



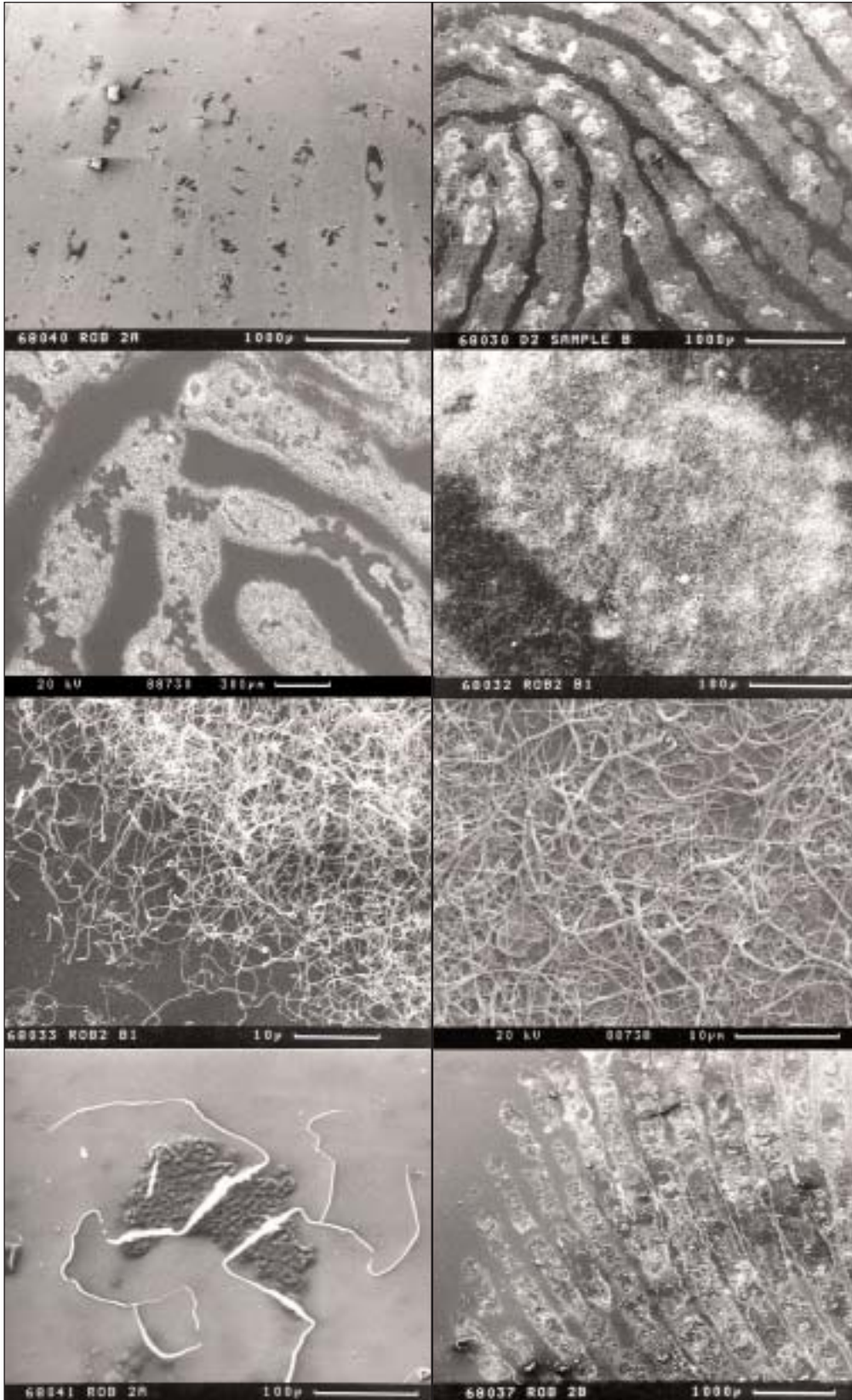
Superglue Treatment of Crime Scenes

A Trial of the Effectiveness of the Mason Vactron SUPERfume Process

**POLICE
SCIENTIFIC
DEVELOPMENT
BRANCH**

Helen Bandey
Terry Kent

Publication No. 30/03



**CRIME REDUCTION
AND COMMUNITY
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HELEN BANDEY, TERRY KENT

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COVER PHOTOGRAPH

A selection of Scanning Electron Microscope (SEM) images of fingerprints treated with the superglue process

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Management Summary

An important aspect of the PSDB's support of crime investigation is advising on the most operationally effective and safe protocols for the development of fingerprints on evidence at crime scenes.

This report presents the results of a trial of SUPERfume, a commercial system for fingerprint development treatment using the evaporation of superglue (ethyl-cyanoacrylate). It is advertised for treatment of large volumes, for the treatment of whole rooms and their contents at crime scenes, or vehicles enclosed in a suitable tent.

The principle objectives of this trial were to establish the contribution this system might make to crime scene investigation and how its use compares with other possible treatment protocols in effectiveness.

A comparative evaluation of superglue at scenes using SUPERfume, superglue used under controlled laboratory conditions and fingerprint powders is reported. Approximately 6000 fingerprints were deposited on a variety of surfaces using different donors, ages of fingerprints and amounts of fingerprint residue. We believe this to be the most extensive study reported comparing the effectiveness and practical application of this process at scenes of crime.

The results of the trial showed that fingerprint powders were at least as effective as SUPERfume on all but textured surfaces and superglue treatment of all surfaces in a controlled environment in a laboratory chamber was more effective than treatment at the scene.

From a Health and Safety perspective, there is evidence that levels of cyanoacrylate will drop relatively quickly to acceptable levels after the treatment cycle but precautions must be taken to protect operational staff and the public for some time afterwards. Further studies to ensure that there is no outgassing from absorbent materials are advisable.

The equipment could make a useful contribution to the development of fingerprints at scenes of crime, provided that all suitable surfaces are powdered first and that all portable items are removed to a laboratory for treatment.

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1 INTRODUCTION

Since the late 1970s PSDB has had a comprehensive programme developing and testing methods for the operational treatment of articles for fingerprints. A Fingerprint Development and Imaging User Group, which reports to ACPO Crime, has guided this programme of work in recent years.

PSDB endeavours to provide the best possible advice on treatment sequences for the many types of surface on which fingerprints may be developed. This advice is presented via the Manual of Fingerprint Development Techniques (MOFDT)¹ and Fingerprint Development Handbook². These are available free of charge to the UK Police Service and are widely purchased by law enforcement agencies around the world.

This report summarises a trial designed to evaluate SUPERfume - a commercial product produced by Mason Vactron (a subsidiary of Foster and Freeman). SUPERfume has been available for purchase since early 2002. The system is designed to permit the superglue (chemically ethyl-cyanoacrylate, sometimes referred to as CNA) fuming process to be carried out in an environment other than a specially designed chamber in a fingerprint laboratory. It is suggested that this equipment might be deployed to treat whole rooms and their contents at crime scenes, or vehicles enclosed in tents at the scene of crime or elsewhere. The principle objective of the trial was to establish the effectiveness of the technique compared with other possible treatment protocols.

1.1 Background

Exposure to superglue vapour was reported as a possible method for the development of latent fingerprints in the late 1970s³. It was reported apparently independently in Japan, North America and a private communication with the UK Home Office from Laurie Wood from Northampton Police in the UK (published at a later date⁴).

Initially little was known about the reaction mechanism, nor the optimum treatment conditions, and fingerprint development was often slow and inconsistent, sometimes taking 24 hours to produce a reaction. Various police forces around the world used, and some still use the technique in a relatively uncontrolled way by treating exhibits in containers such as fish tanks with various proprietary cyanoacrylate adhesives^{5,6,7}. Some experimented with heating the glue to speed up the process^{8,9}. Superglue fuming, using various systems has also been used for the development of fingerprints in cars^{10,11} and at scenes^{12,13} for many years.

In the early 1980s PSDB carried out a series of exploratory experiments and found that the most important variable was the relative humidity (RH). We issued recommendations in 1986¹⁴ that for optimum development on most surfaces the relative humidity should be 80% ± 2%. We developed the first controlled humidity rapid treatment system, the 'Sandridge' superglue cabinet¹⁵, marketed from 1985. This had a capacity of approximately half a cubic metre and controlled the humidity by injection of vapour from an ultrasonic humidifier. The humidity was monitored, during the typical 15 to 30-minute treatment time, by wet and dry thermocouples linked to an electronic control system. It was manufactured by the original Mason Vactron Company in Acton, London and was installed in most fingerprint laboratories in the UK and in many across Europe - many of these are still in use today. This cabinet produced much more rapid and consistent results than the ad hoc arrangements most had been using and provided police forces with an effective and reliable process for the development of fingerprints on many non-porous surfaces. More recently, PSDB was involved in, and funded in collaboration with the US, the initial development of a larger cabinet with capacity of approximately 2 cubic metres, the prototype was

purchased, and is currently still used by Thames Valley Police. The design was substantially modified after the original Mason Vactron Company was purchased by Foster and Freeman and is now marketed as the MVC5000.

