The Malaysian Journal of ANALYTICAL SCIENCES ISSN 1394-2506

THE EFFECTIVENESS OF SOOT REMOVAL TECHNIQUES FOR THE RECOVERY OF FINGERPRINTS ON GLASS FIRE DEBRIS IN PETROL BOMB CASES

(Keberkesanan Kaedah Penyingkiran Jelaga Bagi Memperoleh Kembali Cap Jari Pada Sisa Kebakaran Kaca Dalam Kes Bom Petrol)

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Abstract

The increased use of petrol bombs as an act of vengence in Malaysia has heightened awareness for the need of research relating physical evidence found at the crime scene to the perpetrator of the crime. A study was therefore carried out to assess the effectiveness of soot removal techniques on glass fire debris without affecting the fingerprints found on the evidence. Soot was removed using three methods which were brushing, 2% NaOH solution and tape lifting. Depending on the visibility of prints recovered, prints which were visible after soot removal were lifted directly while prints that were not visible were subjected to enhancement. Glass microscope slides were used in laboratory experiment and subjected to control burn for the formation of soot. Soot was later removed following enhancement of the prints over time (within 1 day, within 2 days and after 2 days). While in simulated petrol bomb ground experiment, petrol bombs were hurled in glass bottles and the fragments were collected. Favorable results were obtained in varying degrees using each soot removal methods. In laboratory testing, brushing and 2 % NaOH solution revealed fingerprints that were visible after removal of excess soot and were lifted directly. As for tape lifting technique, some prints were visible and were successfully lifted while those that were not visible were subjected to superglue fuming for effective fingerprint identification.

Keywords*:* Soot removal, Glass, Petrol bomb, Brushing, NaOH wash solution (2%), Tape lifting

Abstrak

Penggunaan bom petrol sebagai alat untuk membalas dendam yang semakin meningkat di Malaysia telah menimbulkan kesedaran untuk kajian mengenai bahan bukti fizikal di tempat kejadian yang dapat dikaitkan dengan penjenayah. Maka, satu kajian telah dilakukan untuk menilai keberkesanan teknik penyingkiran jelaga pada kaca tanpa merosakkan cap jari yang berada pada bahan bukti. Jelaga disingkirkan dengan menggunakan tiga kaedah, iaitu memberus, larutan NaOH 2 % dan pengangkat pita. Bergantung kepada ketampakan cap jari yang ditimbulkan, cap jari yang tampak selepas penyingkiran jelaga akan diangkat terus manakala cap jari yang tidak tampak akan ditimbulkan. Sisip kaca mikroskop telah digunakan dalam uji kaji makmal dan dibakar dalam pembakaran terkawal untuk pembentukan jelaga. Jelaga disingkirkan dan diikuti dengan penimbulan cap jari dalam tempoh tertentu (dalam masa 1 hari, dalam masa 2 hari dan selepas 2 hari). Manakala dalam simulasi bom petrol, bom petrol yang terisi dalam botol kaca telah dilontar dan fragmen-fragmennya dikutip. Keputusan yang memuaskan diperoleh pada tahap yang berbeza menggunakan setiap jenis kaedah penyingkiran jelaga. Dalam uji kaji makmal, kaedah memberus dan larutan NaOH 2 % telah menimbulkan cap jari yang tampak selepas menyingkirkan jelaga yang berlebihan dan direkod terus. Dalam kaedah pengangkat pita, sebahagian cap jari adalah tampak dan berjaya direkod manakala sebahagian cap jari yang tidak tampak diproses dengan kaedah pewasapan *superglue* untuk penimbulan cap jari.

Kata kunci: Penyingkiran jelaga kaca, bom petrol, memberus, larutan cuci NaOH 2%, pengangkat pita

Introduction

Arson is a crime that may be defined as the willful and malicious burning of other people's properties or burning one's own properties for some improper purposes [1]. Unlike other crimes, fire will not burn and destroy the particular target at the fire scene but destroy whatever is in its path [2]. One of the aspects in arson investigation involves chemical analysis of the collected fire debris resulting from the fire [2, 3, 4]. In chemical analysis, the chemist will deal with extraction, isolation and analysis of the target compound that could be used to accelerate a fire that was set intentionally [5]. The search for evidence of any accelerant used at the scene is a difficult task because the volume of accelerant used is very little and accelerants contain volatiles which evaporate quickly [2].

