Detection of Methamphetamine from Fingerprint Powder-Dusted Surfaces

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ABSTRACT: Fingermarks found at a crime scene can aid in identifying individuals. Such fingermarks, usually invisible, can appear on any surface within a crime scene and they could also be contaminated by the exogenous substance. Whenever there are drug-related crimes, either clandestine drug manufacturing or abuse of illicit drugs, fingermark and the drug substances are the two important forensic evidence where their evidential values shall be maximised. Hence, this study was aimed to investigate the influence of fingerprint powders towards the detection of methamphetamine from the dusted surfaces. Fingermarks on eleven types of surface materials, contaminated by methamphetamine, were developed using black and white fingerprint powders. Subsequently, the samples sampled from fingerprint powder-dusted surfaces were examined using Simon's chemical test and gas chromatography (GC) method, respectively. From the study, Simon's chemical test and GC method were useful in detecting the presence of methamphetamine, where the fingermark and fingerprint powder particles were found less likely to interfere the positive detection. To conclude, methamphetamine could be detected from fingerprint powder-dusted surfaces, suggesting the possibility of contact between an individual with the drug substances in any crime.

Keywords: forensic science, methamphetamine, fingermark, fingerprint powder, colour test, gas chromatography

Introduction

Searching for fingermark with an intention to identify the suspect in possession at a crime scene is usually the first step of forensic investigation [1]. Nearly all the surfaces or items with potential fingermarks will be applied with necessary fingermark development techniques to track the suspect. Amongst, dusting using conventional fingerprint powders is the more commonly used technique due to its simplicity, portability, and availability [2]. Application of fingerprint powder might or might not succeed in developing the fingermarks; however, contamination of a surface or item by the fingerprint powder particle is definite in all instances. Due to the contamination or the darkening of dusted surfaces, such potential "forensic evidence" is less likely to be sampled for further analysis, including testing for the presence of any illicit drug to prove an illegal act.

Exogenous substances could be detected from a contaminated fingermark to suggest that fingers might have contacted such substances prior to the deposition [3,4]. Instead of transference of exogenous substances from a contaminated finger onto a surface, a fingermark could also be deposited on a surface which had been priorly contaminated with the exogenous substances, but that finger appeared clean (no other substances except the residues originated from the finger). Apart from that, a fingermark that had already been present on a surface might also be post-contaminated by any exogenous substance. Questions were arisen whether such fingermarks could still be detected with the exogenous substance, in this study, the methamphetamine substance, and such studies were found lacking in the literature.

Highly advanced instrumental techniques are established [5-7]; however, it was noted also that such instruments might not be readily available to all forensic communities including our country. In general, most forensic

laboratories are only equipped with the basic instruments, including routinely utilised chemical tests which need no complicated instrumentation. In this study, the presence of methamphetamine from fingerprint powder-dusted surfaces was determined using two basic methods, namely the colour test and gas chromatography (GC) method. With that, the existence of fingerprint powder particles, whether they would interfere with the analytical results, was investigated. Influence of fingerprint powders, concentration of methamphetamine applied, as well as prior- and post-contamination conditions on the detection of methamphetamine from fingerprint powder-dusted surfaces were evaluated.

Materials and Methods

Chemicals and fingerprint powders

Methamphetamine hydrochloride (98% purity) was obtained from the Department of Chemistry, Malaysia. Analytical grade methanol (Merck, Kenilworth, NJ) was used to prepare the methamphetamine standard solution. Both "Hi-Fi" Volcanic Latent Print Powder, Indestructible White (Sirchie, Youngsville, NC) and "Hi-Fi" Volcano Latent Print Powder, Silk Black (Sirchie, Youngsville, NC) were used, and their application to develop fingermarks was performed using squirrel fingerprint brushes (Sirchie, Youngsville, NC).

