Science and Justice 56 (2016) 241–246

Contents lists available at ScienceDirect

Science and Justice

journal homepage: www.elsevier.com/locate/scijus

An investigation into effective methodologies for latent fingerprint enhancement on items recovered from fire

Sarah Jane Gardner [a,*], Thomas H. Cordingley [a], Sean C. Francis [b]

[a] Bond University, Health Sciences and Medicine, Robina, Gold Coast, Queensland, Australia
[b] Queensland Police, Queensland, Australia

ARTICLE INFO

Article history:
Received 11 May 2015
Received in revised form 9 February 2016
Accepted 11 February 2016

ABSTRACT

A common assumption is that fire destroys fingerprint evidence. Recent studies have sought to challenge this assumption. This study presents a comparative evaluation of soot removal and fingerprint enhancement techniques, following fire(s) to ascertain optimal process efficacy for recovering fingerprints. Two car burns and a cremation oven were used to determine the temperature range. Temperatures of 300, 450 and 600 °C were used in simulated, controlled fires wherein cars had prints deposited on rear view mirrors. Burning occurred in a shipping container designed to approximate the variables relating to car arson. Soot removal was undertaken by tape lifting, sodium hydroxide solution, or liquid latex casting. The fingerprint enhancement techniques comprised black magnetic, aluminium and black suspension powders, or cyanoacrylate fuming with BY40 dye. A fingerprint expert classified prints as un/identifiable according to standards to be submitted as evidence in court. Multinomial logistic regression analyses were performed on the data using a p value of <0.05 to determine statistical significance. Temperature was the biggest factor affecting fingerprint recovery. There were no statistically significant differences found between any of the soot removal methods used. Higher counts of identifiable prints were recovered with black magnetic powder and cyanoacrylate/BY40 compared to the other methods used but these findings were not statistically significant. It is recommended that recovery of fire-exposed fingerprints (which are not protected) is undertaken where suspected maximum temperatures are <450 °C. Evaluation of optimal soot removal and fingerprint enhancement techniques should be conducted on a case by case basis.

1. Introduction

Arson, or the international use of fire to damage property, is a significant issue worldwide [1]. Natural fires, particularly Bushland fires in Australia are a regular occurrence, especially in the summer months, where temperatures can reach 50 °C (World Meteorological Organization (Accessed [12]).

Currently in Queensland, Scenes of Crime Officers do not collect items for prints if they have been involved in a fire largely due to the 'limited success of developing identifiable prints on surfaces subjected to fire' [8].

Previous studies have shown that fire/heat exposed fingerprints can be recovered [2–7]. Similar studies have not yet taken place in Australia.

This study aimed to look at the effectiveness of current soot removal and fingerprint enhancement techniques following the exposure of prints to fire at various temperatures and to put previous work into operational context in Australia.

A complication that is often encountered following a fire is the presence of a layer of soot, partially or completely covering the print. A range of soot removal techniques have been investigated by Bleay et al. [2] and Stow and McGurry [11]. The use of light brushing, tape lifting, silicon rubber casting, sodium hydroxide solution, an eraser and Absorene were all tested on porous and non-porous soot covered surfaces with some success.

Fingerprint components such as amino acids, lactic acid and fats possess a limited tolerance to exposure to extreme conditions [9]. In contrast, salts are capable of withstanding increased heat [10].

Dominick et al. [7] noted that temperature and time of exposure had a significant effect on fingerprints on glass and ceramic objects which exposed to direct heat and air flow did not survive temperatures of 350 °C and over.

Bleay et al. [2] stated that marks are much more likely to survive if the exhibit has not been exposed to temperatures >300 °C and if they have been protected in some way from the direct effect of heat and smoke. They also found that the effectiveness of powder and powder suspension methods decreased significantly when the print was exposed to temperatures in excess of 200 °C whilst cyanoacrylate fuming was effective until the temperature climbed >500 °C.

Deans [5] found that ridge detail was visible on prints exposed to temperatures of around 500 °C with cyanoacrylate fuming but that this was a 'noteworthy exception'.

* Corresponding author.
E-mail address: sgardner@bond.edu.au (S.J. Gardner).

http://dx.doi.org/10.1016/j.scijus.2016.02.003
1355-0306/

2. Materials and method

2.1. Preliminary car burns

The car burns were carried out at the Fire Academy, Port of Brisbane in four-door Sedan vehicles, each fitted with thermocouple probes drilled into the driver's side, positioned 150 mm and 700 mm from the roof. The fire was lit on the driver's seat, without the use of an accelerant. Once the fire began to spread from the passenger compartment, it was extinguished with water. The first car burn was carried out to record the progressive temperature as the fire proceeded. The second, in the same manner, but with 36 introduced rear view mirrors (without prints) suspended at ceiling height on a wire frame. The condition of each mirror following the burn was then examined.