Molotov cocktail, also known as petrol bomb or fire bomb, is relatively easy to be constructed and is used by arsonist in order to set a fire. Molotov cocktail is not a bomb as popularized by media but an incendiary device where a mechanical explosion occurs when the bottle with a burning wick is thrown and, upon impact the bottle breaks and permits the fuel to spread or splatter [6].

Latent fingerprints consist of a variety of inorganic and organic substances which mainly composed of five basic components i.e., water, skin oils, proteins, salts and contaminants [4]. These components are mainly secreted by eccrine gland and sebaceous gland as fingers and palm were contaminated with secretions from sebaceous glands which mainly consist of oily components though eccrine glands were primarily located at such parts [7, 8]. The fingerprint recovered from glass fragments of petrol bomb would have greater evidential value because this can link the suspect with the bottle that has been thrown [9]. However, fingerprints are one of the evidences that may be overlooked by the fire investigators because they have a misconception that fingerprints are unlikely to be recovered from associated fire damaged evidence [7, 10]. Many of them, including the arsonists assumed that the evidences will be destroyed by the fire.

Several researches regarding soot removal processes have been developed aimed at removing soot that covered the underneath fingerprint and revealed that fingerprints could still be recovered. The most effective method for soot removal and development of marks depended on the type of matrices where prints are deposited [7, 10, and 11]. Ultra high frequency sonication as a method to removed soot had been carried out by Shelef *et al.* [12] with 34 % recovery rate. Spawn [13] had demonstrated the used of running water and tape lifting method to remove soot from household objects. Application of 1% and 2% sodium hydroxide (NaOH) wash solution onto glass surfaces to remove soot was done by Stow and McGurry [9] with successful recovery of fingerprints. They also recommended the use of NaOH solution as soak to loose the soot. Bradshaw *et al.* [10] found that tape lifting was the most effective method to remove soot on nonporous surface and Absorene on porous surface for latent fingerprints. Soot was also found to be successfully removed from larger areas such as window and wall by using latex in recent researches [14, 15].

As there is a significant increment of petrol bomb cases in Malaysia especially when sensitive issues that caused civil unrest in society occurred and lack of research regarding recovery of fingerprints from fire damaged evidence being reported, an initial study was therefore carried out to determine the most suitable method for removal of soot and recovery of fingerprints from glass surfaces.

Experimental

Materials and Chemical Reagents

The materials and chemical reagents used in this study were soft fingerprint brush, fingerprint lifting tape, superglue fuming cabinet, retort stand, forceps, tray, magnifying lamp, Polilight PL500 (Rofin, Australia), Acetone (QRëC, Pulau Pinang), Sodium hydroxide pellet (MERCK, Germany), superglue, Small particles reagent (SPR) 100 (Sirchie, USA), SPR400UV (Sirchie, USA), black fingerprint powder (SPEX Forensics, USA), fluorescent fingerprint powder (Lightning Powder Company, USA), petrol, beer glass bottles, glass microscope slides and cotton cloth (Good Morning towel).

Methodology

The method used was adapted from the work of Stow and McGurry [9]. The quality of finger marks recovered were rated according to Table 1.

Table 1 Fingerprint rating scale

Scale	Description
0	No visible ridges
1	Poor quality
2	Reasonable quality or partial print
3	Good quality, clear ridges

Laboratory Experimentation

The experiment was carried out in laboratory using glass microscope slides to cover every eventuality that may occur in actual cases. The following were the possible conditions for:

i. Unburned glass
   - Clear unburned glass containing uncontaminated fingerprint.
   - Unburned glass containing uncontaminated fingerprint that have been contaminated with accelerant after being placed onto glass surface.
   - Unburned glass containing accelerant contaminated fingerprint.
   - Unburned glass containing uncontaminated fingerprint on accelerant contaminated glass surface.

ii. Burned glass
   - Burned glass containing uncontaminated fingerprint.
   - Burned glass containing uncontaminated fingerprint which have been contaminated with accelerant after being placed onto glass surface
   - Burned glass containing accelerant contaminated fingerprint
   - Burned glass containing uncontaminated fingerprint on accelerant contaminated glass surface

Fingerprint was deposited onto nine glass slides for each type of glass condition. These samples were divided into 3 sets. The attempt of removing soot and recovering the fingerprint was conducted within 1 day for the first set, within 2 days for the second set and after 2 days for third set.