Surface materials

There were 11 surface materials selected in this study. The surface materials included glass sheet, white plastic tray (Daiso, Higashihiroshima, Hiroshima), uncoated aluminium sheet, metal tray (Daiso, Higashihiroshima, Hiroshima), metal plate (Eco-Shop, Jementah, Johor), beige coloured tile, white coloured tile, brown coloured laminated medium-density fibreboard (MDF) sheet, quartz countertop, brown melamine particle board and white polyvinyl chloride (PVC) laminated particle board. These surface materials, unless specified, were obtained from a local hardware store. They were selected as representative non-porous and semi-porous materials that are commonly found in a household, assuming clandestine laboratories set up within a residential structure.

Fingermark samples preparation

Sebaceous-eccrine groomed fingermarks were applied on the 11 different surface materials, and they were developed using two fingerprint powders, namely black and white fingerprint powders. Sebaceous-eccrine fingermarks were chosen as the representative fingermark to standardise the compositions, in which such fingermark consisted of both sebaceous and eccrine components, producing clear and consistent fingermarks as suggested by Sears et al. [8]. Sebaceous-eccrine fingermark was groomed by wiping cleaned, dried fingers around the nose and forehead regions prior to deposition. Each surface was priorly cleaned using methanol before the depositions. The groomed thumb was pressed onto a glass surface at 300 g for 5 sec as adapted from Fieldhouse [9].

These fingermarks were either deposited on a surface which was already contaminated with methamphetamine or deposited on a clean surface and subsequently contaminated by the methamphetamine. Fingermarks in relation to the state of contamination of a surface, both the (i) "prior-deposition contaminated fingermark" that referred to the fingermark deposited on surface which has already been contaminated by methamphetamine and it was not subjected to further contamination after its deposition, as well as (ii) "post-deposition contaminated fingermark" that referred to the fingermark was deposited on a clean surface but the surface bearing the fingermark was subjected to subsequent methamphetamine contamination [10]. The fingermarks were also prepared either uncontaminated or contaminated with concentration levels of 1.0 mg/mL, 0.5 mg/mL, and 0.25 mg/mL of methamphetamine hydrochloride dissolved in methanol. Note that all the deposited fingermarks were left air-dried for 30 min before development using fingerprint powder. This study was approved by the Human Research Ethics Committee (JEPeM) of Universiti Sains Malaysia (USM/JEPeM/18050228).

Colour test

During routine forensic analysis, colour tests are used to rule out the classification of illicit drugs [11]. Sodium nitroprusside (Merck, Kenilworth, NJ), acetaldehyde (Merck, Kenilworth, NJ), anhydrous sodium carbonate (Merck, Kenilworth, NJ), and distilled water were used to prepare Simon's reagents. Filter paper (Whatman®, Maidstone) was used as

wiping tools. Simon's test involved a combination of two reagents. Reagent A was prepared by mixing 1 g of sodium nitroprusside in 50 mL of distilled water followed by the addition of 2 mL of acetaldehyde. For reagent B, 2 g of anhydrous sodium carbonate was added into 100 mL of distilled water. Both reagents were then stored in separate amber bottles prior to use [11].

Sebaceous-eccrine fingermark samples prepared in different conditions were tested with Simon's test. Surface materials without any fingermarks and methamphetamine was treated as negative control. Fingermark-negative control was prepared by depositing fingermarks on cleaned surfaces (without methamphetamine). Positive control was prepared by spraying the methamphetamine standard solution to the clean surfaces.

For all the samples, the surfaces with the methamphetamine-contaminated fingermark samples, both powdered and unpowdered, were wiped using filter papers. For unpowdered fingermarks, the surfaces were wiped with filter papers after 30 minutes of the deposition of fingermarks or methamphetamine, while for powdered fingermarks, the fingermarks were developed with fingerprint powders prior to the wiping step. Each wiped sample was tested using Simon's test. 1 mL of reagent A was sprayed onto the wiped samples, followed by 2 mL of reagent B (the ratio of reagent A: reagent B was 1:2). Any colour changes on wiped samples were observed. It was noted that a positive reaction would give brilliant blue colour, while no colour change was observed with negative detection [11,12].

The same procedure was carried out to compare the experimental results, varied in the concentration levels and status of contamination by methamphetamine, as well as the influence of fingerprint powdering procedure and types of surfaces. Statistical analyses were conducted using IBM® SPSS® Statistics Version 26 (Armonk, NY) for chi-square test for the determination of influence of drug-contamination on the colour test and the effects of concentration levels of methamphetamine on the colour test.

