Latent Fingerprint Detection by Various Formulae of SPR on Wet Non-Porous Surfaces

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ABSTRACT: Latent fingerprints are valuable pieces of evidence that are often found when a crime has been committed. This type of evidence is hardly visible so the application of techniques to make it more visible is necessary. Furthermore, latent fingerprints can be found in wet environments, and these surfaces can be wet by water from several sources that differ in their pH and particulate matter, such as rain, roadside, canal or sea water. Small Particle Reagent (SPR) is an advantageous technique for latent fingerprint detection on wet surfaces. In this study, surface samples were moistened by soaking in various solutions to represent water from different sources. Eleven formulae of SPR, three (SPR I, II, III) from the published references and eight new modified ones, were investigated to evaluate the optimal formula for latent fingerprint detection on wet non-porous surfaces. The best quality of developed latent print was obtained from the SPR containing molybdenum disulfide in tergitol NP-7 and choline chloride. However, on a dark surface, the best quality was obtained from a suspension containing zinc carbonate as small particles. The soaking solutions used in this study did not affect the effectiveness of SPR. Nevertheless, the salt solution affected the fingerprint impression.

Key words: Latent fingerprint, SPR, small particle reagent, wet-non porous surfaces

INTRODUCTION

At a crime scene, most of the information (evidence) can be used to provide information for evaluating what did or could not have happened and involving whom.

Fingerprints are a type of evidence that are often found at crime. Unique characteristics, and the unchanged friction ridge of each individual's skin over their life renders the ability to use fingerprints to identify the individual concerned.

There are two general types of fingerprint evidence that can be found at the crime scene or on objects related to it that is the visible and the latent fingerprint, but they are not mutually exclusive. This study is mainly concerned with latent prints.

Latent fingerprints are not often left in heterogeneous or protected environments, so there is the need to be able to detect their presence on different surfaces and after they have undergone the action of atmospheric agents or have been found, for example, on objects soaking in water of different types of impurities and sediments.

Small particle reagent (SPR) is a physical development technique for fingerprint detection on wet or moist surfaces.(1) There are many formulae of SPR available nowadays but the optimal formula has never been reported. In this study, the best SPR-formula for detecting latent fingerprints on wet non-porous surfaces was demonstrated.

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In fact, there are many conditions of water that can contact with the fingerprint containing material surfaces, such as water from rain, roadside, effluent, canal or sea. The water from each source is quite different in its pH, salt types and levels and suspended particulate matter. However, the effect of the pH or salt concentration of the soaking solution upon the ability of each SPR to detect latent fingerprints has never been investigated. In this study, various types of surface samples soaked in each different solution (tap water, weak acid, weak base, and various concentrations of sodium chloride), which represents water from some of the different available sources, was used to evaluate the effect on latent fingerprint detection by SPR.

MATERIALS AND METHODS

Eleven formulae of SPR solutions, three (SPR I, II, III) from the references[2,3] and eight new modified ones, were prepared. Each formula was different in its salt and particles used, such as MoS_2, Fe_3O_4, TiO_2, ZnO and $ZnCO_3$, so as to create different contrasts. In addition, the proportion of particle and detergent was also varied in order to evaluate the best results. The fingerprints were impressed on each set of the non-porous surface samples (glass, metal plate, plastic and ceramic) before or after soaking in various soaking solutions. Soaking solutions evaluated were: acetic acid pH 5.5, NaOH pH 8.0, NaCl solutions at 10, 30, 50 and 70% (w/v), and tap water, and were used for 30 min. All surface samples with fingerprints were sprayed with each formula of SPR in order to compare its effectiveness, and left until the fingerprint developed (2- min). The fingerprints were washed gently with distilled water, left to dry and photographed with a digital camera. Then, they were lifted by a tape lift, analyzed and compared.

RESULTS

When dark particles in the SPR were used, the best quality of developed latent print on the wet surface was obtained from SPR II for every type of soaking solution. SPR II contains molybdenum disulfide, tergitol NP-7 and choline chloride, with a proportion of particles and detergent at 13.1. The fingerprint image was nearly complete (moderate), and had a ridge count of 12.98 (Tables 1 and 2).

Next the quality of developed latent print obtained from SPR III (10.25) was quite similar to that of SPR II (12.98). Nevertheless, SPR III is suitable for latent print detection on glass surfaces; providing a ridge count of 14.85 (Table 1).