1.2 Enhancement with Fluorescent Dyes

The white deposit of a superglue-developed fingerprint can be difficult to see and photograph, especially on light coloured surfaces. A number of fluorescent dyes can be used to dye the deposit and when viewed by fluorescence examination may improve the contrast. Rhodamine 6G was one of the first dyes to be used for this and has been widely used in conjunction with argon-ion lasers and other light sources; there are however some health concerns over the use of rhodamine dyes. PSDB introduced the use of ethanol-based Basic Yellow 40 (BY40) in 1986 and has found it to be one of the most effective and low toxicity dyes for this purpose. Its absorption in the violet-blue part of the spectrum and emission in the green-yellow are particularly convenient. It has been shown to enhance the superglue-developed fingerprints to the extent that up to twice as many identifiable fingerprints are detected on some surfaces¹⁶ and is therefore an important step in the effective application of the superglue process. A less effective water-based version was introduced at a later date for use on surfaces not compatible with ethanol such as varnish and some printing inks or in areas with poor ventilation.

Figure 1 shows an example of a white plastic article treated with superglue followed by BY40. It should be noted that although oblique lighting can be used very effectively to produce a good quality image, it is much quicker and easier to locate and visualise a fingerprint using fluorescence examination.

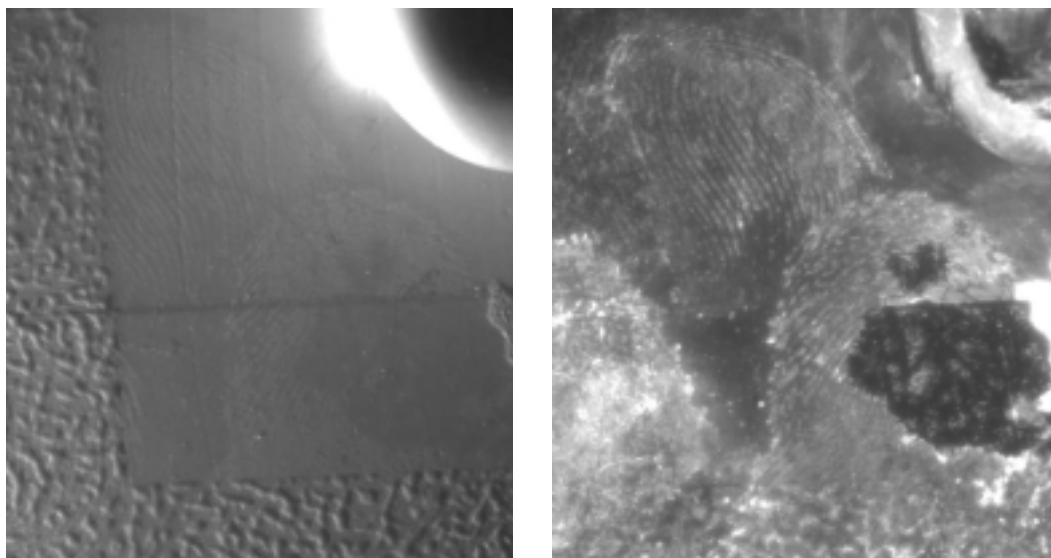


Figure 1: Image of a white plastic article treated with superglue and BY40 viewed with (a) oblique lighting, and (b) Q2000 light source with excitation filter 400-469nm and viewing filter 476nm

1.3 Growth Mechanism

The precise mechanism of the growth of poly-ethyl-cyanoacrylate on fingerprint residue is unclear. Electron microscopy studies by PSDB showed the growth of long fibrous deposits when the humidity was elevated (see Figure 2). Cyanoacrylate polymerisation is base initiated and even weak bases, such as water, will initiate polymer growth. We believe that elevating the RH to around 80% causes sodium chloride (NaCl) crystals in the latent fingerprint to take up water. A saturated solution of NaCl with excess solid in a closed volume will create an RH above the solution of

75% at equilibrium¹⁷. Therefore, at RH values above this, NaCl crystals will absorb water from the environment around it. Similarly, any NaCl crystals in fingerprints will absorb water from the environment when the cabinet is set to 80% RH. Figure 3 shows an optical interference micrograph of salt crystals on a fingerprint ridge that has been allowed to dry normally in the air.

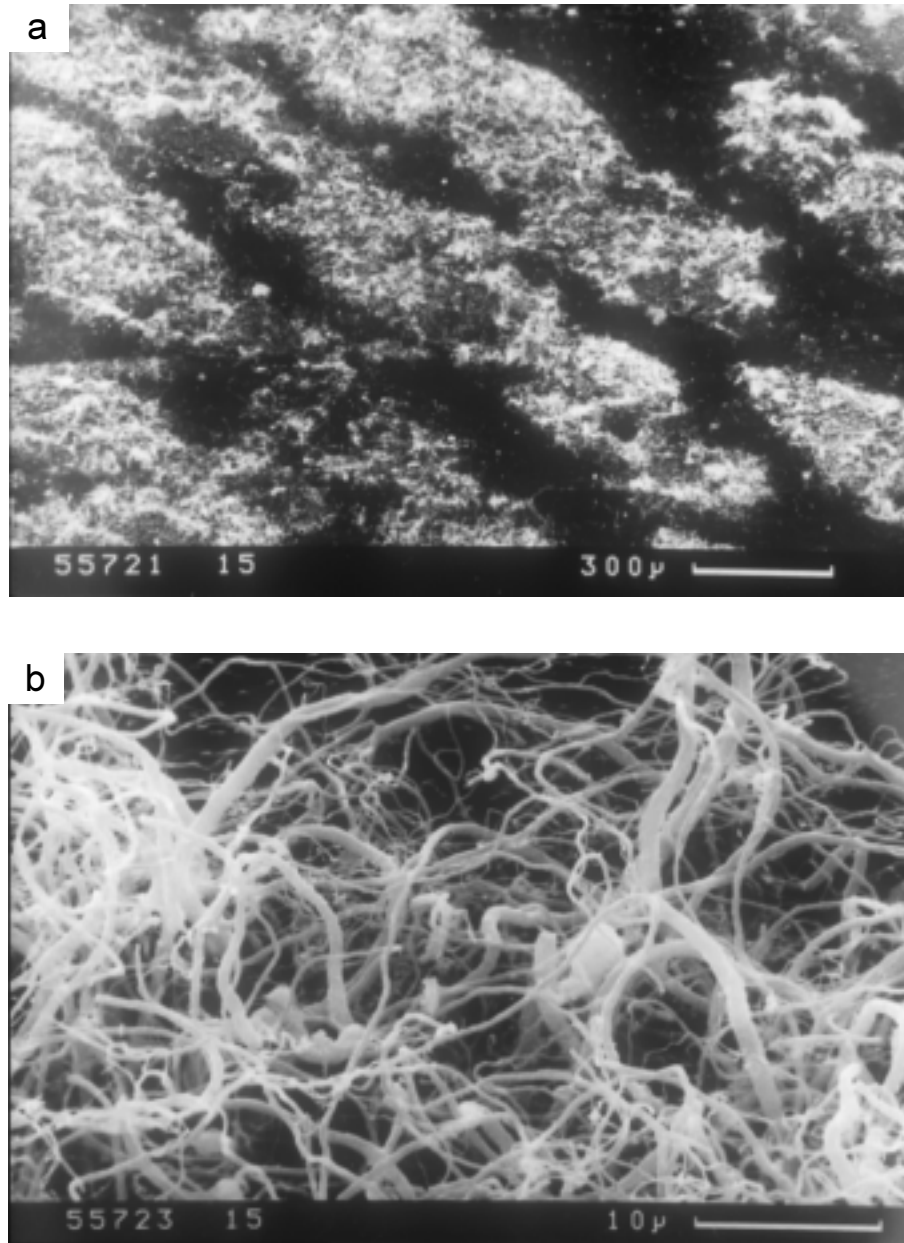


Figure 2: Scanning Electron Microscope (SEM) images of (a) superglue evaporated onto latent fingerprint ridges at 80% relative humidity, and (b) a close-up image of the fibrous growth on an individual ridge

This description explains one possible mechanism for polymer growth. There are undoubtedly other bases within fingerprint residue and some may initiate polymerisation. Most fingerprints however have an initially significant water and chloride content, this is therefore likely to be a significant initiation mechanism. Humidification above 80% RH is undesirable leading to heavy deposits of superglue on some surfaces.

It is also suggested that short chains, oligomers, of cyanoacrylate may be formed due to atmospheric humidity which may take part in further polymerisation on the fingerprint or substrate.