Chromatographic technique

In this study, gas chromatography-flame ionisation detection (GC-FID) was performed to determine the presence of methamphetamine. All the surfaces were contaminated with 0.25 mg/mL methamphetamine solution and such concentration level was selected based on the experimental results obtained from Simon's colour test. This was noted that the other two concentration levels i.e., 0.5 mg/mL and 1.0 mg/mL with more concentrated methamphetamine carried higher possibility to be detected by the colour test, and therefore further analysis was conducted to determine whether the lowest tested concentration could be detected through instrumental analysis. Black fingerprint powder was the only powder being investigated. A further experiment was also conducted by swabbing the lifted site of the methamphetamine-contaminated fingermarks with tape (Daiso, Higashihiroshima, Hiroshima). A lifted site here referred to an area where a successfully developed fingermark was removed from the surface by the tape.

A 7890A GC system equipped with split/splitless injector and FID (Agilent Technologies, Inc., Santa Clara, CA) equipped with 7963 Series Autosampler. The protocol was adapted from Girod and Weyermann [5]. The column used was the HP-5 phenyl methyl siloxan (30 m × 0.25 mm × 0.25 µm). Purified nitrogen gas (99%) was used as the carrier gas and flowed at 1 mL/min. The injector was set at a temperature of 250°C. 1 µL of the sample was injected into the system in a splitless mode. The temperature programme was set at 80°C for 1 min, ramped at 10°C/min to 230°C and kept for 2 min, followed by another ramping at 6°C/min to 290ºC, and lastly at a rate of 3°C/min to 320°C and held for 2 min. The detector temperature was set at 300°C. Purified hydrogen, purified air, and the makeup (purified nitrogen gas) flows were supplied to the detector at 30, 300, and 15 mL/min, respectively. ChemStation software (Rev. B.04.02, Agilent Technologies) was used for GC automation and data analysis.

Positive control, namely the methamphetamine standard solution was tested to determine its retention time. Once determined, the prepared samples were analysed. The GC profiles of prepared samples were generated and the presence of methamphetamine on surfaces with fingermarks and fingerprint powders as contaminants was determined. The possibility to detect both latent fingermarks and methamphetamine simultaneously in a single run was also evaluated.

Results and Discussion

Colour test

Simon's test was used to determine the presence of secondary amines, including methamphetamine [11]. A positive Simon's test with methamphetamine produces brilliant blue on the tested surfaces [12]. For positive controls with only deposition of 1.0 mg/mL methamphetamine on the surfaces, Simon's test gave positive results for nine surfaces except for two which were the quartz countertop and brown melamine particle board. This could be due to the interaction between the drug substances and surface materials, making them hard to remove from the surfaces. Figure 1 shows the representative results for both positive and negative results, respectively. Through the observation, blue colour spots were evident on the filter papers.

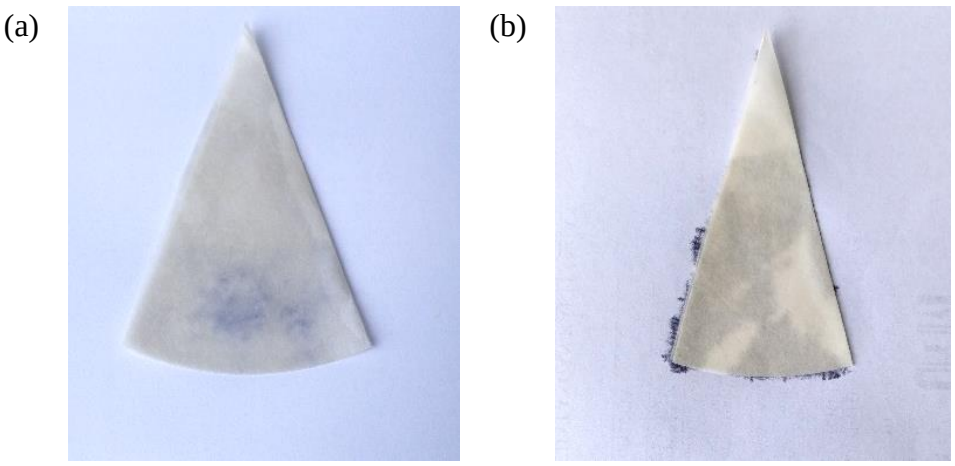

Figure 1: (a) Positive result and (b) negative result of Simon's test.