Poor results were obtained from SPR XI, where only a poor image with a low ridge count was obtained 1.21 (Table 1). SPR I and VII could not be used to develop latent fingerprints on any type of the tested surfaces.

With respect to the use of white particles, no moderate or better quality images were obtained, only poor partial images. Within this the best quality was obtained from SPR VI with a ratio of zinc carbonate and tergitol NP-7 of 12.5 (Table 2). Moreover, SPR VI was quite effective at developing latent fingerprints on metal surfaces (Table 1). Poor results were obtained from SPR IV, V, VIII, IX, X and XI, with average ridge counts on every type of surfaces of between 0.35 and 1.75 (Table1).

The soaking solvents such as tap water, acid, base and salt solutions did not affect the effectiveness of SPR suspension; but a high salt [50% and 70% (w/v)] concentration affected the fingerprint impression.

Latent prints on glass surfaces prior to soaking in various solutions and after development with SPR II are shown in Figure 1.

DISCUSSION

From this study, the best quality of developed latent prints on wet non-porous surfaces in every type of soaking solution was obtained from SPR II, which contains molybdenum disulfide particles in 0.8% (v/v) tergitol NP-7 (detergent), and 1.05% (w/v) choline chloride, and the proportion of particles to detergent of 13.1. The average number of ridge counts obtained was 12.98 which is sufficient to allow identification of a given individual from the fingerprint in a forensic investigation, and the fingerprint image was nearly complete (moderate, ++). When the composition of SPR II, the best in this study, and SPR III, the best formula in a previous study[3] were compared, it was found that the type of particle (MoS_2) and detergent (tergitol NP-7) were similar, as were the percentages of particles, detergent and the proportion of particle to detergent. The main difference between these two formulae then was the addition of 0.4% (w/v) choline chloride to SPR II. It is plausable then that the higher number of ridge counts in the developed latent print obtained from SPR II (12.98) compared to those detected with SPR III (10.25) is due to the presence of choline chloride.

The principle of SPR is based on the reaction between the fatty components in the traces and the hydrophobic tails of each specific reagent. These tails are linked to the hydrophilic heads which react with metal salt to give a precipitate.[1] Choline chloride is one such water soluble organic compound with a hydrophilic cation with the chloride anion, and a hydrophobic tail. Thus, the presence of choline chloride in SPR II may help to enhance the effectiveness of this formula by giving more attachment sites between the metal salt and the hydrophilic head based upon its polar property.

The lowest number of ridge counts on the developed latent prints was obtained using the SPR I (0) and SPR VII (0) developers, and they could not be used to detect latent fingerprints on any type of the tested surfaces. SPR I contained 10% (w/v) molybdenum disulfide in 0.8% (v/v) tergitol NP-7, with a particle and detergent proportion of 10 and 0.8%, respectively, and a ratio of particle to detergent of 12.5. SPR VII contained ferric oxide suspended in tergitol NP-7 which could not be dissolved completely and precipitated and so fogged the background. Indeed, it has been reported before that too many particles will fog the background and too much detergent or detergent itself will degrade the latent print.(4) Thus, the percentages of Fe_3O_4 particle (10), detergent (0.8) and particle/detergent (12.5 g/ml) of SPR VII were similar to those in SPR I.

However, the quality of the SPR formula was determined by the suitable particle and detergent components and their appropriate concentrations in the suspension. For example, molybdenum disulfide and tergitol NP-7 were used as the particle and the detergent in SPR I, II and III. SPR II and SPR III were effective solutions, with proportions of particle to detergent of 13.1 and 13, respectively, whereas that of SPR I was 12.5. The important factors that affect the quality of SPR are the type of particle, detergent and their proportion.

It had been reported that adjusting the pH of the suspension to pH 3 - 4 increases the effectiveness of the SPR.(4) The pH of SPR II solution was 3.1. The lowest quality of developed latent prints was obtained from SPR I and SPR VII which had a pH of 2.45 and 7.42, respectively. Thus, a suitable pH of the SPR reagent may be between 3 and 4, but this awaits confirmation. It has also been shown that in acid conditions, the enhancement of fingermarks with ninhydrin or cyanoacrylate was inhibited but SPR could be used instead.(5) Nevertheless, the present study demonstrated that under more acidic conditions the enhancement of latent prints with SPR was inhibited, as shown with SPR I (pH 2.45). Thus, pH is an additive factor that affects the SPR solutions.

