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ORIGINAL ARTICLE

A novel method for the development of latent fingerprints recovered from arson simulation

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Abstract A diverse range of physical and chemical methods is available for the development of latent fingerprints. But fingerprints exposed to extreme conditions like fire or arson are generally perceived to have been damaged. Electromagnetic radiations, soot deposition and high temperatures are the forces generated in a fire, which may affect the fingerprints at the scene. Thus, the potential value of highly crucial evidence like fingerprints remains unutilized. This study was conducted to determine if fingerprints could be developed after being subjected to an arson/fire scene simulation. Fingerprints on nonporous surfaces were subjected to high temperatures, soot deposition and subsequently treated with water. A novel fluorescent and a pre-existing small particle reagent was investigated for the same. Zinc carbonate based fluorescent small particle reagent was capable of developing latent fingerprints exposed to a maximum temperature of 800 °C.

1. Introduction

Fingerprints are a source of useful evidence and essential for establishing identity. The detection and subsequent development of fingerprints is thus necessary in criminal investigations.[1] This becomes a difficult task in the case of certain extreme conditions like fire. A fire scene may be accidental or a case of arson. The evidence subjected to fire is generally overlooked as there is a misconception that it is damaged.[2] There are several scientific approaches to determining whether the fire was deliberate or not.[3] In such a scenario, fingerprints may be extremely critical to linking the perpetrator to the crime.[2]

Extensive research has been carried out to study the fire initiation mechanism and spread pattern, but studies on recovery of fingerprints from such scenes are scanty.[4] The reason for this may be the destructive nature of fire. Fingerprints subjected to fire are exposed to high temperatures, soot deposition, electromagnetic radiation and subsequent water force.[2]

It is believed that these phenomena damage the fingerprint. Different soot removal methods have been tested for their efficiency. Stow and McGurry demonstrated the use of 1% and 2% NaOH as an effective means for soot removal.[5] Wylie recommended 2% sulfo-salicylic acid and 0.1 M NaOH.[4]

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Gentle washing with water has been successfully used.[6] Moore and co-workers investigated the use of different matrices and reported silicone rubber casting and Absorene as the best techniques for soot removal.[7]

Harper suggested that soot deposition itself may protect the marks.[8] He further stated that even three-month-old impressions with a high sebaceous content can be developed.[8] For successful development and enhancement of the fingerprint, a prerequisite is that the surface should have survived the damage.[6] Different development techniques for fingerprints exposed to arson or high temperatures have been employed in various studies. Cyanoacrylate fuming and aluminum powder followed by BY40 have been reported, but they produced a 50% success rate.[4] Powder methods have been suggested for fingerprints exposed to high temperatures, but cannot be used in wet scenarios.[9] Blood fingerprints subjected to high temperatures have been developed using amido black.[2] Small particle reagent (SPR) formulations have also been recommended, especially for fingerprints exposed to water after fire/high temperatures.[6,10]

SPR is an effective and a widely used method for developing fingerprints exposed to wet surfaces. Conventional SPR was based on molybdenum disulfide.[11] Zinc carbonate, titanium dioxide and ferric oxide are some other materials used in SPR. Fluorescent SPR is better than the conventional method since the contrast and the visibility are highly improved in the former.[11] The present study deals with preparing a novel fluorescent SPR formulation based on zinc carbonate for developing fingerprints on articles subjected to arson simulation. The novel formulation and a pre-existing fluorescent SPR formulation were examined for development of fingerprints subjected to arson simulation.

2. Materials and methods

2.1. Subjects

A number of individuals, both males and females, with variable donor capabilities, were asked to give groomed fingerprints for the study.

2.2. Surface

Before fingerprints were deposited, the surfaces were cleaned using detergent and then air dried. Latent fingerprints were placed on various smooth surfaces like glass and ceramic tile, and metallic surfaces like aluminum foil, tin cans and metallic spoons. Substrates were then exposed to high temperatures (100–900 °C) in a muffle furnace for 1 h. Small paper pieces were also put in the furnace which cause soot formation on the substrates. The objects were then cooled and sprinkled with water. These conditions are set to simulate the natural arson scenario. Sprinkling with water not only aided in arson/fire scene simulation, but also proved to be a gentle yet efficient method for soot removal. For each temperature and surface, a minimum of eight samples were taken.