The experiment continued with the testing on the fingermarks on methamphetamine-contaminated surfaces, both prior-deposition contaminated fingermark and post-deposition contaminated fingermark. This was done to compare if the immediacy of contamination by the exogenous substance would produce different outcomes. The influences of drug-contamination conditions on Simon's colour test were analysed using a chi-square test to determine the association of these two scenarios on the colour test. Table 1 demonstrates the statistical output where no significant association between the sequence of contamination was determined, $\chi 2(1, N = 198) = 0.253$, $p = 0.688$. In other words, both prior-deposition contaminated fingermark and post-deposition contaminated fingermark have equally produced positive or negative results. This result indicated that whether a fingermark was deposited on surface which has already been contaminated by trace methamphetamine but was not subjected to further contamination after its deposition, or a fingermark was deposited on a clean surface but the surface bearing the fingermark was subjected to subsequent methamphetamine contamination could not be differentiated based on the Simon's test.

Table 1: Chi-square test results on the prior- and post-contamination conditions on Simon's colour test.

Sequence of contamination	Simon's test result		*p*-value*
	Positive	Negative	
Post-deposition contaminated fingermark	99 (50.0%)	99 (50.0%)	0.688
Prior-deposition contaminated fingermark	94 (47.5%)	104 (52.5%)	

*Chi-square test, significant at $p < 0.05$.

Simon's test is a good chemical test towards the detection for the presence of methamphetamine. However, its sensitivity on detecting the drug substance at different concentration levels in this setting was not clear; hence, an experiment investigating the effects of concentration levels of methamphetamine for Simon's testing was carried out on both contaminated fingermark samples without and with the application of fingerprint powders. For the former, a chi-square test was carried out and found that there was a significant association between the concentrations of methamphetamine on a surface and the Simon's test result (Table 2), $\chi 2(1, N = 198) = 8.256$, $p = 0.016$.

Table 2: Chi-square test results on the concentrations of methamphetamine on Simon's colour test.

Concentration	Simon's test result		*p*-value*
	Positive	Negative	
0.25	29 (43.9%)	37 (56.1%)	0.016
0.50	42 (63.6%)	24 (36.4%)	
1.00	44 (66.7%)	22 (33.3%)	

*Chi-square test, significant at $p < 0.05$.

To simulate a clandestine methamphetamine laboratory situation, 0.25 mg/mL methamphetamine served as the concentration of the illicit substance investigated in the study. It was found that as the concentration reduced, the chance for the detection of methamphetamine had also decreased. Only 43.9% of the experiments tested with such concentration produced positive results through Simon's test. In this case, the wiping procedure might have contributed to reduced percentage of positive detection where the trace amount of methamphetamine was hardly to be removed from surfaces, in addition to the nature of interaction between the surfaces and the drug substance [13].

Upon the application of fingerprint powders onto the surfaces containing methamphetamine, the positive detection was still positive for the presence of the illicit drug. However, whenever the concentration of methamphetamine appeared at a lower concentration, the chance for positive detection was further reduced. A Chi-square statistical test was conducted to determine the association of the application of fingerprint powder and the positive Simon's test detection (Table 3). Simon's test results of the detection of methamphetamine from surfaces sprayed with 1.0 mg/mL drug solution followed by application of fingerprint powder were compared with those without application of the powders.

Table 3: Chi-square test results on the application of fingermark powders on the Simon's colour test.

Application of fingerprint powders	Simon's test result		*p*-value*
	Positive	Negative	
No	47 (71.2%)	19 (28.8%)	0.709
Yes	44 (66.7%)	22 (33.3%)	

*Chi-square test, significant at $p < 0.05$.

