to 80% is suggested and the treated fingerprints shall remain cool in the dark since light and oxygen will degrade Ruhemann's purple [9,18]. The use of higher temperatures requires careful monitoring due to its flammable properties [19] and has the potential to significantly discolour the background resulting in reduced contrast and sensitivity [9]. The ninhydrin method also can cause background staining and ink dissolution [18,19].

The 1,8-diazafluoren-9-one method

The 1,8-diazafluoren-9-one method is a ninhydrin analogue which is another amino acid reagent that is used to identify latent fingerprints on porous surfaces, particularly paper [20]. Due to its high sensitivity, high efficiency, and simple operation, this technique is believed to be crucial for fluorescently generating latent fingerprints on porous surfaces. Nevertheless, the method is considered hazardous and causes carcinogenic effects [9]. Contrary to ninhydrin, heat is necessary to elevate the reaction but prolonged exposure to high heat and humidity will affect the luminescence of the treated fingerprints. Thus, employing a heat press at 180 °C for 10 s or heating at 100 °C not exceeding 20 minutes is advisable [18, 21]. It is often recommended to perform ninhydrin treatment after the 1,8-diazafluoren-9-one method since this reagent may not react with some types of amino acids present in the exudate to obtain the best result [22].

Silver nitrate method

The silver nitrate technique is an old method introduced more than 100 years ago to develop latent fingerprints on porous surfaces before ninhydrin. Silver ions that react with chloride ions from the remaining fingerprints remains forming the silver chloride compound. Upon exposure to light, it will develop black, brown, or violet stain prints. The silver nitrate approach is not recommended as a standard method since the appearance of the prints and the paper background may strongly change with time [9,23].

Powder dusting method

Powder dusting is the simplest and most commonly used technique for developing latent fingerprints. It is also the oldest technique used by fingerprint experts with one of its earlier references dating back to 1891 [5]. The effectiveness with which the powder adheres to the ridges depends on the particle morphology. Small, fine particles adhere more easily than large, coarse particles [5, 24]. Moreover, the thicker coating of micron- or larger-sized powders tends to reduce the little ridge features, particularly the sweat pores thus reducing its sensitivity [9]. Therefore, most formulations consist of either very fine, rounded particles (with a diameter of about 1 μm) or fine flake particles (with a diameter of about 10 μm) [24]. The efficacy of using fingerprint powder also depends on the colour of the fingerprint powder itself to ensure a good contrast, the age of the fingerprint under investigation, temperature, and the nature of surfaces in which the latent fingerprints are deposited either porous or non-porous [5]. Several powder formulations have been terminated due to the hazardous effects of heavy metals and their salts. Numerous studies have suggested that powder formulations pose health risk to experts in fingerprinting [24]. Current research has improved the method such as using non-toxic substances to overcome the issues.

Carbon dots

Carbon dots can be classified as graphene quantum dots, carbon quantum dots, carbon nanodots, and carbonized polymer dots [25]. Carbon dots are smaller-size fluorescent carbon-based nanoparticles that are generally defined as discrete, zero-dimensional carbonaceous materials of less than 10 nm in size with an identical form of surface passivation [26]. The application of carbon dots to develop fingerprints can be divided into two aspects which are carbon dots in a solution phase and a powdered form. However, carbon dots in a solution phase require a long development time (usually an hour or more), which is an obvious obstacle to the rapid development of latent fingerprints at crime scenes. Carbon dots in the solid state still suffer from aggregation-induced luminescence quenching, so only small amounts of carbon dots have been incorporated into some sort of solid to maintain their flowability and fluorescence when used for dusting. This results in weak luminescence intensity, thus giving a low contrast between the fingerprint and the background [3]. Researchers develop new methods based on carbon dots to overcome the limitations. The improved carbon dots exhibited unique features, like aqueous solubility, low toxicity, chemical inertness, functional ability, biocompatibility, photochemical stability, good conductivity, and environmental friendliness. It has been hugely applied in the fields of bio-imaging, therapeutics, diagnosis, chemo-sensing, nanomedicines, drug delivery, fluorescent marker, and optoelectronic devices [27].

Application of starch in latent fingerprints detection

Starch in nano or micro size is a suitable compound for picturing latent fingerprint impressions. The main components of starch are amylose and amylopectin with abundant hydroxyl groups as shown in Figure 1. The combination of amylose from starch-based non-conventional powders such as gram flour, wheat flour, and corn flour with the fat deposits in the fingerprints can produce high-quality fingerprints [5]. Moreover, starch-based particles offer several benefits over other techniques, including affordability, biodegradability, availability, nontoxic, and natural abundance. Despite being highly hygroscopic, starch is capable in detecting latent fingerprints for a very long period [28]. The application of starch in the development of latent fingerprints commonly as coating materials and coated materials is particularly for fluorescent powder to enhance its optical properties. Starch also undergoes a simple grinding process with fluorophore powder to enhance the visibility of the prints.