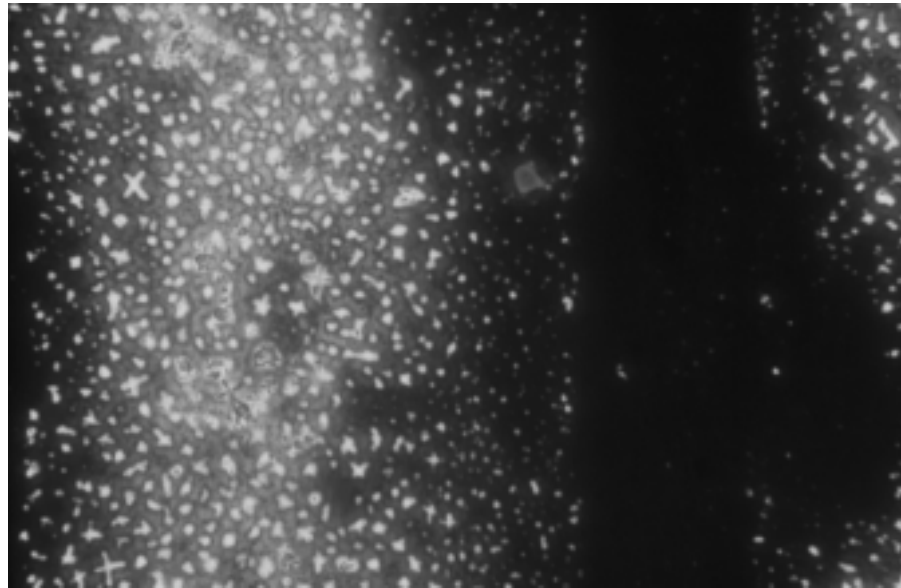


Figure 3: Optical Interference Micrograph image of a dehydrated fingerprint ridge showing the formation of sodium or potassium chloride salt crystals

The reaction of cyanoacrylates with fingerprints under low humidity, and low pressure, is also reported in the literature¹⁸, and many comparisons have been made to the high humidity technique^{19,20,21}. In general the reaction does not give rise to the fibrous white deposit, instead it produces small beads of polymer (Figure 4). It is generally less sensitive or effective in the development of latent fingerprints although some authors claim that it has the advantage of being less prone to over development.

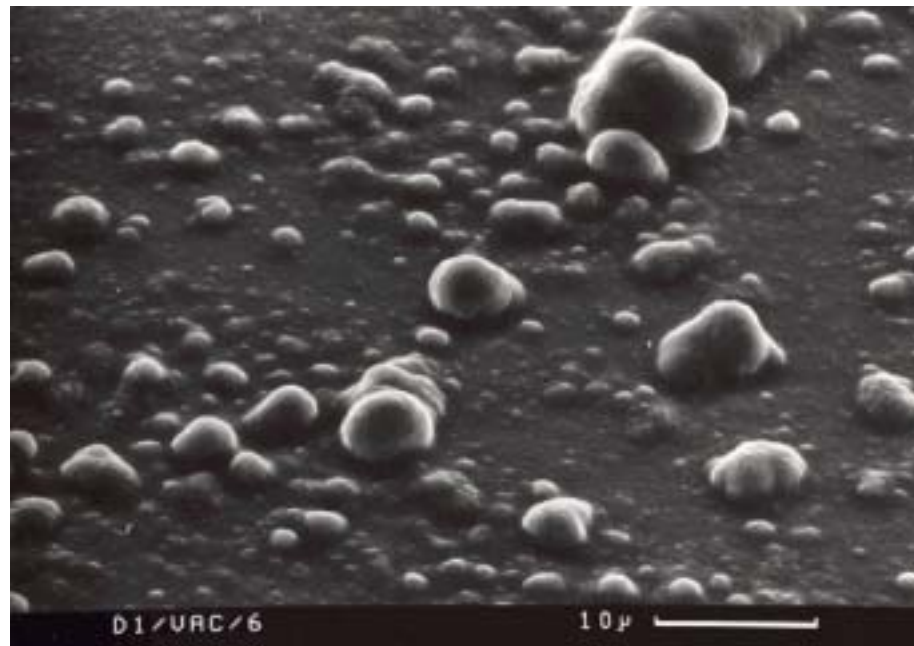


Figure 4: Scanning Electron Microscope (SEM) image of a fingerprint ridge developed using the vacuum superglue method

1.4 Operational Requirement

There are four important considerations when moving any chemical treatment for fingerprint detection from the laboratory to the crime scene:

- i) Can process conditions obtained in a laboratory be created at a crime scene so that similar operational performance may be achieved?
- ii) Can procedures be implemented to ensure the safe application of the process?
- iii) Will there be environmental implications with regard to cleaning up of the scene and restoration to normal use or occupancy?
- iv) Will application at the crime scene be more cost effective than removal of items, where possible, to the laboratory?

If a method is to be used at volume crime scenes such as burglary or vehicle theft there may be specific emphasis on speed and simplicity of use.

Where methods are likely to be used at major scenes the emphasis will usually be on the ultimate performance and sensitivity of techniques.

Most crime scenes present a range of potential surfaces and hence articles for treatment:

- i) Those which are small, portable and may if necessary be taken back to a laboratory.
- ii) More bulky items which are more difficult to move and may require dismantling and special transport.
- iii) Fixed surfaces that are difficult or impossible to move.

There are many techniques that may be used to develop fingerprints on surfaces. Choice of process will depend on the nature of the surface, its previous history and the resources available. PSDB and others have carried out substantial trials to determine the most effective sequences of reagents for a range of common surfaces and made a series of recommendations based on laboratory and operational trials¹. It is against this background that the evaluation of this process is necessary to ensure that investigating officers receive the best possible advice on the choice of process.

1.5 Health and Safety

1.5.1 Ethyl-Cyanoacrylate

The Health and Safety Commission's Advisory Committee on Toxic Substances (ACTS) have given ethyl-cyanoacrylate an Occupational Exposure Standard (OES) of 0.3 ppm (1.5 mg m⁻³) for a 15 minute reference period^{22,23}. Although there have been reports of individuals working within the field of fingerprint development becoming sensitized to cyanoacrylates, currently ethyl and methyl cyanoacrylates are not listed as sensitizers.

Methods have been developed for the measurement of cyanoacrylate vapour at low levels and a service is available for the post event processing and analysis of air samples. PSDB is not aware of any current viable technique for the simple dynamic monitoring of vapour concentrations at scenes.

Precautions must be taken to ensure that the user is not exposed to superglue vapour concentrations at, or above, the OES.

1.5.2 Ethanol

Ethanol has a flash point* of 12°C¹⁷ and is classed as being highly flammable and for this reason we would not normally recommend its use at crime scenes. PSDB has tested a wide range of dye solutions but currently are only able to recommend a water-based Basic Yellow 40 solution which is generally rather less effective in terms of sensitivity and contrast than the ethanolic formulation.

1.6 Manufacturer's literature

Current promotional literature in the form of flyers, advertisements in journals and web-site information from Mason Vactron suggests that:

- i) 'SUPERfume saves time by locating fingerprint evidence at the scene-of-crime'.
- ii) 'Scene-of-crime processing avoids the need to transport bulky items back to the laboratory'.
- iii) It is 'Ideal for detecting latent fingerprints on cars and commercial vehicles'.
- iv) It is 'Capable of fuming domestic rooms, offices and garages, the kit enables latent fingerprints to be detected and recorded at the crime scene without the need for transporting bulky items back to the laboratory or dismantling fixtures and fittings, saving time and labour'.

It is against this background that PSDB has sought to establish the effectiveness of the technique in comparison with the most commonly available alternative protocols.

* The lowest temperature, as determined by standard tests, at which a liquid emits vapour in sufficient concentration to form an ignitable mixture with air near the surface of the liquid in a test vessel.

2 OBJECTIVES

In general, the superglue process has to date been recommended for use on non-porous articles that have been removed from the crime scene and taken back to the laboratory for processing in a superglue chamber. The SUPERfume system offers the opportunity to apply superglue to larger items *in situ* at scenes of crime.

The primary objective of this trial was to compare the effectiveness of the SUPERfume process to other techniques that could be used directly at the scene.

Since superglue treatment may not be the most effective process for some of the non-porous surfaces at crime scenes it should also be compared with other viable techniques. The most obvious technique is, of course, powdering, which is by far the most commonly used development process at scenes. It has been used for ~100 years and is cheap, simple to use, can be removed from many surfaces and if used correctly, presents no adverse health hazards to the householder or the user. It can also be one of the most effective processes for fingerprint detection on smooth, clean surfaces. Powdering is one of the few fingerprint development techniques that can be carried out at the scene without requiring specialist facilities, making it ideal for volume crime as well as serious crime. A comparison with powdering was therefore included in the trial on a variety of typical surfaces (See Table 1). It should be noted that for serious crimes other processes, such as initial fluorescence examination, Sudan Black etc., should be considered. This is briefly discussed in Section 5.4.

For articles and surfaces that may be transportable, it was important to compare the results that might be obtained in a laboratory. In this case the most obvious comparison was with a fully controlled superglue laboratory chamber.

It is widely accepted that enhancement of fingerprints with the use of superglue is dependent on humidity and temperature. Situations could arise where exhibits, perhaps with some effort, could be taken for laboratory examination under fully controlled conditions, rather than treating them at the scene of crime. It was therefore thought important to compare results following the use of SUPERfume on objects placed in a simulated scene of crime to a comparable set of objects treated in a controlled humidity laboratory cabinet, such as the MVC5000.

Post-treatment staining followed the accepted recommended method for use at scenes of crime or for laboratory use, as stated in the MOFDT in order to ensure a true comparison of the two protocols.