The Pearson chi-square statistic was reported, $\chi 2(1, N = 132) = 0.140$, $p = 0.709$. At a significant level of 0.05, no association was found between the application of fingerprint powder and the positive detection of methamphetamine by Simon's test. In other words, whenever the fingerprint was applied onto a surface for the recovery of fingermarks, the existence of the exogenous substance could still be detected if the target substance was successfully transferred onto the filter paper prior to the testing by the Simon's reagents.

Chromatography analyses

GC technique was conducted for qualitative analysis in this study. The GC method was utilised to examine the methamphetamine-contaminated fingermarks recovered from all the 11 surface materials. For standardisation, methamphetamine prepared at a concentration level of 0.25 mg/mL was tested as it could still be detected by the Simon's colour test depending on the surfaces and conditions of the samples. The identity of methamphetamine was determined through the comparison of retention time. Upon analysis, the methamphetamine peak appeared at 8.00 min

(Figure 2). With less sensitive Simon's test, a concentration level of 0.25 mg/mL might provide negative result with no observable colour change; however, a more sensitive GC method had allowed the detection of methamphetamine at the defined concentration level.

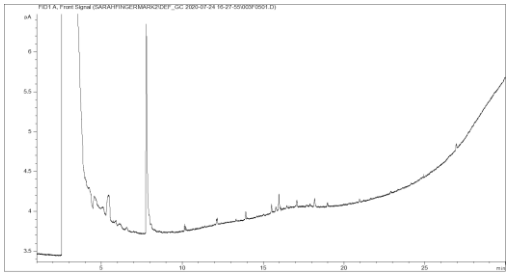

Figure 2: Chromatogram of methamphetamine hydrochloride.

Fingermark residues were analysed using this chromatographic technique. At the retention time of 24 and 27 min, prominent fingermark peaks could be detected (Figure 3). Although no attempt was made on the identity of each component of fingermark in the GC chromatograms, the main compositions of fingermarks are mainly composed of lipids and amino acids. The chromatogram profiles of fingermark residues varied depending on the lipid compositions of the residues as the regions of the fingermark residues were mainly containing alkenes (C25-C32). In the study conducted by Girod and Weyermann [5], squalene was detected at 27.00 min, similar to this current study.

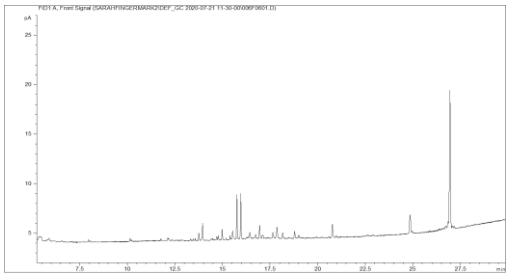

Figure 3: Chromatogram of fingermark residues.

Figure 4 shows the chromatograms of methamphetamine-contaminated fingermarks recovered from a glass surface by swabbing procedure. The methamphetamine peak appeared at 8.00 min, similar to the retention time reported in running the methamphetamine standard alone. This peak was found not to overlap with the peaks originated from the fingermark residues. The result showed that the recovery steps have simultaneously collected both the drug of interest from the surface as well as the fingermark residues.

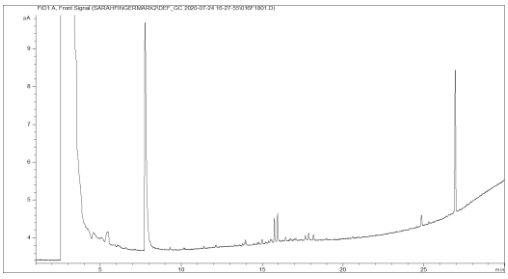

Figure 4: Chromatogram of methamphetamine-contaminated fingermark swabbed with cotton swab.

Application of fingerprint powder on surfaces with suspected fingermark is a common practice by the forensic investigators. With that, a methamphetamine-contaminated surface could be further contaminated with the fingerprint powder. If a methamphetamine-contaminated fingermark was submitted for testing of exogenous substance, the contaminant originated from the fingerprint powder is unclear if it interfered with the detection of methamphetamine.