Powder dusting method, superglue fuming method and SPR method were carried out on recovery of fingerprint from unburned glass slides. For uncontaminated print on unburned glass slide, fingerprint was placed on glass and recovered directly. While for glass slide containing uncontaminated fingerprint which has been contaminated with accelerant after being placed onto glass surface, the glass slide which has been placed with fingerprint was doused with accelerant. The glass slide was left to dry in a fume-cupboard for 30 minutes before the recovery of print was done. As for uncontaminated fingerprint on accelerant contaminated glass surface, clean glass slide was firstly doused with accelerant and was left to dry in fume-cupboard for 30 minutes. The print was then placed onto the glass surface. Lastly, for glass containing accelerant contaminated fingerprint, finger bearing accelerant was placed on the glass before recovery of print was carried out.

In burned condition, each type of the fingerprint was applied to the glass slides individually and subjected to control burning. A sheet of towel (5 cm x 10 cm) was placed in a metal tray and filled with 3 mL of accelerant. The slides were then suspended over the metal tray using retort stand and the accelerant was ignited in a fume cupboard (Figure 1). After soot was formed on the glass, the soot was removed by brushing method, using sodium hydroxide wash solution (2 %) and tape lifting method. Once the soot was removed, the slides were subjected to latent

fingerprint examination. The quality of fingerprint mark on the glass was assessed if the print was visible after removal of soot. Development of fingerprint was carried out for print which was not visible by superglue fuming method. Further enhancement was carried out by using combination of fluorescent SPR and fluorescent powder and viewed under UV source from Polilight for prints which were difficult to see. Prints developed were assessed and photographed.

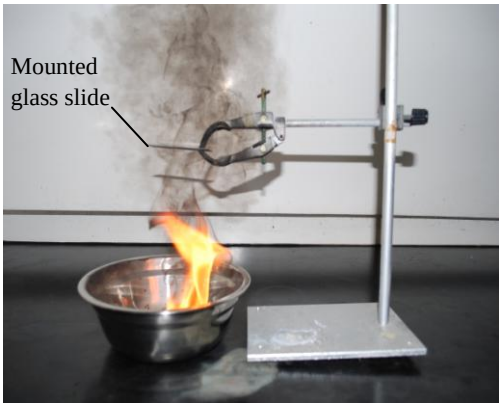

Figure 1: Experimental set-up of control burning in laboratory experiment

Ground Experiment

The throwing of petrol bomb was conducted to assess the practicability of each soot removal method in real petrol bomb cases. The experiment was conducted at Headquarters of Fire and Rescue Department Negeri Selangor at Bukit Jelutong, Shah Alam. Petrol bomb was hurled by fireman under close supervision of police officers from Bomb Disposal Unit and PDRM Forensic Laboratory, Cheras.

The beer glass bottles were initially cleaned thoroughly with soap and water followed by using acetone. A volume of 250 mL accelerants was then funneled into each bottle using gloves followed by insertion of towel wick (11 cm X 31 cm). Prints were deposited onto the glass bottles at the position where the bottles will be held, both on the body and neck of the bottle and the locations of the deposited prints were marked and outlined. The site of petrol bomb throw was cleaned thoroughly prior to ignition. The wick was then ignited and petrol bomb hurled to the explosion site. The fire was then allowed to extinguish naturally. All glass fragments from the broken glass bottle were collected using forceps, stored in a card box and transported back to laboratory for analysis.