3 EXPERIMENTAL

Initial plans were for Mason Vactron to make a Foster and Freeman demonstration room available for a trial but unfortunately this became unavailable at short notice. A substantial number of fingerprints had been prepared and these were distributed around a small laboratory at PSDB's Sandridge facility. Additional fingerprints were laid on a variety of suitable surfaces in the laboratory, resulting in a total of around 6000 fingerprints. We believe this to be by far the most extensive study reported looking at the effectiveness and practical aspects of the superglue process at scenes of crime. The study includes a range of donors and ages of fingerprint using 'depletion series' to create a range of weights of latent fingerprint deposit in accordance with PSDB's well established and widely accepted method for the comparison of processes.

3.1 SUPERfume System Overview

The SUPERfume kit comprises:

2 × mixer/glue heater units (preset at 120°C)

1 × purge/filter unit (6kg activated carbon filter)

1 × steamer unit (2.3kW)

1 × control box

1 × distribution box

1 × set of mains connection cables

1 × hand held digital RH meter

1 × organic vapour respirator facemask

1 × set of 4 warning notices/quick start guides

plus various bags, superglue, spare filters etc.

3.2 Mock 'Crime-Scene' Set-up

The room that was used in this trial was a small chemistry laboratory (~40m³) located within the fingerprint department at PSDB, Sandridge (See Figure 5). The room contained a number of surfaces that could be found at many crime scenes such as windows, painted doors and walls. It also contained specialist equipment including a laboratory oven and fridge, wet benches, dye tanks, a fume cupboard and numerous cupboards and drawers. All non-removable drawers were taped up and electrical equipment was covered with plastic sheets to avoid contact with superglue vapour. The ceiling consisted of polystyrene tiles with some air handling vents and was covered in sheets of plastic so that superglue vapour did not get into the air supply system. The walls were made of plasterboard coated with magnolia matt paint. Apart from the walls, most of the surfaces in the room were non-porous. There were no soft furnishings in the room and the room had not been redecorated for several years.



Figure 5: 40m³ room used for the trial. The SUPERfume equipment is shown set-up prior to the experiment

3.3 Preparation of Surfaces

In order to get a good representation of the effectiveness of the different processes, it is important to use a variety of surfaces with different characteristics (material, texture, cleanliness, colour etc.). Non-removable surfaces located within the room were utilised - in a real situation some of these surfaces could however be removed and treated in a laboratory by cutting or dismantling. Other surfaces, typically found either at scenes of crime or on vehicles, were also placed in the room, see Table 1 for a list of surfaces.

Surfaces Planted with Fingerprint Depletion Series	
Blue Cupboard Door	Smooth Office Tray
Blue Laminate	Textured Red Ringbinder
Fume Cupboard Glass	Toughened Glass Sheets
Glass in Door	u-PVC Sheets
Magnolia Painted Door 1	Varnished Wooden Table
Magnolia Painted Door 2	White Car Bonnet
Magnolia Painted Internal Door	White Melamine
Magnolia Painted Matt Wall	White Painted Metal
Peach Bathroom Tiles	White Plastic Socket Rail
Rough Office Tray	White Tiles
Side of Fume Cupboard	

Table 1: Surfaces used in the SUPERfume trial

Surfaces fixed within the room were not cleaned prior to donors leaving their fingerprints. For these surfaces, 2 panels were marked out next to each other as shown in Figure 6a. One of the panels was powdered prior to SUPERfume, whilst the other was used for SUPERfume alone. For these surfaces, the fingerprints were aged for 1 day only.

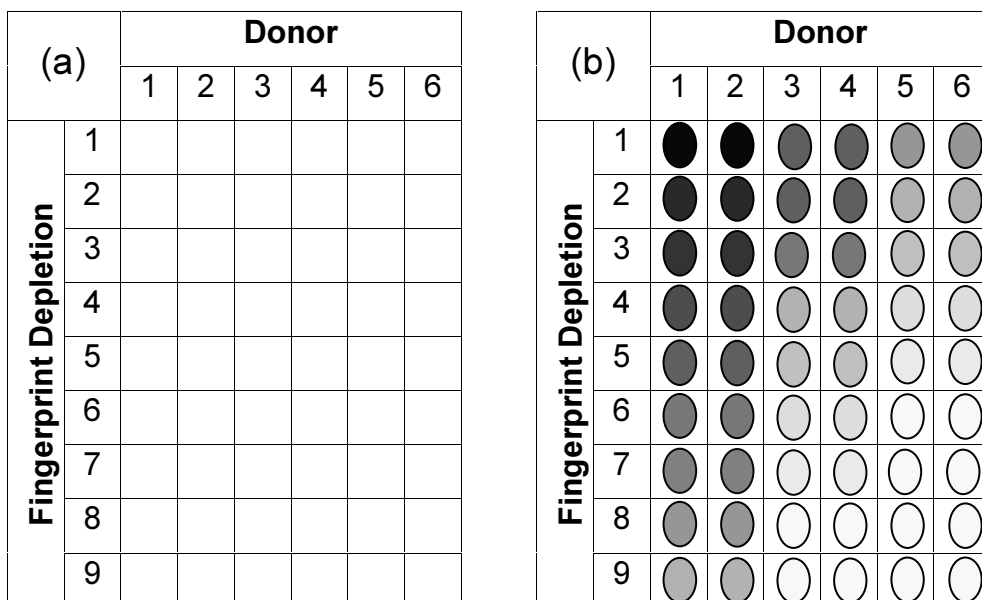


Figure 6: Schematic diagram showing a typical panel drawn on surfaces (a) prior to fingerprint donation, and (b) after fingerprint donation, where the ovals represent fingerprints with varying amounts of deposit. For all surfaces: columns 1&2 - heavy donors; columns 3&4 - medium donors; columns 5&6 - light donors.

Additional sample surfaces were cut into approximately A4 size panels. These were washed in general-purpose laboratory detergent and rinsed thoroughly with water and allowed to dry before the grid in Figure 6a was marked on it. For many of these surfaces 9 panels were used: 3 were to be used in the SUPERfume experiment; 3 to be powdered; and 3 to be superglued in the MVC5000 superglue cabinet. Of the 3 panels used for each process, one was aged for 1 day, another was aged for 1 week, and another aged for 1 month, after fingerprint donation.

3.4 Fingerprint Donation

Fingerprints consist of varying mixtures of eccrine and sebaceous sweat, as well as contaminants picked up from surfaces, toiletries, food etc. Since the amounts of the potentially hundreds of constituent chemicals vary widely from person to person and from day to day it was important to obtain fingerprints from a range of donors. This was an attempt to simulate likely real world variability at the same time as providing a mechanism for comparison. For major fingerprint development research projects carried out at PSDB normal procedures are in-house comparative trials with donated fingerprints, followed by carefully controlled operational trials of apparently successful processes, prior to making recommendations.

In this trial, fingerprints were obtained from PSDB staff members specially selected to represent a range of heavy to light donors. Donors were requested that they did not wash their hands for at least 30-minutes prior to leaving fingerprints on the sample surfaces in order to allow adequate fingerprint residue to collect on the fingers. Just prior to donating, they were asked to rub their hands together to distribute their sweat evenly over all fingers and thumbs.

For each surface 6 donors were used. The panels were divided into 6 columns - one for each donor as shown in Figure 6a. A donor would use the same finger/thumb and deposit a fingerprint depletion down a column. For example, donor 1 would place a fingerprint in column 1, row 1 and using the same finger would place fingerprints in column 1, row 2 all the way down to column 1, row 9. The same donor would then use a different finger and place a fingerprint depletion down column 1 of a similar panel

(same surface, different panel). In the case of the non-removable surfaces within the room the donor would only have 2 panels (2 depletions) to use, whilst for other surfaces the donor will have 9 panels (9 depletions) to use (as described in Section 3.3).

This process was repeated with all 6 donors until each panel had a full set of fingerprints (see Figure 6b). It should be noted that different surfaces do not necessary have the same donors, however, for a particular surface the donors across the various panels are the same[†]. In all cases, 2 heavy, 2 medium, and 2 light donors were used (as shown in Figure 6b). A4-sized panels were aged in racks, open to the air and protected from direct sunlight.

3.5 Treatment Procedures

Three treatment procedures were compared - each is described below. It was decided for the purpose of this trial that we would try to mimic as closely as possible the procedure that would be followed in a real investigation of a crime-scene in the UK.

3.5.1 Powdering

A Scene of Crime Officer was invited to PSDB to take part in the trial. The SOCO's role was to powder one panel from each of the surfaces fixed in the room and three panels for most of the removable ones (3 ages) in a way that was typical of how it would be done at a scene. PSDB staff did not seek to advise or influence the SOCO's methodology or choice of powder or brush. The principle difference from a real crime scene is that the approximate position of fingerprints was known.

The SOCO used aluminium powder with a Tetra SOC Ltd brush for all surfaces. This brush has polyester fibres and has the advantage of being washable. After developing the fingerprint with powder, J-lar or 3M lifting tape were used to lift the 1st and 8th fingerprints in the depletion series and these were subsequently stuck down onto acetate sheets. These were printed onto paper using a CAMTAC machine to produce a high contrast black and white photograph of the lift.