Black fingerprint powder is mainly consisted of iron, carbon black lycopodium based on the product specification [2]. Black fingerprint powders applied on clean glass surfaces without fingermark and methamphetamine were processed through the preparation procedure and subjected to GC analysis. Prior to analysis, the samples were filtered to filter out particles larger than the size of 0.45 µm. Even through filtrations, the presence of contaminations such as the alkanes, phthalates and benzophenone might still be found [6]. This, however, could lead to contamination of the GC column if additional steps of filtrations have not been applied [6], and therefore, care must be exercised when analysing filtrate bearing fingerprint powders.

GC analysis of the recovered methamphetamine-contaminated fingermarks from glass surface which had been applied with fingerprint powders showed that the black fingerprint powder had contributed to the existence of peaks originated from the powder in the chromogram, nonetheless, the powder did not interfere with the detection of the methamphetamine (Figure 5). Methamphetamine and fingermarks could still be detected regardless of the sample preparation procedures, suggesting the good

recoverability of these substrates from the surface under the experimental strategies used [7].

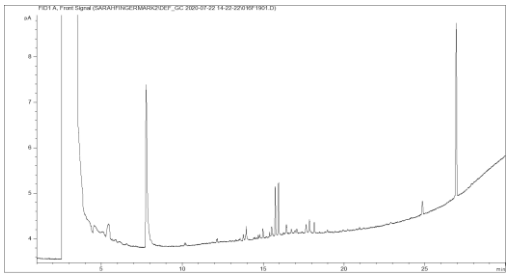

Figure 5: Chromatogram of methamphetamine hydrochloride contaminated fingermark developed with black fingerprint powder and swabbed with cotton swab.

In a previous study, another type of fingerprint powder i.e., black magnetic powder was also utilised in developing fingermarks on drug-contaminated glassine stamp bags and was found to be superior to ninhydrin and 1,8-diazafluoren-9-one (DFO) [14]. Cyanoacrylate fuming, another common fingermark development technique on non-porous surfaces; however, was found to have reduced the possible detection of the explosive contaminants as the fuming trapped the contaminants within the cyanoacrylate polymers [15]. This could be assumed to give similar effects to drug contaminants as polymerisation occurred during cyanoacrylate fuming process. A study conducted by Barnes et al. [14] on developing fingermarks on heroin packaging found that the utilisation of fingermarks development techniques did not affect the analysis of the drug. In fact, drug identification could still be detected using spectrometry analysis after the application of fingerprint powder [7]. Supporting the findings by Koenig et al. [6], the fingerprint powder did not affect the detection of squalene residue of the fingermark. The squalene residue could still be observed even after the contamination of fingerprint powder. This showed that the fingerprint powder and fingermark residues (specifically squalene) could be detected at different retention times.

For analysis on the lifted sites, samples swabbed on the tape lifted sites of the methamphetamine-contaminated fingermarks found that the methamphetamine was successfully detected from all surfaces, even from the quartz countertop and white PVC laminated particle board. Such findings had shown the persistence of the drug on the surfaces. A published work by Jang et al. demonstrated the persistency of drug was found to be up to 48 hours on fingertips. The study demonstrated the ability to detect exogenous substances even after tape lifting or hand washing [16]. Future work could be conducted to investigate whether other exogenous substances or even DNA could be further analysed. It could be beneficial, especially if the fingermarks failed to be developed by fingerprint powder.

Conclusion

Simon's colour test is quick and could be conducted in-situ. However, its visualisation of the colour changes could be influenced by the presence of fingerprint powders. To minimise such problem, further investigation using chromatographic analyses could be explored, if necessary, during forensic investigation of a drug related case. Even at the lowest concentration of methamphetamine hydrochloride tested at 0.25 mg/mL, the drug substance could still be detected on the tested surfaces. It is hoped that this study would be beneficial to the law enforcement agencies, especially those involved in forensic investigation of drug-related activities in suggesting the most appropriate method for the development of both uncontaminated and contaminated fingermarks, as well as the possibility to detect the presence of exogenous substance from fingerprint powder-dusted surfaces.

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