2.3. Reagents

SPR suspensions were prepared using zinc carbonate (Glaxo laboratories), eosin B (Sigma–Aldrich), eosin Y (Sigma–Aldrich), detergent (Genteel^{R}) and distilled water. Formulation A is comprised of a suspension of 5.0 g of basic zinc carbonate in 75 ml of distilled water, to which 0.01 g of eosin B and 0.3 ml commercial liquid detergent were added. The contents were thoroughly mixed. To formulation B, in a suspension of 5.0 g of zinc carbonate in 75 ml of distilled water, .01 g of eosin Y and 0.3 ml of commercial liquid detergent were added. The contents were thoroughly mixed.

2.4. Development of fingerprints

SPR suspension A was poured on the treated samples. After waiting for two minutes, the surface was washed with a gentle stream of water for 30 s and then allowed to dry under natural conditions. The same procedure was done using suspension B. Fingerprints were then illuminated with radiation having 505–550 nm wavelength. When observed through orange goggles, the fingerprint exhibited green fluorescence.

2.5. Photography and evaluation of the fingerprints

Photographs were taken with a SLR camera (D3100 Nikon) in the macro mode. The images were stored in jpeg format. For evaluation quality scale was prepared as per the SWGFAST (scientific working group on friction skin analysis, study and technology) guidelines. Factors like print clarity, smudging, contrast and background noise were considered and the values were assigned accordingly.

Identifiable

10. Ridges clear, ideal quality and clarity for identification
9. Ridges clear (minutiae and ridges visible, light background noise)
8. Ridges clear except for background noise
7. Ridges clear but smudges interfere with the print
6. Ridges clear but contrast is lacking
5. Only partial prints or prints with smudges, background noise

Possibly identifiable

4. Small ridge characteristics visible, only partial prints or more prints with much interference

Not identifiable

3. Few ridges and points visible but not enough points available for identification
2. Bad print, high background noise
1. Almost entire print smudged not able to make any comparison points
0. No print can be developed

3. Results and discussion

Table 1 depicts the ridge quality of fingerprints developed using formulation A and Table 2 shows ridge quality of fingerprints developed using formulation B. The novel zinc carbonate formulation is a highly effective means for development of latent fingerprints exposed to high temperatures and fire. The method is especially appropriate for fingerprints treated with water, as occurs in a normal fire scenario. Recovery

Table 1 Ridge quality of latent fingerprints developed using formulation A.

Surface	Temperature(°C)	Quality
I. Glass	100	10
	200	10
	300	10
	400	9
	500	8
	600	5
	700	5
	800	3
	900	0
II. Aluminum foil	100	10
	200	10
	300	10
	400	9
	500	8
	600	8
	700	2
	800	0
	900	0
III. Ceramic tile (white)	100	6
	200	6
	300	5
	400	4
	500	2
	600	1
	700	0
	800	0
	900	0
IV. Ceramic tile (Black)	100	10
	200	8
	300	8
	400	7
	500	7
	600	5
	700	1
	800	0
	900	0
V. Tin can	100	8
	200	8
	300	7
	400	6
	500	1
	600	0
	700	0
	800	0
	900	0
VI. Metallic spoon	100	9
	200	8
	300	8
	400	6
	500	3
	600	1
	700	0
	800	0
	900	0

Table 2 Ridge quality of latent fingerprints developed using formulation B.

Surface	Temperature(°C)	Quality
I. Glass	100	10
	200	10
	300	9
	400	9
	500	9
	600	5
	700	5
	800	1
	900	0
II. Aluminum foil	100	10
	200	9
	300	9
	400	7
	500	7
	600	4
	700	1
	800	0
	900	0
III. Ceramic tile (white)	100	6
	200	5
	300	5
	400	3
	500	1
	600	0
	700	0
	800	0
	900	0
IV. Ceramic tile (Black)	100	10
	200	10
	300	10
	400	7
	500	6
	600	4
	700	1
	800	0
	900	0
V. Tin can	100	9
	200	9
	300	7
	400	7
	500	2
	600	0
	700	0
	800	0
	900	0
VI. Metallic spoon	100	9
	200	7
	300	6
	400	5
	500	1
	600	1
	700	0
	800	0
	900	0

rate of latent fingerprints which produced clear ridge details was 89.5%.