3.5.2 Superglue in the Laboratory: MVC5000 and Ethanolic Dye Solution

The Mason Vactron MVC5000 superglue cabinet was used according to the manufacturers instructions using 3g of superglue. This cabinet has recently been tested by PSDB and meets the current requirements for optimum performance when properly maintained. Obviously the non-removable surfaces could not be treated in the cabinet, however 3 panels of most of the removable surfaces (3 ages) were treated.

The panels were then dyed with Basic Yellow 40 in ethanol as described in the MOFDT¹ and imaged, 1st and 8th fingerprint in the depletion series only, on PSDB's Integrated Rapid Imaging System (IRIS). These images were printed using a Fuji Pictography Printer.

3.5.3 Superglue at Scenes: SUPERfume and Aqueous Dye Solution

The SUPERfume equipment was set-up and operated by Bob Dartnell a director of Mason Vactron. The equipment was set up in the room, as shown in Figure 5, with one heater at either end of the room and the purge fan and humidifier in the middle. A hand held humidity meter was placed inside the room close to the door. The panels of fingerprints were placed at various locations throughout the room. Similar panels e.g., u-PVC, 1-day, 1-week, and 1-month old prints, were placed next to each other.

Once all of the surfaces were positioned in the room and the equipment set up, a 28g pot of ethyl-cyanoacrylate was split between the two heaters. The humidifier was

[†] It was not possible in all cases to obtain the same donor for fingerprints taken 1 day, 1 week and 1 month prior to the experiment due to staff being absent on that day. When this was the case, a replacement providing fingerprints of apparently similar reaction with superglue was used

turned on and the RH within the room was measured. As soon as the humidity meter was reading 80% RH, the humidifier was switched off and the heaters were switched on. At this point, the room was evacuated and sealed with duct tape around the outside of the door.

The room was processed for 30 minutes - this was sufficient to evaporate virtually all of the glue. The system then went into a purge cycle that lasted for 1 hour. After this time, the room still smelled strongly of superglue. Bob Dartnell entered the room wearing a mask provided with the system and opened the windows and switched the fume cupboard on. This method of clearing the air was much more effective than the purge fan, and within 10 minutes there was no longer a strong smell of superglue.

Most of the surfaces treated with SUPERfume were dyed with Basic Yellow 40 in water as described in the MOFDT¹ (the ethanol formulation is highly flammable and should not be used at scenes). Surfaces that absorbed the dye solution were not treated.

In order to photograph the fixed surfaces within the room, black plastic sheets of 'Studio Vinyl' were stuck onto the outside of the windows in order to darken the room. A Quaser-2000 light source was used with the 400-469nm excitation filter and 476nm viewing filter in order to see the fluorescent marks. These marks were captured with a Minolta 7000 SLR camera using Kodak TMax 100 film. Fingerprints on removable surfaces were captured on IRIS also utilising a Quaser-2000 light source and similar filters.

3.6 Grading of Developed Fingerprints

Developed prints were graded in terms of the amount of clear ridge detail present on the CAMTAC image or photograph using the following scoring system:

0 = No development

1 = < 1/3 clear ridge detail

2 = < 2/3 clear ridge detail

3 = < full ridge detail

4 = Full ridge detail

Contrast and other artefacts of the processes used (e.g., background effects, brush damage) were accounted for in the ridge detail scoring system.

Approximately 6000 fingerprints were used during this experiment. It was neither necessary nor feasible to fully evaluate every fingerprint. It was decided that the 1st and 8th fingerprint in each depletion series would be examined in detail and graded. The other fingermarks were, of course, available should there be a need to verify anomalous results.

4 RESULTS

The variable condition of surfaces and the huge variation in latent fingerprint constituents mean that relatively large numbers of sample fingerprints and surfaces must be used for any meaningful trial. Care is necessary in the interpretation of results and the fact that a particular technique does not work effectively on a surface on one occasion does not mean that it will never work and vice versa. Extensive experience in evaluating techniques has shown the need for caution and not basing judgements on a few developed fingerprints.

The objectives of the trial were to obtain an overall indication of the likely comparative performance of the several alternative protocols.

4.1 Superglue at Scenes Compared to Superglue in the Laboratory

There was superglue development on a number of the surfaces around the test room using the SUPERfume system. Many of the test surfaces, as are common in domestic or commercial premises, were however light in colour and some superglue deposit was difficult to see and photograph. As indicated in Section 1.2, dyeing a superglue treated fingerprint with Basic Yellow 40 and exploiting its fluorescence will aid in the visualisation of such prints and reduce the chance of very weak fingerprints being missed.

Figure 7 shows the percentage of fingerprints with greater than 1/3 clear ridge detail for fingerprints developed with the three processes. An important point to draw from the data is that superglue in the laboratory cabinet is significantly more effective than superglue at scenes for most surfaces. A typical example is shown in Figure 9a and 9b.

Both superglue processes were ineffective on the two doors – primarily due to the lack of contrast of the superglue deposit on the light painted background, this could not be dyed with basic yellow 40 due to heavy take-up of the dye by the paint.

4.2 Superglue at Scenes Compared to Powders

All of the surfaces studied in this trial were both powdered and treated with the SUPERfume process. The results are presented in Figures 7 and 8 and again show the percentage of fingerprints with greater than 1/3 clear ridge detail. It is clear that there is a large variation in performance between the two techniques and also between the various surfaces.

Powder was significantly better than superglue at scenes for the following surfaces: the 3 doors, the wooden table, white tiles, white melamine and the smooth office tray (Figure 9a and 9c). For some of these surfaces SUPERfume did not produce any fingerprints that could be photographed primarily due to the lack of contrast e.g. white fingerprints on a cream background. Also, upon dyeing with water-based BY40, the dye was absorbed into the background offering no improvement to the contrast[‡]. This also occurred for the wooden table – although superglue did not appear to have been deposited on this surface. Powder was more effective on the white tiles, primarily due to the over-development of the superglued fingerprints, thus giving filled in ridges and lack of clarity as shown in Figure 10.

[‡] It was noted that the Superglue treated fingerprints could be powdered to improve contrast. This is a separate experiment looking at the effectiveness of sequential processing

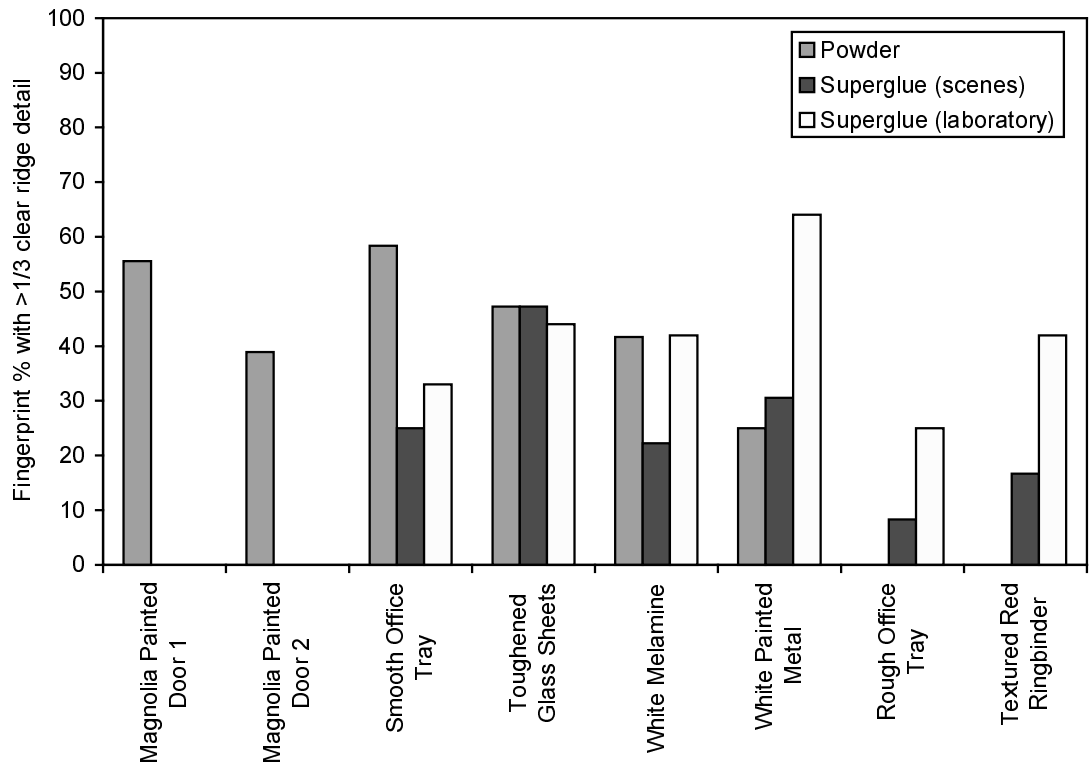


Figure 7: Percentage of fingerprints with >1/3 clear ridge detail for powders, superglue at scenes and superglue in the laboratory on a variety of surfaces