The samples collected were subjected to brushing method, NaOH wash solution (2 %) and tape lifting method for glass fragments which were covered with soot. Each type of soot removal method consisted of 9 samples with 3 in a set. One set of the samples were subjected to soot removal process within a day after collection. This process was repeated within 2 days and after 2 days for the other two sample sets. Once the soot was removed, the fragments were subjected to latent fingerprint examination under magnifying lamp. Enhancement was carried out for prints which were not visible under normal condition using superglue fuming method. Further enhancement was carried out by using combination of fluorescent SPR and fluorescent powder and viewed under UV source using Polilight for prints which were difficult to see using similar procedures as in laboratory experiment. The prints developed were thus recorded, assessed and photographed.

Soot Removal Method

In brushing method, excess soot covered on glass was removed using soft brush by brushing gently [16]. For samples subjected to NaOH wash solution (2 %), the solution was applied by using a plastic bottle wash. The

sample was immersed into the solution if the sample was small in size [9]. As for tape lifting method, the adhesive tape was applied to the soot covered glass surface gently to remove excess soot. This step was repeated until print was visible or soot was completely removed [16].

Results and Discussion

Fingerprint Quality Score

Images of print which corresponded to the scores on scale 0 to 3 are shown in Figure 2. The assessment of print quality was subjective and relied on consistent visual scoring by the examiner.

Scale 0 Scale 1 Scale 2 Scale 3

Figure 2: Fingerprint quality with scale 0 to 3 according to the clarity of the fingerprint marks

Laboratory Experimentation

Unburned Condition

The quality of fingerprints developed by powder dusting, superglue fuming and SPR method is shown in Table 2. SPR was found to be the most effective method in developing types of fingerprint. Powder dusting and superglue fuming method on the other hand, were the least effective methods because fingerprint marks could only be developed from uncontaminated samples and samples treated with petrol.

Table 2: Fingerprint quality of different glass condition developed within 24 hours in unburned condition using fingerprint development method

Glass condition	Fingerprint quality		
	Powder dusting	**Superglue fuming**	**SPR**
Uncontaminated fingerprint	3	3	3
Petrol contaminated fingerprint	3	3	3
Uncontaminated fingerprint doused with petrol	3	3	3
Uncontaminated fingerprint on petrol contaminated surface	3	3	2

The results of this work is in close agreement with that reported by Stow and McGurry [9] with successful development of petrol contaminated fingerprint and uncontaminated fingerprint doused with petrol using SPR and powder dusting method.

Burned Condition

Table 3 showed the fingerprint quality of soot covered sample. The most effective soot removal method is brushing method that gave clear fingerprints (score 3) being recovered, followed by tape lifting method and lastly, NaOH wash solution (2 %). It was found that visible prints were recovered after removal of excess soot covered on glass surface using brushing and NaOH was solution (2 %).

Table 3: Fingerprint quality of different glass condition recovered within 24 hours in burned condition using soot removal method

Glass condition	Fingerprint quality		
	Brushing	**NaOH wash solution (2 %)**	**Tape lifting**
Uncontaminated fingerprint burned with petrol	3	3	3
Petrol contaminated fingerprint	3	2	2
Uncontaminated fingerprint doused with petrol	3	1	3
Uncontaminated fingerprint on petrol contaminated surface	3	2	2

Persistency of Fingerprint

Unburned Condition

The fingerprint were intact throughout the tested period and the overall success rates of fingerprint developed under unburned condition decreased to 75 % on the third day after preparation. The rate of success in development of print is shown in Figure 3. Based on the types of fingerprint which were able to be developed by each method, both superglue fuming method and SPR method gave 100 % success up to 3 days after preparation while powder dusting method has a success rate of 75 % on the third day after preparation. It was reported that fingerprint washed with petrol were successfully developed with 80 % to 90 % and 50 % to 60 % success up to 5 days after preparation using SPR and superglue method [17]. Compared to this study, both methods gave 100 % success on the first day in the test which is similar with the results obtained in this experiment.