Both eosin B and eosin Y gave positive results. Though enhancement due to fluorescence was more prominent with eosin B, it exhibited more background noise in relation to eosin Y. The surfaces chosen in this study were those which could survive high temperatures. Fingerprints could not be developed at 900 °C and above. Glass started to disintegrate above 830 °C. Aluminum foil became excessively crinkled and disintegrated at 750 °C. Hence, the latent fingerprint development was impaired on both the surfaces at respective temperatures. Ceramic tile served as an inert substrate, offering little or no background noise. However, in white ceramic tiles, the contrast impaired visibility. Prints with clear ridge details could

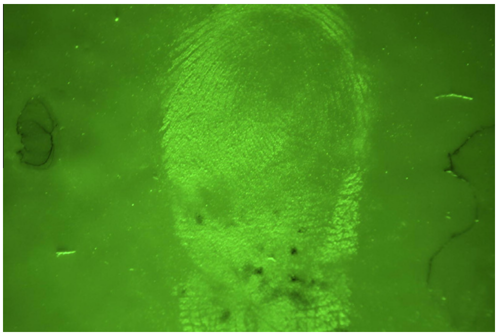

Figure 1 Latent fingerprint developed on a white ceramic tile exposed to 500 °C with formulation B.

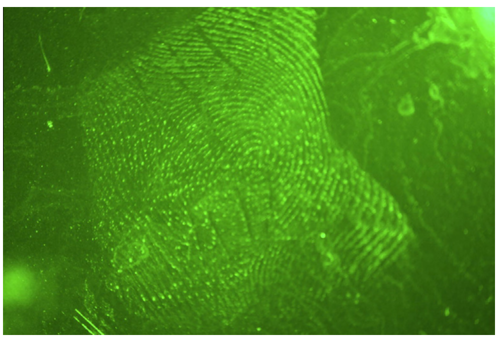

Figure 2 Latent fingerprint developed on a black ceramic tile exposed to 700 °C with formulation A.

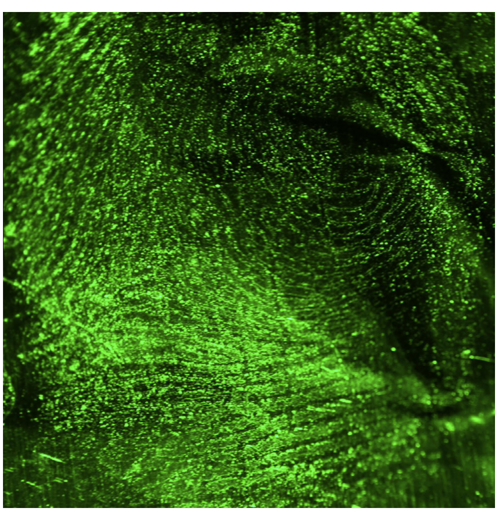

Figure 3 Latent fingerprint developed on aluminum foil exposed to 700 °C with formulation A.

be developed only until 700 and 600 °C on the black ceramic tiles and metallic spoons respectively. Fingerprints with clear ridge details could be developed up to 500 °C on the base of tin cans. Poor results were obtained on the side walls of cans. Figures. 1–8 show some of the fingerprints developed at high temperatures on different surfaces using formulation A or B.

Studies have promulgated various chemical methods for development of latent fingerprints subjected to fire. Cyanoacrylate fuming (+ BY40) or aluminum powder have been reported to give positive results in 50% of fingerprints exposed to arson

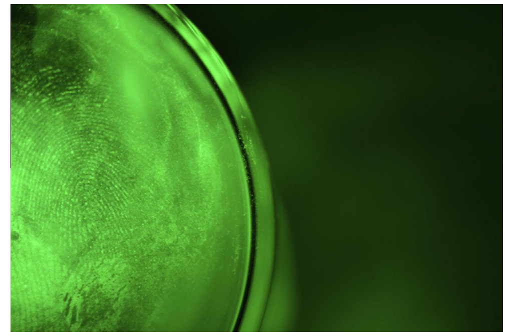

Figure 4 Latent fingerprint developed on a glass surface exposed to 800 °C with formulation A.

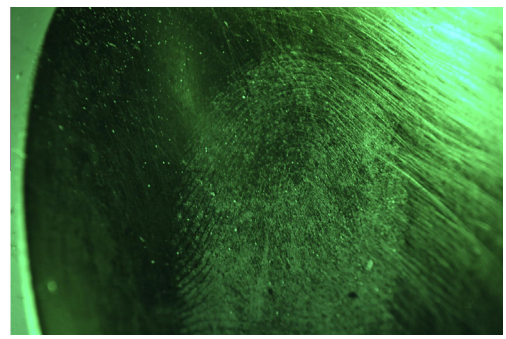

Figure 5 Latent fingerprint developed on a metallic spoon exposed to 500 °C with formulation B.