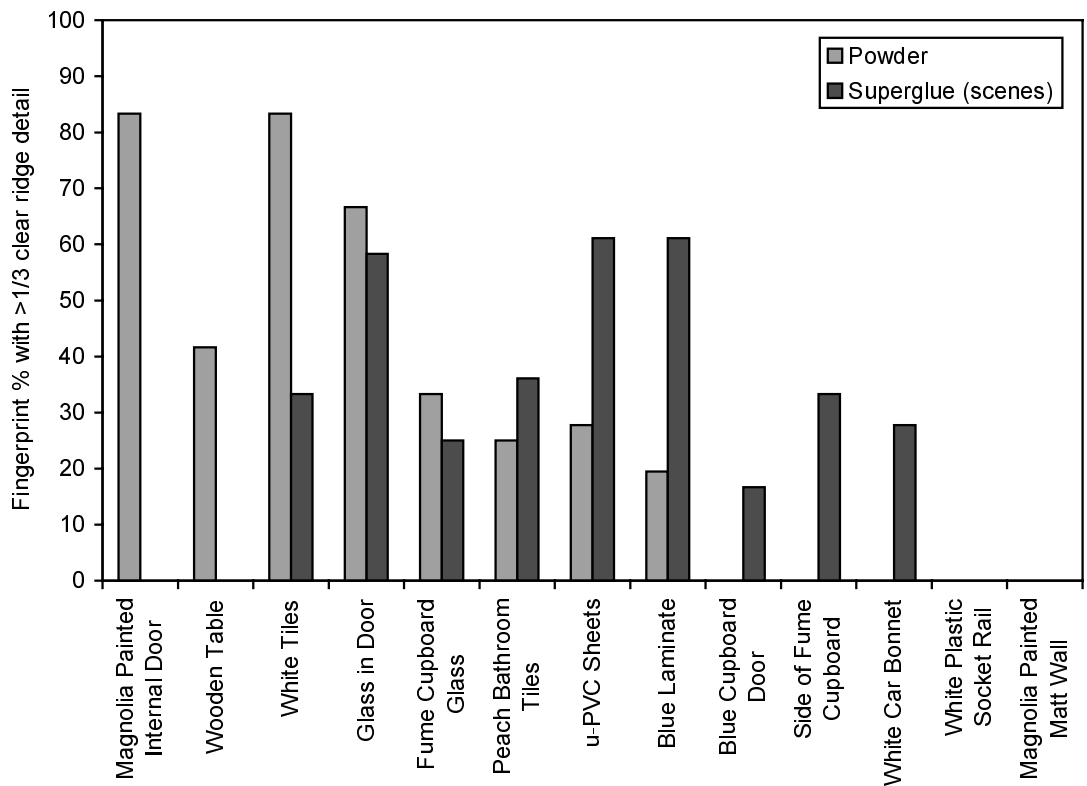


Figure 8: Percentage of fingerprints with >1/3 clear ridge detail for powders and superglue at scenes on a variety of surfaces

SUPERfume offered a significant advantage over powders for the following surfaces: the rough office tray, textured ring binder, white car bonnet, side of fume cupboard and the blue cupboard door. Most of these surfaces are, with the exception of the car bonnet, textured and powder tended to develop the surface texture instead of the fingerprint. These surfaces are traditionally very difficult to develop fingerprints on and SUPERfume only managed to develop prints from heavy donors as shown in Figure 11.

With respect to glass, there is no evidence that superglue is more effective than aluminium powder as shown by the results obtained on the fume cupboard glass, glass in a door and toughened glass sheets (Figure 12). Neither technique worked at all on matt walls or the u-PVC socket rail, both gave very heavy background interference.

For the blue laminate, peach bathroom tiles and u-PVC sheets a mistake was made in the dying of these articles. After dying with water-based BY40, they were then re-dyed with ethanol-based BY40 before photographing. As a result, the number of useful fingerprints developed using SUPERfume was likely to be greater than it would have been with just the aqueous version of the dye. It is therefore difficult to say whether or not SUPERfume performs better on these surfaces than powder, as the ethanol-dye formulation would not normally be used at scenes of crime.

A summary of the results is presented in Table 2. The table is split into four sections: (a) significantly better development with powders than superglue at scenes; (b) significantly better development with superglue at scene than powders; (c) no significant difference between the two processes and; (d) no development with either process.

Performance Significantly Better with Powders	
Magnolia Painted Internal Door	Varnished Wooden Table
White Tiles	White Melamine
Magnolia Painted Door 1	Magnolia Painted Door 2
Smooth Office Tray	
Performance Significantly Better with SUPERfume	
Blue Cupboard Door	Side of Fume Cupboard
White Car Bonnet	Rough Office Tray
Textured Red Ringbinder	
Small Difference in Performance of Powders and SUPERfume	
Fume Cupboard Glass	Glass in Door
Toughened Glass Sheets	White Painted Metal
No Development With Powders or SUPERfume	
White Plastic Socket Rail	Magnolia Painted Matt Wall
HOWEVER, superglue in the laboratory was significantly more effective than the SUPERfume process	

Table 2: Performance of powders and SUPERfume on a variety of surfaces

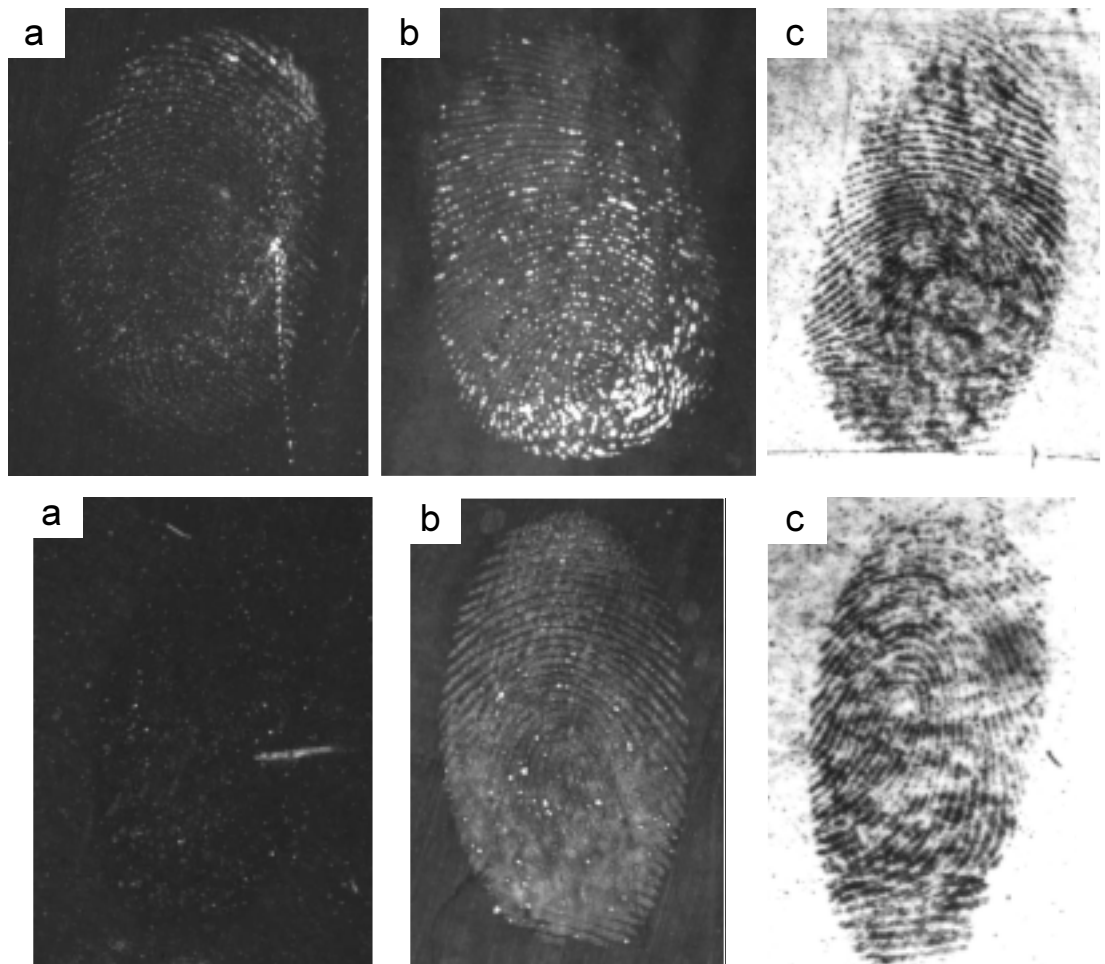


Figure 9: Typical fingerprints obtained on white melamine treated with (a) SUPERfume + water-based BY40, (b) MVC5000 + ethanol-based BY40, and (c) aluminium powder applied with a polyester brush, for two fingerprint donors

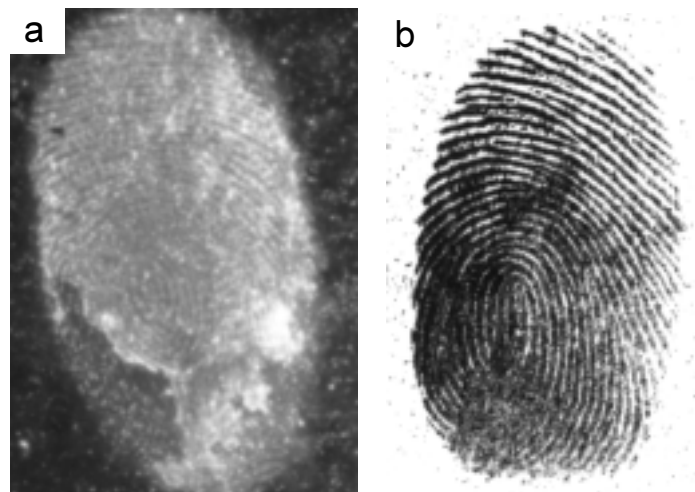


Figure 10: Typical fingerprints obtained on white tiles treated with (a) SUPERfume + water-based BY40, and (b) aluminium powder applied with a polyester brush