Burned Condition

The success rate of fingerprint recovered for each soot removal method throughout 3 days period were decreased (Figure 4). Brushing and NaOH wash solution (2 %) have success rate of 91.67 % and tape lifting method has 83.33 % success rate after 2 days preparation. The overall fingerprint mark recovery success rate in this condition is 100 % for first two days and 75 % for the third day.

Most types of fingerprint which were able to recover by each method remained intact and able to be recovered after 2 days preparation except for uncontaminated fingerprint doused with petrol. As only good quality fingerprint marks were tested in this study, the success rate of fingerprint marks recovered from brushing and NaOH wash solution (2 %) within 1 day were both 100 % compared to 100 % and 75 % success rate respectively in the test conducted by Stow and McGurry [9] in recovery of fingerprint from good quality donor and from poor quality donor.

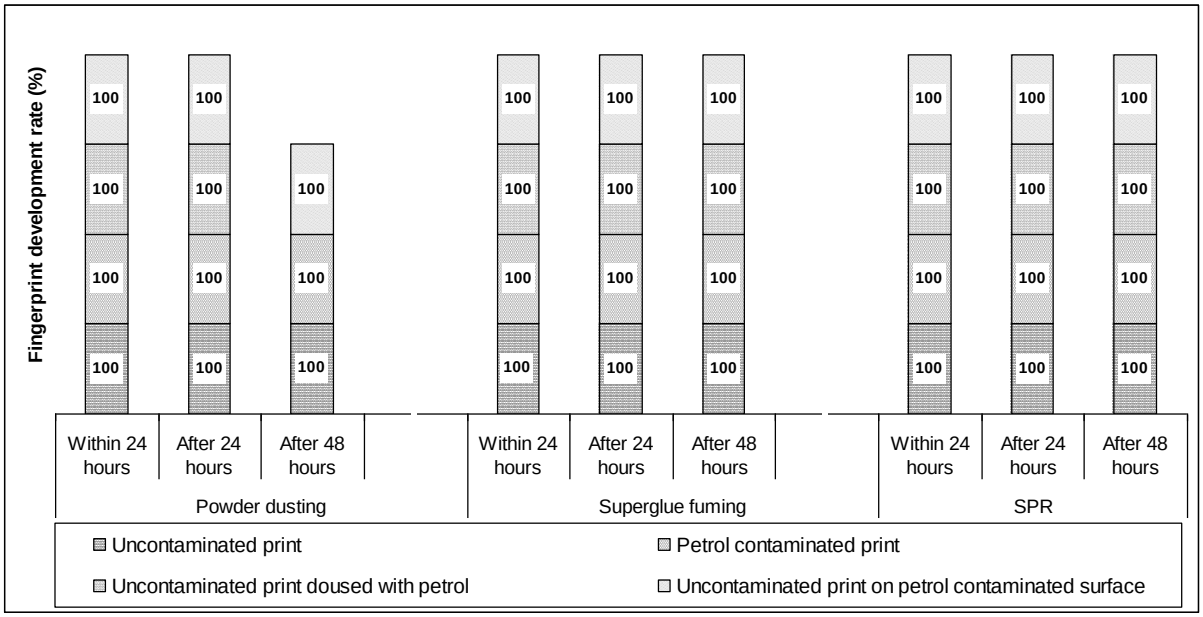

Figure 3: Development rate of different fingerprint types under unburned condition over 3 days period. (Test were conducted in triplicate for each type of fingerprint in each period)