2.2. Fingerprint deposition

Car rear view mirrors were purchased from local wrecker's yards. The number chosen enabled triplicate repeats and control experiments to be carried out.

The mirrors were cleaned with warm soapy water then washed in 70% ethanol and left to air dry, a day before print deposition.

Four donors (two male, two female) washed their hands with soap and water 30 min prior to deposition and rubbed their hands together between deposits to distribute constituents. They each deposited one single print with their right index finger to three different mirror sides of the rear view mirrors (to enable triplicate repeats). This was repeated until each of 160 mirrors held a single print from all four donors. This took place the day before the experiment to be conducted.

2.3. Cremation oven experiments

These experiments were carried out at Newhaven Funerals in Stapylton.

Car rear view mirrors with deposited prints were placed inside a pre-heated cremation oven (model IE43-PPII Plus) to temperatures 300, 450 or 600 °C for a duration of 15 min. These experiments allowed for the investigation of extreme heat on prints whilst negating the effect of soot and smoke. The fingerprints were enhanced with four different techniques and were evaluated for identifiability by a fingerprint expert.

2.4. Simulated fire experiments

These experiments were carried out at the Fire Academy, Port of Brisbane in a shipping container designed to represent the space of a vehicle interior without internal furnishings.

The mirrors were placed on a metal tray on the ground at the end of the container, situated to ensure even exposure. A thermocouple probe was placed at ground level to measure the progressive temperature. The fire was lit with kerosene accelerant and fuelled with wood shavings. Temperatures were allowed to progress until they reached 300, 450 or 600 °C which was between 5 and 15 min depending on the temperature required. Once reached the tray was removed and the fire extinguished.

2.5. Control experiments

Car rear view mirrors with deposited prints were stored under laboratory conditions at room temperature (24 °C).

2.6. Soot removal and fingerprint enhancement methodology

Sodium hydroxide solution, liquid latex casting (Mikrosil™) and tape lifting were chosen as the soot removal techniques (applied according to the manufacturer's instruction and as described by Bleay et al. [2].

The sooty mirror was immersed in a 1% w/v 5-sulphosalicylic acid fixing agent for 30 s followed by immersion in a 0.5% w/v sodium hydroxide solution for 15 s.

Mikrosil™ casting agent was coated over the mirror surface for 15 min (or until fully dry) and then peeled away.

Scotch 3M pressure sensitive tape was applied to the sooty surface with a roller and then peeled away.

Black magnetic powder, aluminium powder, black powder suspension (magnetic iron oxide based) and cyanoacrylate fuming (using 3 g of cyanoacrylate in a Cyanosafe CAS-30 chamber at 85% relative humidity for 18 min) with BY40 dye (as an ethanol based immersion solution followed by a water wash) were chosen as the print enhancement methods.

These techniques were applied in accordance with processes described in the Home Office Fingerprints Source Book, UK [3].

2.7. Fingerprint assessment

The quality of the recovered prints was independently assessed by a fingerprint expert at Queensland Police. The fingerprints were categorized as either identifiable (and given the notation 1) or not identifiable (and given the notation zero). An identifiable print was one that met the Queensland Police internal standard to be submitted as evidence in court. (Note that ridge detail present that was insufficient to meet the criteria for identifiability was recorded as zero).

3. Results

3.1. Control experiments

All of the fingerprints from the positive control group were deemed identifiable (100% recovery) following application of the four fingerprint enhancement techniques.

3.2. Car burns

For both car burns, the temperature initially increased before reaching a peak at approximately 200 °C. At this point the temperatures decreased over 150 s before rapidly rising to nearly 600 °C (see Figs. 1 and 2).

The mirrors which were exposed to the second car burn (exceeding temperatures of 500 °C) were recovered in various states. Table 1 shows that 42% were recovered entirely or nearly intact. Contamination of the mirrors from the vehicle interior such as melted plastics and roof lining meant that the mirror surface, in a number of cases, was only partially exposed. In addition, warping of the wire frame used to suspend the mirrors meant that some were damaged when they fell to the vehicle floor. Given these difficulties these results were not statistically evaluated. However, temperatures of 300, 450 and 600 °C were chosen for subsequent experiments, covering a range which the mirrors could still be largely recoverable.

3.3. Cremation oven experiments

Following exposure of the prints to 300, 450 and 600 °C in the cremation oven and subsequent fingerprint enhancement with the four techniques, it was found that there were statistically significant differences ($* = p < 0.05$) between the three temperatures, in the number of prints categorized as identifiable (see Fig. 3).

The black magnetic powder and cyanoacrylate fuming methods recovered 30 and 29% identifiable prints respectively across the three temperatures, aluminium powder and black powder suspension recovering 19 and 16% respectively. No statistically significant differences were found with these results.