For the detection of latent fingerprints on smooth surfaces, ferric oxide was found to be superior to molybdenum disulfide with regard to sensitivity, clarity and contrast,(6) which is different to results of this study. This apparent discrepancy could be due to the particle size and / or to the oxide concentration in the solution.

Concerning the white particles, the highest quality obtained was from using SPR VI, which has a ratio of zinc carbonate to tergitol NP-7 of 12.5. The proportions of particle and detergent were 10 and 0.8%, respectively. However, this solution was quite effective only on the metal plate surface and the quality of the ridge counts in the developed latent print (on every type of surfaces) were not good (6.6) (Table 1). Thus an improvement of this formula is necessary. In contrast to the results presented here, it has been shown that titanium dioxide, zinc oxide and zinc carbonate can be used as effective particles in a SPR suspension,(7) in contrast to the results of this study. The differences in the quality of the ridge counts might due to the particle size and oxide concentration. To improve upon the SPR VI formula, a reduction in the size of zinc carbonate particles, or a suitable proportion of particle and detergent as well as ratio of the two, or the use of a 10% (v/v) Aerosol OT solution(8) or Kodak Photo Flo-200(9) as the detergent should be considered. Since Photo Flo helps the Small Particle Reagent to mix into solution or suspension.

Comparison of the contrast prints on surfaces which had been wet with tap water, acid or base solutions before or after fingerprint impression, revealed no significant differences in the effectiveness of the SPR solutions used. However, the difference was seen when soaked in different concentrations of the salt solution, where the resolution of the fingerprint impression varied directly with the increasing salt concentration, decreasing with higher salt levels. The differences were distinctly demonstrated with the SPR II, III and X developers. In general, fingerprint impression was adversely affected by high salt concentration, where if the surfaces had been soaked in a high salt solution before fingerprint impression, the quality of the impressed prints as well as the number of the ridge counts were decreased.

Finally, the quality of the latent fingerprint developed by each formula of SPR was related to the different amount of dermal traces left by each impression, as a consequence of their different emotional state and physiology.(1)

CONCLUSIONS

The quality of SPR formula was determined by the type and proportion of particles and detergent, and their ratio as well as the pH.

With respect to the use of dark particles, the best quality of developed latent print on wet non-porous surfaces was obtained from SPR II, which contained molybdenum disulfide, tergitol NP-7 and choline chloride at a pH of 3.1. Poor results were obtained from all SPR compositions containing white particles.

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Table 1. The average number of ridge counts on each type of surface obtained from each formula of SPR.

Surface samples	Average number of ridge counts from each SPR formula								
	SPR II	SPR III	SPR IV	SPR V	SPR VI	SPR VIII	SPR IX	SPR X	SPR XI
Glass	18.85±1.22	14.85±1.64	0.50±0.83	1.79±1.14	8.50±1.52	0.25±1.81	0.57±1.34	1.28±1.14	1.71±2.07
Metal	12.55±1.30	14.75±1.58	0.30±0.54	0.50±1.58	8.00±1.14	4.50±0.89	2.84±2.70	4.50±1.30	1.57±2.38
Plastic	11.88±1.52	5.80±0.83	0.25±0.89	0.45±1.14	7.50±1.64	0.07±1.48	0.40±1.52	0.71±0.54	1.20±2.88
Ceramic	8.65±1.64	5.60±1.14	0.34±0.83	1.64±1.92	2.64±1.58	0.00	2.44±1.92	0.50±0.89	0.36±0.83
The average number of ridge counts on every type of surface	12.98±4.26	10.25±5.25	0.35±0.11	1.10±0.82	6.60±2.71	1.21±2.17	1.56±1.26	1.75±1.86	1.21±0.61

Table 2. The average number of ridge counts on every type of surface obtained from each formula of SPR.