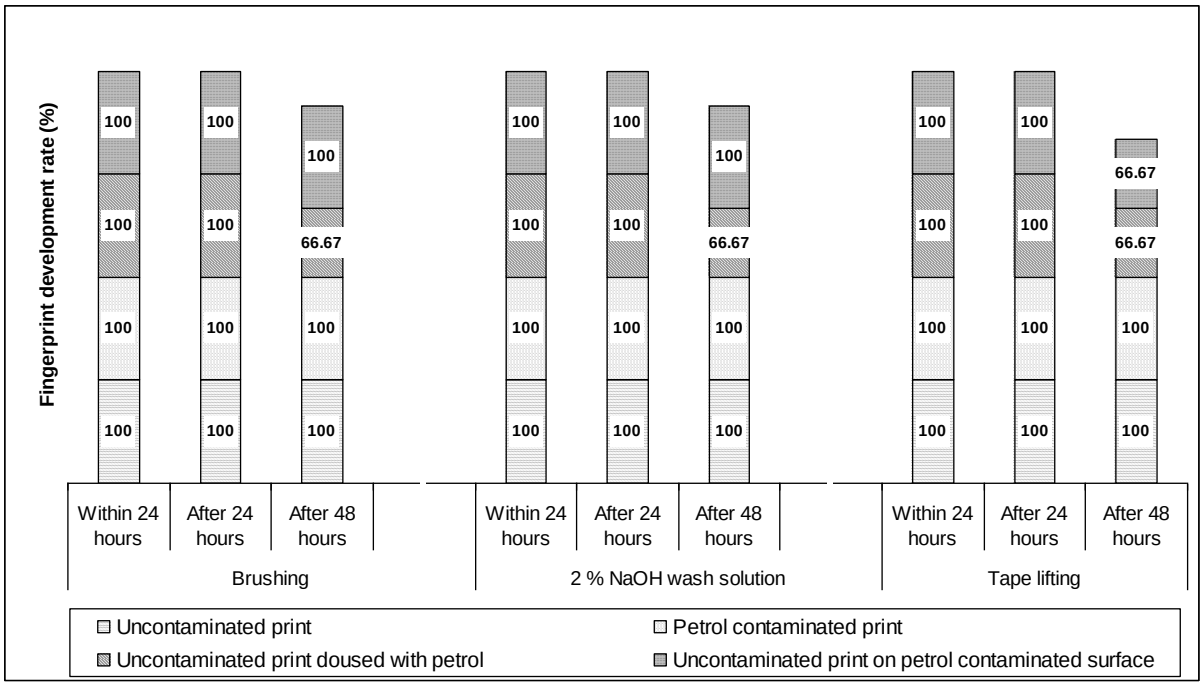

Figure 4: Recovery rate of different fingerprint types under burned condition over 3 days period. (Test were conducted in triplicate for each type of fingerprint in each period)

Ground Experiment

A total of 27 bottles were exploded in this stage and 27 bottles were broken into fragments as the bottles were thrown against a cement wall. Among 27 broken bottles, 26 of the bottles were burned and soot was formed on these bottles. The number of fragments collected from each bottle varied from 1 to 65 pieces. Total fragments collected in whole experiment were 1133 pieces which consisted of 663 pieces of soot covered fragments. All of the fragments were examined for the presence of fingerprint and 58 fingerprints were recovered from soot covered fragments.

Furthermore, fingerprint with score 0 was not accounted for in this stage because the exact number of score 0 fingerprint mark could not be determine. There were two possibilities to explain this finding; either there was no fingerprint deposited by on the fragment or the fingerprint on the glass surface was destroyed.

Soot Covered Fragments

The soot removal methods discuss here were conducted on glass fragments recovered from petrol bomb. Prints were successfully recovered using brushing, NaOH solution (2 %) and tape lifting method (Figure 5). Similar to laboratory experiments, most of the fingerprint marks recovered using each soot removal method were visible after removal of excess soot. The exposure of fingerprint to heat and fire has led to fusion of soot to the ridges thus the fingerprint was revealed when excess soot was removed [10, 13]. The recovery of prints from sample B3 was unsuccessful while no soot covered fragments were recovered from sample T2 because sample T2 was not burned.

