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Application of acid-modified *Imperata cylindrica* powder for latent fingerprint development

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ABSTRACT

A novel powdering material that utilizes acid-modified *Imperata cylindrica* (IC) powder for the development of fingermarks was studied. Experiments were carried out to determine the suitability, adherence quality and sensitivity of the acid-modified IC powder. Fingermarks of different constituents (eccrine, sebaceous and natural fingermarks) on different types of surfaces were used. Acid-modified IC powder was also used to develop fingermarks of different ages as well as aged fingermarks recovered from the water. From the visual inspection, acid-modified IC powder was able to interact with different fingermark constituents and produced distinct ridge details on the examined surfaces. It was also able to develop aged fingermarks and fingermarks that were submerged in water. A statistical comparison was made against the Sirchie® Hi-Fi black powder in terms of the powders' sensitivity and quality of the developed natural fingermarks. The image quality was analyzed using MITRE's Image Quality of Fingerprint (IQF) software. From the experiments, acid-modified IC powder has the potential as a fingermark development powder, although natural fingermarks developed by Sirchie® black powder showed better quality and sensitivity based on the results of the statistical comparison.

1. Introduction

Fingermark is the most widely used biometric method for identifying an individual. Fingermarks found at crime scenes can be classified as patent, latent and plastic impressions [1]. Patent and plastic prints are noticeable to the human eye without any particular treatment where the contrast between the fingermark and its background is sufficient for viewing. On the other hand, latent fingermark is present but not visible without further processing. Therefore processing techniques have to be applied to render the fingermarks visible. To date, various techniques have been introduced for fingermark development such as optical (e.g. ultraviolet, UV imaging), physical (e.g. powdering) as well as chemical methods. Powdering method has been widely used since the early 1900s [2] due to low cost, simplicity of design and it does not require much expertise [3]. Powdering method is also suitable for detecting fingermark on the object of a crime scene that cannot be transported back to the laboratory [4].

Fingermark powders can be categorized into four classes: regular, luminescent, metallic and thermoplastic [5]. In general, powdering method works based on the mechanical adherence of fingermark powder to the moisture and oil components of the skin ridge deposit on substrates [5]. The powder's relative surface area, shape, particle size and charge are factors that could affect the adhesion between the powder and the moisture and oil components of the fingermark. Two essential elements that most commercial powders rely on to provide adhesion to fingermark residue are pigment and binder. Pigment in the fingermark powder provides contrast between fingermark and substrates whereas binder offers maximum and preferential adhesion to fingermark residue. Some pigment powders provide enough adhesion to be used individually [1]. An ideal fingermark development powder should provide color with acute contrasting, good adherence properties and desirable sensitivity [6]. Therefore, a good fingermark powder can adhere to the fingermark residue which consists of moisture and oil components. Besides, it can provide good contrast between the fingermark and substrates, and the powder should not be attracted strongly to the surface so that the excessive powder deposited on skin furrows can easily be brushed off. Generally, the powder size for fingermark development is in the range of 1–50 μm [7].

Various new fingermark powder formulations derived from herbaceous plant have been introduced over the years. Garg et al. [2] presented a new powdering method for fingermark development using turmeric powder obtained from rhizomatous herb. Kumari et al. [8] introduced a new powdering method using synthetic food and festival color for fingermark development. Gaskell et al. [9] introduced a novel fluorescent reagent that contained natural yellow 3, a dye that is used

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as a food coloring, for grease-contaminated fingermarks on non-porous dark surfaces.

In present study, a new powder — *Imperata Cylindrica* (IC) powder was used for the development of fingermark. IC is a kind of rhizomatous perennial grass that is common in tropical countries. It is mostly found at dilapidated land or soil that is not properly maintained. This pestilent weed has been used as a low cost raw material for activated carbon preparation to treat particularly heavy metals from industrial waste water [10]. The idea of using the acid-modified IC powder as the fingermark powder was inspired from the reaction between the acid-modified IC powder and fingers whereby the acid-modified powder will stick to the finger ridges, causing the finger skin to become black when contacted.

This study was conducted on low cost acid-modified IC powder to investigate its feasibility as a powder for fingermark development which has not yet been reported. Various fingermark constituents and surfaces were used to experimentally determine the effectiveness of the powder. The quality of developed natural fingermarks using acid-modified IC powder was compared with the Sirchie® Hi-Fi black powder using a statistical analysis tools known as the Paired T-Test and Confidence Interval Procedure. The fingermarks' image quality was evaluated using Image Quality of Fingerprint (IQF) Software.