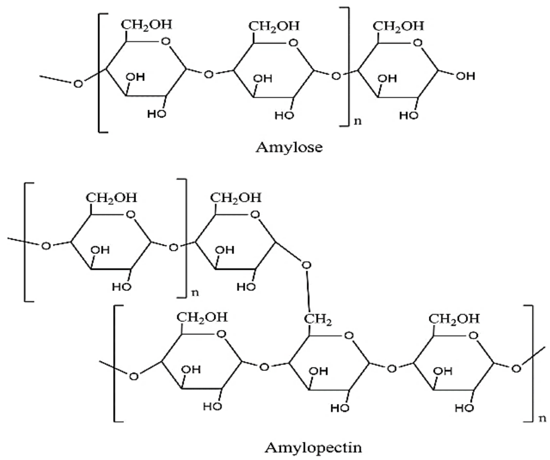

Figure 1. Chemical structure of starch

Starch as coating materials

The adherence of fluorescent powders to fingerprint residue increases after the incorporation of dye into the starch matrix due to the interaction between the matrix and dyes through hydrogen bonding [29, 30]. These powders preserved selectivity and retained sufficient contrast when tested on fingerprints and were effective as commercially available fluorescent powders [30]. This indicates that starch is a good coating material. The optical properties of fluorescent powder increase after incorporation of dye into the starch matrix due to an increase in photostability and fluorescent yield of the dye [29, 31]. Coating of dye with starch prevents photodecomposition since it helps to isolate dye from oxygen and water from the ambient [29].

Starch as coated materials

Starch plays a role as coated materials for research based on starch-fluorescent carbon nanoparticles in the development of latent fingerprints. This fluorescent carbon dots nanoparticle then coating on starch to form phosphors. The process is needed since fluorescent carbon nanoparticles must be combined with hydroxyl groups to emit fluorescence [1]. In one study, malic acid and ammonium oxalate are used as the starting materials for the development of a pyrolysis technique to synthesis N-doped carbon nanoparticles. When the fluorescent carbon nanoparticles are coated on starch (0.1:10 weight ratio) it gives extraordinarily intense blue fluorescence images under UV irradiation on non-porous surfaces in a solid state. Developing latent fingerprints by using this technique on non-porous surfaces [1] is interesting because of their great stability, adjustable fluorescence emission, and luminosity [32]. The author concludes that this fluorescent powder has better sensitivity than iodine vapor [1].

On the other hand, Dong et. al. was the first group of researchers who had studied red fluorescence carbon dots powder for latent fingerprint detection and established an artificial intelligence program to evaluate the similarity of the developed latent fingerprint images quantitatively. The intense red fluorescence of developed phosphors under green light irradiation enhanced the ridge patterns of latent fingerprints without interference from background fluorescence [7].

Carbonized polymer dots have a polymer/carbon hybrid structure rather than the main body carbon structure, which contributes to the predominant properties of carbonized polymer dots. They have unique properties such as high oxygen/nitrogen content, excellent aqueous solubility, and outstanding photoluminescence quantum yield, which are due to the polymer/carbon hybrid structure and the special photoluminescence mechanism [25]. Coating the carbonized polymer dots on the starch surface makes the fingerprints that had been aged for a long period and fingerprints on frequently used substrates are easily recognised where the created latent fingerprint images reveal the distinct, well-defined ridge features [10].

Starch-based near-infrared organic fluorophores

Near-infrared irradiation has a higher potential over visible light for imaging latent fingerprints. This is due to less interference by the background fluorescence of the bio-tissue and has higher contrast and resolution. The technique is independent of the substrate material and may be used for latent fingerprint formation in a variety of scenarios [33]. Near-infrared radiation is safe for DNA in fingerprint residue during fingerprint development and less harmful to users' skin and eyes than UV light [34]. Ran et. al. developed a new near-infrared-emissive composite material composed of a near-infrared fluorophore, and porous starch via a simple grinding method. The fluorophore powder showed strong near-infrared emission, while the porous starch enabled high adsorption capability for fingerprints. This near-infrared composite offers advantages such as reduced background fluorescence, ease of handling, high photostability, low cost, and low toxicity to developers, indicating its great potential in the field of trace inspection and biological imaging [35].

Future directions

The application of starch in latent fingerprint detection commonly focuses on the role of starch as a coating and coated material. The method is quite simple through the blending of different materials in solvents at a certain time and temperature. The mechanism involved is not clearly mentioned on how starch reacts with fluorescent powders and fat deposits from latent fingerprints. A particular emphasis will be put on the physicochemical principles of latent fingerprint detection and coated/coating principles to enhance the selectivity, sensitivity, and stability of the fluorescent powders.

Conclusion

Amongst other methods in developing latent fingerprints, powder dusting become the one that is most used. Researchers have improvised this method to overcome its limitation. One of the techniques is by incorporating starch forming a fluorescent powder. The friction ridges of the fingerprints using this powder give sharp edges, provide better resolution and offer less background interference. The application of starch has been used quite successfully in the detection of latent fingerprints. Further research is needed as the study on starch powder dusting in the detection of latent fingerprints is still limited.

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