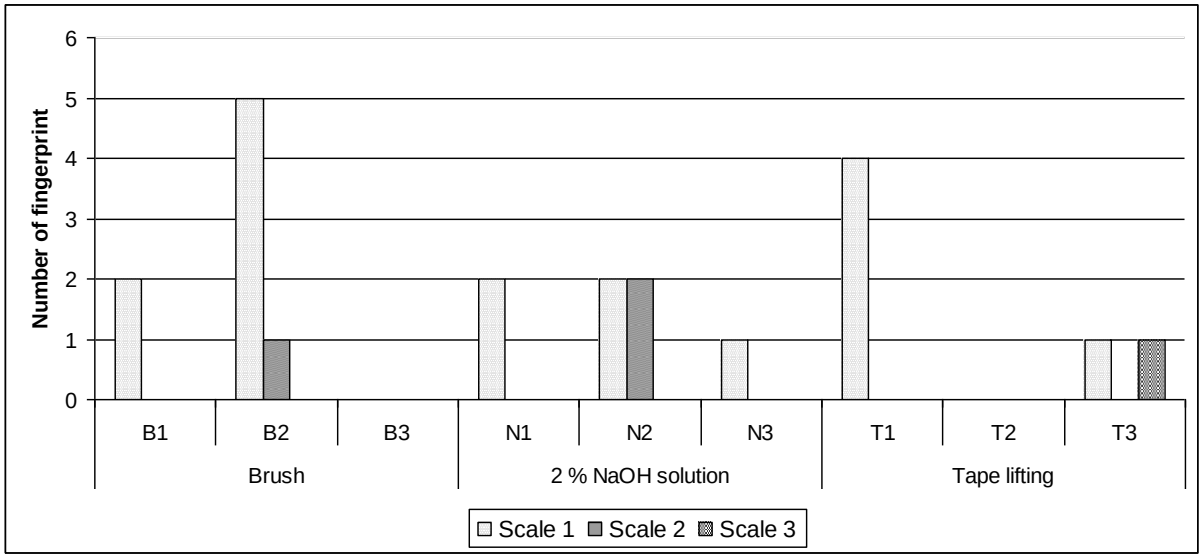

Figure 5: Number of fingerprints recovered in each fingerprint quality by brushing (B), NaOH wash solution (N) and tape lifting (T).

Removal of soot by brushing method is an easy and simple method because the extensive soot on glass surface can be removed easily with light brushing action. The use of NaOH wash solution (2 %) also success in removing excess soot covered on glass fragments and revealed the fingerprint mark underneath it. Some fragments with extensive soot were also subjected to soak in the solution as recommended by Stow and McGurry [9] but no fingerprint marks were recovered from such fragments. Heavy application of NaOH solution (2 %) was found to disrupt the fingerprints [9]. Selection of this method should be used with caution because the used of this solution

will have detrimental effect to DNA [10, 16]. It was also observed that white deposits formed on the glass surface which had been treated with this solution when the sample was left overnight.

In the use of tape lifting method to remove soot result recovery of fingerprint mark, it was only visible when examine at oblique angle. Prints were attempted to develop by superglue fuming method but the fingerprints were still not visible when view at parallel angle. Enhancement of fingerprints was carried using combination of fluorescent SPR suspension and fluorescent powder and the samples were viewed using light source at specific wavelength. Best contrast of fingerprint marks was obtained when viewed under UV light.

Tape lifting method was found to be the most effective method among the three although brushing is the most effective in laboratory experiment. Fragments that had been treated using brushing and NaOH wash solution (2 %) methods were further processed using tape lifting method. The combination of brushing and NaOH solution (2 %) with tape lifting method increased the recovery of fingerprint. Combination of brushing with tape lifting increases the recovery of fingerprint marks from one to eight fingerprint marks while combination of NaOH solution (2 %) with tape lifting increases the recovery of fingerprint marks from three to seven fingerprint marks. Combinations of such methods were also suggested by Bradshaw *et al*. [10].

Persistency of Fingerprint

Figure 6 shows the number of fingerprint recovered from soot covered fragments in the 3 days period. Fingerprints were also unsuccessfully recovered from sample B3, B6, N7, M3 and M6. For sample B5, B9, N4 and T2, there was no recovery of soot covered fragments from these samples.

