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Development of latent prints exposed to destructive crime scene conditions using wet powder suspensions

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Abstract Fingerprints are the most affirmative source of personnel identification and are also one of the most ubiquitous evidences found at the crime scenes. However, successful latent print recovery is not always possible from the crime scenes especially when the prints have been exposed to destructive conditions. Crime scenes are often despoiled due to destructive conditions such as arson, explosion, exposure to drainage water and soil or snow burial. Moreover, the offender often intends to destroy the fingerprint bearing crucial evidence, using these destructive forces. Furthermore, the fingerprints exposed to despoiled crime scenes are generally neglected due to the misconception of impossible recovery. In the present study, zinc carbonate, zinc oxide and titanium dioxide based fluorescent small particle reagents were formulated, compared and evaluated for the development of latent prints exposed to destructive conditions. Fresh latent prints and prints exposed to natural or simulated destructive crime scene conditions, namely, arson, explosion, burial in soil, immersion in drainage water and burial in snow were developed using the three compositions. Latent prints were successfully recovered even from the destructive crime scene simulations. Better quality prints were obtained from fresh prints, arson, soil burial and drainage water. Relatively poor results were obtained from explosion and snow burial conditions. Wet powder based suspensions were found suitable for development of fingerprints exposed to destructive conditions and the efficiency of the reagents was found in the order: $TiO_2 > ZnCO_3 > ZnO$.

1. Introduction

Fingerprints have been recognized as the most reliable evidence for personnel identification. Advancements in the physical, chemical and optical techniques have led to the emergence of a plethora of fingerprint development methods.[1] The choice of development technique is governed by the composition of the finger mark residue, surface and the

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environmental condition the mark is exposed to, prior to the treatment, as demonstrated by the concept of the triangle of interaction.[2] Despite the advancements and techniques available, the latent print recovery remains a challenging task. This is because the offender often attempts to destroy the fingerprint bearing crucial evidences or the print may get deteriorated due to the destructive environmental conditions. Various destructive conditions such as arson, explosion, exposure to drainage water and soil or snow burial are often found at crime scenes. The fingerprint evidence subjected to such destructive conditions is generally neglected due to the misconception of impossible recovery.[3]

Fingerprints subjected to fire are exposed to extreme conditions such as high temperatures, soot deposition, electromagnetic radiation and subsequent water force. Subsequently, a suitable soot removal method as well as an effective enhancement technique is essential.[4] Likewise, studies have reported the recovery of latent prints from aquatic environments.[5] However, the offender may not always dispose of the evidence in clean environments. Reports on development of fingerprints exposed to dirty or drainage water are sparse, even though it is the most common means of unburdening the incriminating evidence by the perpetrator.[6] Furthermore, the studies dealing with fingerprint recovery from soil or snow burial are insufficient. Temperature, pH, humidity, micro flora and fauna in soil and snow conditions may contribute to the rapid deterioration of fingerprint residue. The chemical, technical and biological aspects of post blast residue analyses have been thoroughly investigated.[7] However, only a few studies[8,9] have been done on the recoverability of fingerprints after the explosion effect. Forces like heat, pressure, shock waves, vacuum, secondary projectile effects and translation effects may disrupt the fingerprints. Successful recovery of groomed prints was reported after detonation of vehicle-borne explosive device.[8] Explosion damage to the print has been reported as a function of mass of explosive charge and of the distance.[9]

Sebum, comprising the lipophylic organic compositions such as fatty acids, glycerides, wax esters and cholesterol, is found in the fingerprint residue. Sebum is secreted from the sebaceous glands which are not present on the surface of hands, but the phenomenon takes place due to the natural touching of other body parts.[10] Lipophylic residue is relatively inert, which makes it an ideal target component for development of fingerprints exposed to destructive conditions. Wet powder suspensions or the small particle reagent (SPR) method comprises of a metal salt suspension. It is based on the adhesion between lipophylic components of the fingerprint residue and the hydrophobic tail of the surfactant, while the hydrophilic head of the surfactant binds to the metal salt in distilled water.[11] Fluorescent SPR method based on white particle suspensions is an advantageous modification of the technique. Commonly used white powder suspensions are generally based on zinc carbonate, zinc oxide and titanium dioxide. The composition, structure, integrity and coating thickness of these powders may affect adherence.[12] The adhesion between the particles and the fingermark residue is also considerably influenced by the size and shape of the powder particles.[13] It is essential to determine the suitability and efficiency of compositions, especially in cases of development of latent prints exposed to destructive conditions.

In the present study, wet powder suspensions were compared and evaluated for their efficiency to develop latent prints exposed to destructive crime scene conditions. Zinc carbonate, zinc oxide and titanium dioxide based novel fluorescent SPR formulations containing rose bengal dye were prepared. The average particle size and shapes of metal powders, adherence to the residue/intensity of print developed and the sensitivity of the commercial metal powders were examined. Furthermore, the efficiency of reagents was examined for development of latent prints exposed to destructive crime scene conditions.

2. Materials and methods

2.1. Powder analysis using SEM

The metal powders were examined using scanning electron microscopy (SEM) examination. The powder particles were mounted on the stubs with the carbon tape and sputter-coated with gold in an ion coater (Jeol Ion Sputter Model, JFC, 1100). The thickness of layer of pure gold coating was 20 nm under vacuum at 7 mA. The particles were examined under vacuum with a scanning electron microscope (FE-SEM, ΣIGMA, ZEISS). The electron images were recorded and the morphological analysis was done using a SEM software (SEM Control User Interface, version1.27, Jeol). The average particle size was determined using ImageJ software. Particle size measurements were done randomly for 25 particles along the highest longitudinal dimension.

2.2. Fingerprint analysis

2.2.1. Fingermark deposition

Five surfaces, namely, glass, aluminum foil, ceramic tiles, tin cans and metal spoons were selected for the present study. These surfaces were chosen since these are true representatives of commonly encountered substrates at various indoor crime scenes. The donor group comprised 25 individuals, both males and females, of varying donor capabilities of the age group 20–55 years. Prior to the deposition of fingermarks, donors washed their hands and subsequently pursued the normal routine activities for a period of one hour. Natural fingermarks were obtained from the donors. Surface selection as well as the natural fingermark deposition was carried out with an intention to model the casework scenarios. At one point of time, each subject deposited one print each on separate glass slides, aluminum foils, ceramic tiles, metal spoons and tin cans. A gap of 24 h was given for collection of more than five prints from the same individual. From each donor, ten latent prints were collected for a single surface type for each destructive condition. Thus, each individual donated 60 latent print samples resulting in a total of 1500 samples. Post deposition the prints were divided into two categories. The first category of the prints was not exposed to any major destructive condition and was kept at room temperature (temperature 25–29 °C) for fifteen minutes and were thus regarded as fresh prints. The second category of prints was subjected to major destructive conditions for different time periods prior to the development.

2.2.2. Substrate treatment

Before fingerprints were deposited, the surfaces were cleaned using detergent and then air dried. Convenient size of each substrate was prepared. The second category prints were then