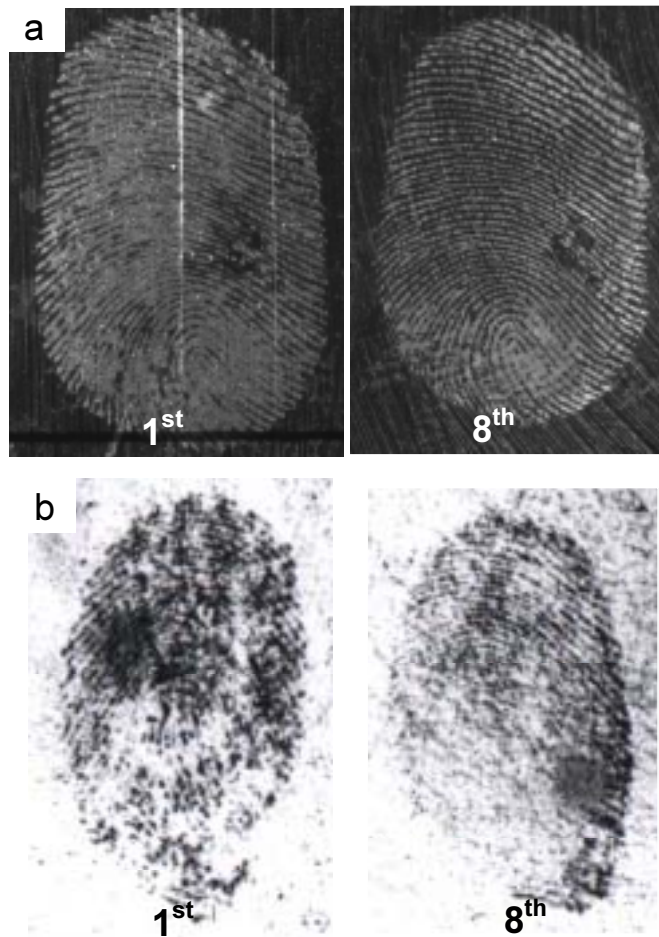


Figure 11: Typical fingerprints (1st and 8th in depletion series) obtained on textured blue laminate treated with (a) SUPERfume and ethanol-based BY40, and (b) aluminium powder applied with a polyester brush

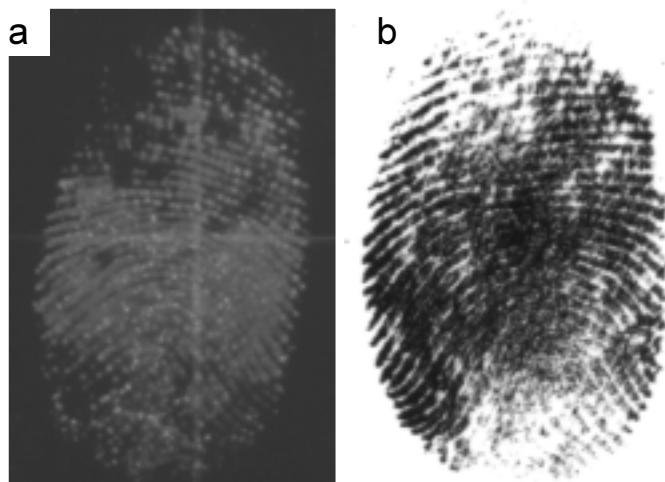


Figure 12: Typical fingerprints obtained on glass in door treated with (a) SUPERfume and water-based BY40, and (b) aluminium powder applied with a polyester brush

5 DISCUSSION

5.1 Superglue at Scenes Compared to Superglue in the Laboratory

There are two principle reasons for expecting improved performance of superglue in the laboratory compared to at a scene, closer humidity and temperature control throughout the volume and the possible use of a more effective solvent for the dyeing process.

5.1.1 Process Conditions: Humidity and Temperature

Section 1.1 talks about the importance of constant humidity in order to get uniform, consistent and optimum fingerprint development on surfaces. The MVC5000 superglue cabinet has been thoroughly tested by PSDB and results showed that provided the wet sensor wick is kept wet the relative humidity is kept at $80 \pm 2\%$ throughout the cabinet during the ethyl-cyanoacrylate evaporation stage.

Constant temperature within the closed system is important in order to maintain constant relative humidity as the former directly effects the latter in a situation where air currents and fans carry air around the enclosed volume. The theoretical plot shown in Figure 13 demonstrates this. The plot is derived from the known mass of water contained in air at 80% RH and 20°C. It demonstrates the effects that a small temperature variation of 1 or 2°C has on the RH. As a broad approximation, there is a 5% RH change per °C resulting in condensation forming in areas of the enclosure on surfaces that are 4°C lower in temperature than the area at 80% RH. Similarly, on surfaces located in parts of the enclosure that are 4°C higher in temperature, the RH may only be as high as 60% resulting in a less effective fingerprint development.

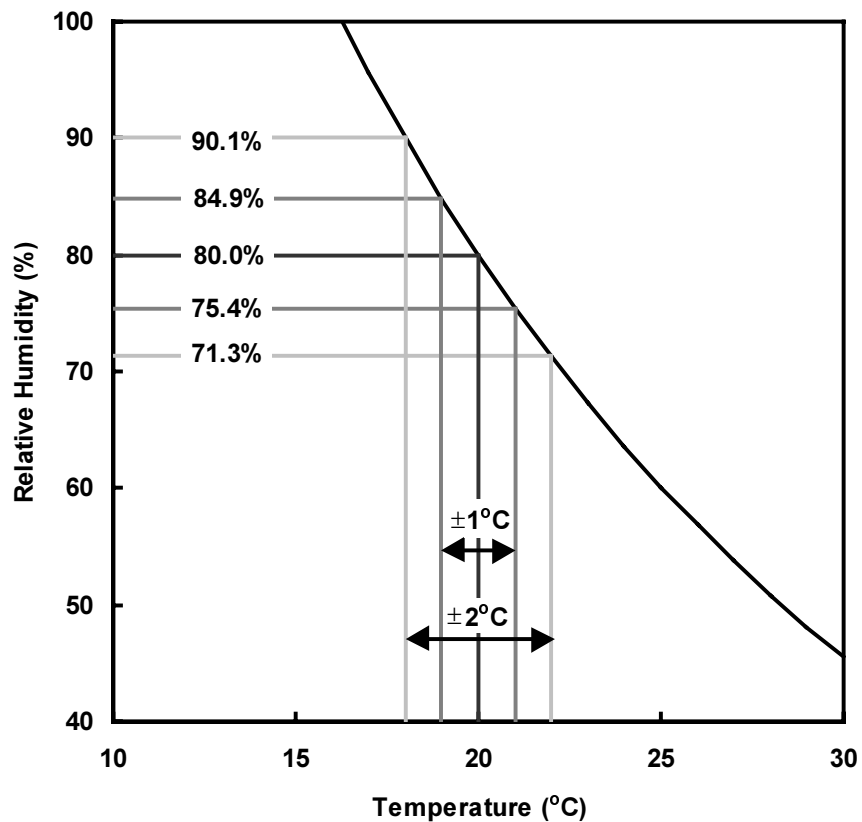


Figure 13: Theoretical plot of the relative humidity (RH) versus temperature showing the effects on RH of small temperature variations of 1 or 2 °C within an enclosure²⁴

As a real example of this PSDB issued guidelines²⁵ in July 2001 concerning the effects on the RH if the lights were left on in the Sandridge superglue cabinet. The standard tungsten light bulbs, if left on all day, increased the temperature at the top of the cabinet by 6°C, resulting in the recommended 80% RH never being reached. In fact, according to the theoretical plot in Figure 13, the RH should only have reached 56% (real measurements were in fact very close to this value). To overcome this problem, we recommended that the light bulbs were replaced with low-energy high efficiency light bulbs where the heating is minimal, or only to turn the lights on for a short period of time whilst viewing exhibits in the cabinet. Similar problems will occur with any superglue cabinet that is positioned close to sources of heat or cold e.g., windows, radiators, drafts etc.). These are problems that are easy to overcome with typical superglue cabinets installed in fingerprint laboratories around the UK.