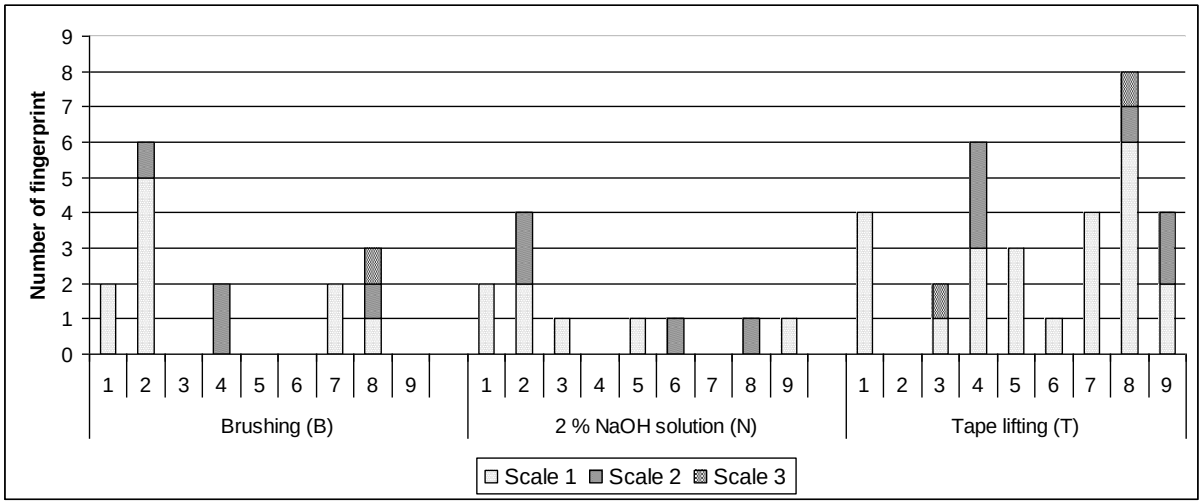

Figure 6. Number of fingerprint mark recovered from soot covered fragments

Comparison between Laboratory Experiment and Ground Experiment

Compared to recovery of fingerprint in laboratory experiment which was in controlled environment, recovery of fingerprint from glass fragments in ground experiment was more difficult. In laboratory experiment, glass slides were suspended at a fixed distance from the heat source. Hence, the heat received by all the samples was consistent. While in the simulated petrol bomb scene, the fragments were scattered over a range of distance from the point of origin with heavily soot covered fragments to a distance where non soot covered fragments were located. The chances to recover fingerprint from soot covered fragments located near to the seat of fire was lower as it was the hottest area where the fingerprint will be destroyed by heat. In addition, the exposure time of fragments to heat also

affect the recovery of fingerprint as the physical and chemical properties of fingerprint will be affected by such exposures [10, 11, 13]. However, the temperature of fire and exposure time of sample to fire in each experiment was not obtained in this study. Furthermore, safety gloves were worn during hurling of petrol bomb due to safety consideration. This may smudge the prints initially planted on the glass bottle and possibly removal of some prints.

The condition of soot covered glass fragment obtained from simulated scene varies too. Some of the fragments were contaminated with dirt and some fragments heavily contaminated with oil which causes the recovery of fingerprint marks becomes more difficult. Furthermore, the outer side of glass bottle that impacted the cement floor could contribute to destruction of fingerprints upon contact with the cement floor. As the glass surfaces were only suspended over the accelerant in laboratory experiment, no contamination of oil were found on glass surfaces.

Conclusion

This work has showed that it is possible to recover fingerprints from soot covered glass fragments from petrol bombs over a three days period of storage in laboratory using brushing, NaOH wash solution (2 %) and tape lifting method. All the methods used show successful recovery to varying degree with tape lifting method as the most effective method in soot removal process for recovery of prints from soot covered fragments. This method can also be used in combination with brushing and NaOH wash solution (2 %). For non soot covered fragments, recovery of fingerprint marks using superglue fuming method follow by examination under light source at specific wavelength proved successful in recovery of prints from uncontaminated fragments.

Acknowledgement

Thanks are due to the Department of Chemistry, Faculty of Science, UTM for research facilities and Forensic Laboratory of Royal Malaysia Police for technical support. Special thank goes to the Fire and Rescue Team of Headquarters, Fire and Rescue Department, Selangor and Bomb Disposal Unit, Bukit Aman for their assistance in the petrol bombs explosion.

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