Figure 6 Latent fingerprint developed on glass exposed to 300 °C with formulation A.

sites.[4] Deans demonstrated development of arson site fingerprints using various physical and chemical methods and reported 18% of samples depicted clear ridge details.[2] Heme specific dyes have been enunciated for blood prints subjected to a maximum temperature of 200 °C and vacuum metal deposition for an elevated temperature range.[7] It has been suggested that the powder methods fail to develop latent fingerprints doused with liquids such as petrol, but partial prints could be recovered under the same conditions using SPR.[5]

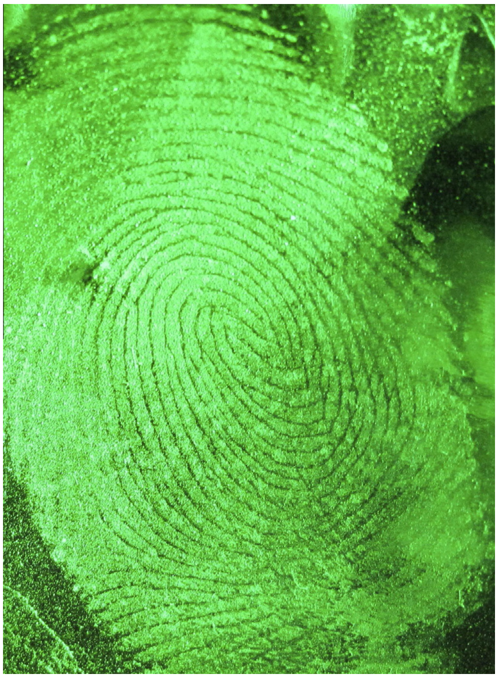

Figure 7 Latent fingerprint developed on aluminum foil exposed to 200 °C with formulation A.

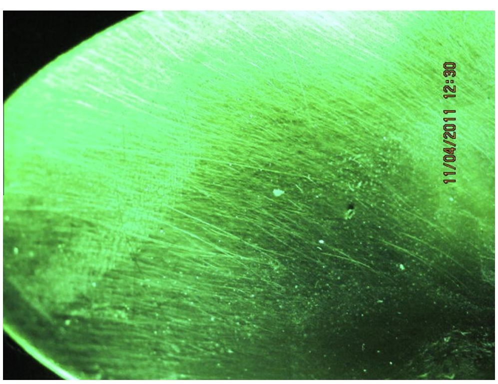

Figure 8 Latent fingerprint developed on metallic spoon exposed to 600 °C with formulation A.

SPR method has been successfully employed for the development of fingerprints exposed to a maximum temperature of 200 °C and subsequently treated with water.[6] SPR particles readily adhere to fatty compositions of the fingerprints. This adherence is aided by the detergent.[12] These fatty compositions are water insoluble. Thus SPR is an effective method for developing fingerprints from arson sites which have been exposed to water.

4. Conclusion

First and foremost, it has been observed that fingerprints can be developed at high temperatures. Thus this crucial evidence should not be overlooked in legal investigations. Furthermore, fingerprints can survive even after rinsing with water. Fluorescent SPR may prove very useful in such cases. Fluorescent SPR reagent based on zinc carbonate is a potential method for developing fingerprints from arson sites. Both eosin B and eosin Y dyes are suitable formulations. The method is cost-effective and non-hazardous. Both the formulations are suitable for developing fingerprints exposed to fire/arson. However, formulation A gave better intensity of fluorescence, more pertinence and a better quality print as compared with formulation B. It was observed that there is a sudden decrease in the quality of the developed print after reaching a particular temperature. This temperature varies for different surfaces. At the maximum temperature at which the fingerprint could be developed, eosin B based composition gave better results for all the surfaces except tin cans. On glass, aluminum foil and black ceramic tiles, good quality fingerprints could be developed at relatively higher temperatures than surfaces like metallic spoons, tin cans and white ceramic tiles.

Conflict of Interest

None declared.

Ethical Approval

Necessary ethical approval was obtained from the Institute Ethics Committee.

Informed consent

Informed consent were enrolled for the study.

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