The situation is quite different if the superglue process is to be used at a scene or in a tent effectively. The volume of a room or tent will be significantly larger than the volume of a superglue cabinet, in this case it was 40m³ compared to 2m³. This raises several issues, the circulation fans must be powerful enough to disperse the ethylcyanoacrylate vapour, and humidity evenly around the room. Temperature gradients within the room must be minimised, a task that gets more difficult as the volume of the enclosure increases particularly where there are surfaces of varying thermal mass, conductivity and external temperature. For the SUPERfume process the humidity within the room was measured with a portable humidity sensor prior to the room being sealed and the glue heaters turned on. In fact, by the time the glue starts fuming, the general relative humidity is likely to have dropped to below 80% and almost certainly would continue to drop during the 30-minute glue cycle. Many surfaces such as timber, soft furnishings, paper, plasterboard etc. will continue to absorb water over considerable periods of time. For these reasons, it is extremely difficult to obtain a uniform temperature and constant humidity within a room or tent.

5.1.2 Treatment Time

Different surfaces will develop fingerprints with superglue at different rates. This problem can be somewhat overcome when using a superglue chamber by either loading the cabinet with similar articles, or stopping the glue cycle when items appear to be overdeveloping. Similarly, if articles are underdeveloped they can be re-treated. Cabinets generally give the user the visibility needed to monitor the progress of the polymerisation. This visibility is greatly reduced at a crime scene, resulting in a degree of luck when it comes to optimum development, this was demonstrated by the overdevelopment of the white tiles as mentioned in Section 4.2.

5.1.3 Dying Protocol

Although the humidity and temperature affect the performance of the superglue polymerisation part of the process the enhancement due to the dye will also have a considerable effect on the overall fingerprint development. As mentioned in Section 1.2 the water-based BY40 dye is less effective than the ethanol-based formulation and must be applied to the surface for a longer period of time in order to maximise the staining of the superglued fingerprint. In section 4.2, three surfaces were dyed with water-based BY40 followed by ethanol-based BY40. Although this was not part of the original experiment, it does demonstrate the difference in performance of the two dyes. Figure 14 gives examples of a fingerprint developed with SUPERfume on the blue laminate surface followed by (a) the water-based dye and then (b) the ethanol-based dye. After treatment with the ethanol-based dye the fingerprints were much brighter reducing background effects and requiring a shorter photographic exposure time.

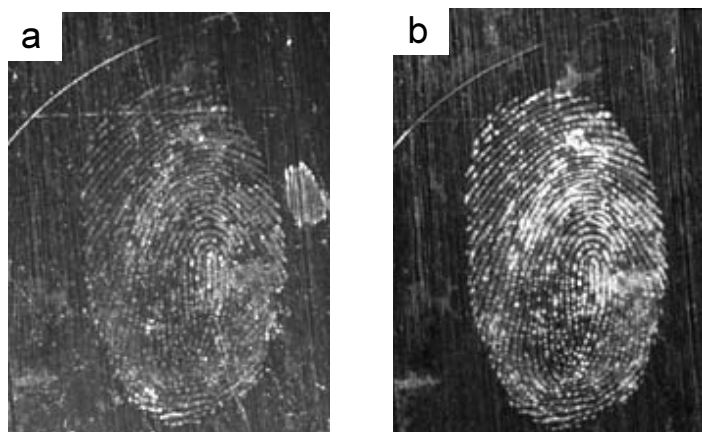


Figure 14: Fingerprint on blue laminate developed with the SUPERfume process followed by (a) water-based BY40, then (b) ethanol-based BY40

5.2 Superglue at Scenes compared to Powders

5.2.1 Surface Dependence

SUPERfume, on many surfaces, did not offer any advantage over fingerprint powders but it did perform better than powders on textured surfaces. The effectiveness of fingerprint development processes on different surfaces varies dramatically. PSDB have issued guidelines (MOFDT¹) to try to provide general advice on what processes are most likely to be effective on a surface and in which order they should be used to maximise the probability of fingerprint detection.

Some fingerprint powders can be very effective on dry, smooth surfaces that are relatively clean. If, however, a surface is heavily contaminated or highly textured then most powders are generally likely to be less effective. Their effectiveness is dependent on the chemical and physical nature of the powder, the type of applicator and, just as important, the care and expertise of the operator. The superglue process is most effective on non-porous materials that have not been wetted; it can also be effective on rough surfaces, vinyl and rubbers.

It was very important, therefore, to study a range of surfaces in order to get an overall picture about the effectiveness of the studied processes. Unfortunately due to the surface dependence and variations in the fingerprint constituents there is no one process that is more effective than others on all surfaces and for all fingerprints. In serious crime in order to maximise fingerprint recovery multiple techniques used in sequence are recommended on most surfaces.

5.2.2 Powder and Brush Selection

In this study, aluminium powder was used on all surfaces. Recent research by PSDB has shown that various granular and magnetic powders can be effective on textured surfaces and may have offered an improved performance – although it still would have been relatively poor. Generally flake powders, such as aluminium, perform worse than granular powders on such surfaces.

Similarly, the choice of brush is extremely important to the effectiveness of the powder. It is possible to purchase brushes made of glass fibre, polyester, nylon, squirrel hair, pony hair etc, all with different characteristics such as fibre diameter, roughness, tip shape etc. In recent trials, PSDB have shown that there is a large difference in performance, some will cause damage to the fingerprint deposit and some will give background streaking causing contrast issues. Generally, glass fibre brushes are considered to be one of the most effective for use with aluminium powder, whilst mop style squirrel hair brushes are considered to be effective with granular powders.

5.3 Health and Safety

Health and safety of SUPERfume, with regards to ethyl-cyanoacrylate vapour exposure, is difficult to assess. Every scene will be unique with different surfaces present, all having varying absorbencies with regards to the vapour. It would be extremely difficult to guarantee that a room or vehicle is free from significant ethyl cyanoacrylate in a form that can desorb from surfaces, especially porous surfaces, over long periods of time. During this experiment, it was clear that the one purge unit supplied with the SUPERfume system would take some time to reduce to fumes to safe levels. A strong cyanoacrylate smell was still present after the purge cycle of 60 minutes and windows had to be opened and the fume cupboard turned on in order to reduce the superglue vapour to levels where it could no longer be detected by smell alone.

Mason Vactron have tried to assess the levels of fumes present by carrying out a series of tests to assess the concentrations of ethyl-cyanoacrylate vapour in cars after SUPERfuming. The samples were taken by Mason Vactron and analysed by the Health and Safety Laboratory (HSL). Generally, the levels were well below the OES, however, under some circumstances levels were close to or exceeded the OES.

It was inconclusive as to whether or not re-humidifying after SUPERfume significantly decreased the concentration of fumes. Although this data provides a good starting point for assessing the safety of superglue fuming for cars, it is not conclusive. If vehicles or rooms are left for a significant period of time before re-occupancy it is likely that significant levels of cyanoacrylate fumes will disperse but at this time PSDB cannot comment on what a safe period is likely to be. It is probably advisable that further testing is commissioned.

5.4 Alternative Processes

Powders and superglue are the main processes that would be performed on non-porous surfaces although at scenes powders are generally accepted as the standard procedure. For serious crimes an initial fluorescence examination with a high power light source should always be considered. There are also other processes that potentially could be used on non-porous surfaces if powdering is not considered suitable due to contamination or texture. These include Vacuum Metal Deposition, Small Particle Reagent (SPR), Iodine, Sudan Black and Gentian Violet. The current PSDB recommended laboratory formulation of Sudan Black is highly flammable, whilst the Gentian Violet formulation is toxic, meaning that these processes cannot safely be used at scenes of crime. Some forces use a water-based version of Sudan Black, and phenol-free versions of Gentian Violet, however, their effectiveness is poor. PSDB are currently working on safer lipid dye reagent for use at scenes of crime – these new formulations will be compared to powders and superglue as well as some other processes.

6 CONCLUSION

- i) Fingerprint powders were at least as effective as SUPERfume on all but textured surfaces.
- ii) On surfaces where superglue treatment in one form or another was effective, treatment in the superglue cabinet was more effective than treatment at the scene.
- iii) If there are textured plastic or rubber surfaces at crime scenes that cannot be removed, treatment of them at the scene using SUPERfume may be the only option and could result in fingerprints that would otherwise probably not be found.
- iv) It is unclear if there will be environmental implications with regard to cleaning up of the scene and restoration to normal use or occupancy. Cleaning up protocols need to be studied in more detail to ensure that there is no risk to subsequent users or occupiers of articles and premises treated and that the ethylcyanoacrylate levels will stay below the OES subsequently.

7 RECOMMENDATIONS

Based on this trial, and unless substantial evidence to the contrary emerges, we would make the following recommendations:

- i) If the SUPERfume system is to be used all smooth non-porous surfaces should be powdered before using the system.
- ii) Any non-porous surfaces which are likely to be effectively treated with superglue should in preference, and where possible, always be removed to a Fingerprint Development Laboratory for treatment in a superglue cabinet system operating at a controlled 80% RH and then if appropriate dyed with ethanol-based BY40.
- iii) Where SUPERfume is used appropriate steps must be taken to ensure the safety of the operators and any others potentially coming into contact with the fumes at the time of treatment or at a later date.
- iv) If the system is used every effort should be directed to thermally stabilising the environment by minimising temperature variations due to draughts, sunlight, radiators etc. so that humidity variations are limited.

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POLICE SCIENTIFIC DEVELOPMENT BRANCH

Sandridge, St. Albans, Hertfordshire AL4 9HQ, UK

Telephone: +44 (0)1727 865051 Fax: +44 (0)1727 816233