SPR formulae	% (w/v) Particles	% (v/v) Tergitol NP-7 (detergent)	% (w/v) Choline chloride	Particle/ detergent ratio	pH	Finger print images	Average number of ridge count on every type of surface
	Dark particles						
SPR I	MoS_2 10	0.8	0	12.5	2.45	-	0
SPR II	MoS_2 1.05	0.08	0.4	13.1	3.1	++	12.98±4.26
SPR III	MoS_2 1.43	0.11	0	13	3.1	++	10.25±5.25
SPR VII	Fe_3O_4 10	0.8	0	12.5	7.42	-	0
SPR XI	Fe_3O_4 1.05	0.08	0.4	13.1	8.2	+	1.21±0.61
	White particles						
SPR IV	TiO_2 10	0.8	0	12.5	7.12	+	0.35±0.11
SPR V	ZnO 10	0.8	0	12.5	6.42	+	1.10±0.82
SPR VI	$ZnCO_3$ 10	0.8	0	12.5	8.7	+	6.60±2.71
SPR VIII	TiO_2 1.05	0.08	0.4	13.1	7.4	+	1.21±2.17
SPR IX	ZnO 1.05	0.08	0.4	13.1	7.4	+	1.56±1.26
SPR X	$ZnCO_3$ 1.05	0.08	0.4	13.1	8.4	+	1.75±1.86

Fingerprint Images

- = The latent print could not be developed.

+ = **Partial (poor)**
(The latent print was unclear and did not contrast. The background was dirty).

++ = **Nearly complete (moderate)**
(The latent print was moderately clear and contrast, with clean background).

+++ = **Complete (good)** (The latent print was clear and clean).

++++ = **Distinctly complete (very good)**
(The latent print was distinctly clear and clean).

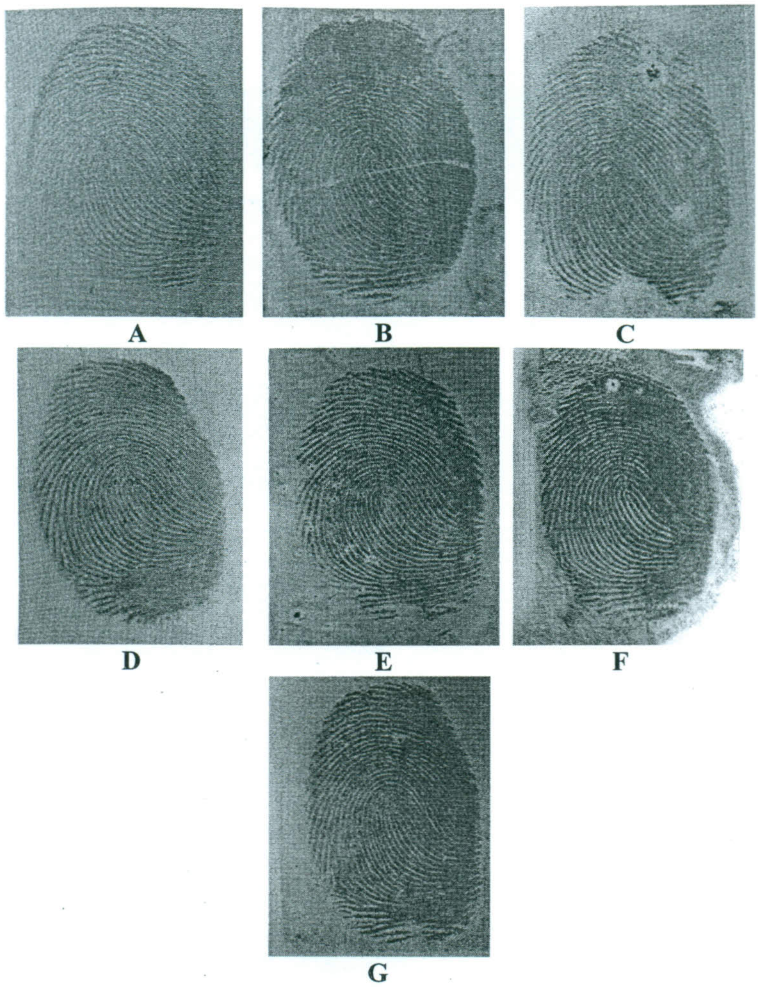

Figure 1. Latent prints on glass surfaces after development with SPR II. The latent fingerprints were soaked in various solutions:

A. Tap water
B. Acetic acid solution, pH 5.5
C. NaOH solution, pH 8.0
D. 10% (w/v) NaCl
E. 30% (w/v) NaCl
F. 50% (w/v) NaCl
G. 70% (w/v) NaCl

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