2. Materials and methods

2.1. Powder selection and acid-modified IC preparation

Withered IC was collected from an abandoned land in Penang, Malaysia. It was washed with copious amounts of distilled water to remove impurities, and then dried under sunlight. The dried IC was then ground to fine powder using Retsch Mill Grinder. The IC powder was washed with boiling distilled water until the residual solution became clear. It was then dried at 100 °C in an oven to constant weight. One gram of the dried IC powder was mixed with 1 mL of sulphuric acid (95–98%). The mixture was dried in an oven at 100 °C for 24 h. The dried IC powder was then cooled to room temperature and washed with boiling distilled water followed by soaking in 1% sodium bicarbonate overnight to remove the residual acid. The IC powder was washed repeatedly with boiling distilled water to remove residual sodium bicarbonate until pH 7.0 was obtained. The IC was dried at 100 °C until constant weight was acquired and sieved using a Retsch Vibrator Steve Shaker. The available sieving sizes are <45, 45–63, 63–125, 125–250, and 250–500 μm. In this study, sieving size <45 was chosen. The resultant IC powder was then kept in a dessicator prior to use.

Also in this study, the initial phase of testing was carried out on raw IC powder and acid-modified IC powder to determine the effectiveness of the powders in developing fingermarks. Two sets of eccrine and sebaceous fingermarks on white A4 writing paper and white plastic were collected from 6 donors. Each set of fingermarks were being developed, respectively with raw IC powder and acid-modified IC powder.

2.2. Fingermark preparation

2.2.1. Fingermarks of different constituents

Fingermarks of different constituents were prepared to investigate whether the proposed acid-modified IC powder was able to interact with various fingerprint constituents. In this study, eccrine, sebaceous and natural fingermarks were used to test the suitability of the acid-modified IC powder for fingermark development. The experiment was conducted at room temperature (25 ± 1 °C). The methods of generating eccrine sebaceous and natural fingermarks were carried out according to the guidelines which were being reported in [11,12] and are outlined below.

Eccrine fingermarks — Hands were washed with soap and allowed to dry. After which, the hands were placed in a clean plastic bag for 45 min before depositing the fingermarks.

Sebaceous fingermarks — Hands were washed with soap and allowed to dry. Fingers were then rubbed on the nose area prior to deposition.

Natural fingermarks — Hands were not washed in the past 3 h and touching the face and head before depositing the fingermarks was avoided.

The fingermarks were deposited by gently pressing a finger on examined surfaces and labeled, respectively. A4 writing paper, white plastic, brushed metal and glass were used as the substrates for fingermark deposition.

2.3. Fingermarks of different ages

Fingermarks that were left at a crime scene might consist of different ages. Here, fingermarks were deposited on brushed metal and white plastic. Natural fingermarks with age of 1 day, 7 days and 14 days were used to test the relative sensitivity of the acid-modified IC powder in developing aged fingermarks.

2.4. Fingermarks on non-porous surfaces submerged in water

Here, acid-modified IC powder was used to recover natural fingermarks on brushed metal and white plastic, which were submerged in stagnant water after 24 h, 48 h and 72 h.

2.5. Comparison with the Sirchie® Hi-Fi black powder

Design of Experiment (DOE) comprises an array of statistical tools to plan an experiment in order to obtain suitable data for statistical analysis which will then result in meaningful and objective conclusions [13]. This section reports on the use of a DOE tool known as the Paired Comparison Design in order to obtain suitable experimental data for comparing the quality of Sirchie® Hi-Fi black powder and acid-modified IC powder for the developed natural fingermarks on white A4 writing paper and white plastic.

Depletion series, which is a series of fingermarks deposited consecutively by the same finger from the same donor on a surface, were used in the experiments. Theoretically, fingermark residue will be degraded after each contact. Therefore, the more good quality fingermarks in a depletion series that a powder is able to develop, the more sensitive and better quality the powder is. The above statement is only true if the fingermarks were deposited with a consistent pressure from the same donor. However, it is difficult to achieve consistent pressure from the donor in an experiment thus biasing the results of the comparison. In order to minimize the above problem, split fingermarks and alternate depletions were used [11]. Split fingermarks were obtained from the deposited fingermarks from donors which were divided into two halves along the center line [11]. Each half of the fingermark was processed with Sirchie® black powder and acid-modified IC powder, respectively. Split fingermark technique however is only suitable for surfaces that can be easily split into two halves after deposition of fingermark [11]. Therefore, split fingermarks were used on a white A4 writing paper which represents a porous surface. Due to the thickness of the plastic making it difficult to split into two halves, alternate depletions were used on white plastic surface which represents non porous surface, whereby the same finger from donors was used to deposit a series of fingermarks across two separate plastic surfaces, each of which was developed using different powders. For example, fingermarks 1, 3, 5, 7, 9 on surface 1 were developed with IC powder and fingermarks 2, 4, 6, 8, 10 on surface 2 were developed with black powder. The experiment was repeated with the development processes used for each surface reversed.