4.1.4 The different types of fingerprint

Fingerprints recovered at an incident scene can usually be placed into one of the three categories outlined below, although sometimes the distinction is a fine one. As such fingerprints are normally transient in nature, categorisation into type enables them to be quickly and appropriately processed.

Latent fingerprints *Fingerprints that are invisible to the naked eye. These need to be visualised using appropriate development techniques before comparison and possible identification.*

Latent fingerprints

Latent fingerprints cannot be seen with the naked eye. They consist mainly of perspiration exuded from the sweat pores, which occur in single rows along the ridges of the friction ridge skin. Perspiration is composed mainly of water (~95 per cent) with the remaining 5 per cent made up of other substances such as salt and amino acids. Some body oil or grease may also be present in latent fingerprints, transferred to the fingertips by touching other parts of the body such as the hair. Latent prints require visualisation before identification (Section 4.1.5). The chemicals used in their development react with the different chemicals present in the perspiration. In some instances, *negative* latent fingerprints may be formed when an individual touches a surface that is either covered in dust, for example, or that is sticky for some reason.

Visible fingerprints *Clearly discernible fingerprints formed by the deposition of substances such as ink or blood.*

Visible fingerprints

As the name suggests, this type of fingerprint contrasts well with its substrate and is therefore easily visible to the naked eye. **Visible fingerprints** are formed when an appropriate substance is transferred by the fingertips onto a suitable surface. Examples of such materials are paint, blood, grease, ink, faeces, cosmetic materials and soot. It should be noted that the nature of the surface upon which a print is deposited might be the only factor that determines whether a print is classified as latent or visible.

Plastic fingerprints *Three-dimensional fingerprints formed when the fingertips are pressed into a suitable material such as putty or clay.*

Plastic fingerprints

The third type of fingerprint does not involve the deposition of substances, visible or otherwise, onto a surface but is formed when a negative ridge impression is made into some suitably soft material. These are known as **plastic fingerprints** and may be found, for example, in fresh paint, clay, soap, candle wax, chocolate or putty. Being three dimensional, they are often reasonably visible to the naked eye.

4.1.5 The development of latent fingerprints

Latent fingerprints may be defined as fingerprints that are invisible to the naked eye. In contrast to visible prints and plastic impressions (Section 4.1.4), latent prints need to be developed in order to make them visible. In the early years of fingerprint collection, the availability of visualisation techniques was restricted largely to the application of various powders. However, over recent years, this situation has changed dramatically with many more new techniques (many of them chemical in nature), together with variations or refinements of existing techniques, becoming available. A brief description of the main techniques is given below.

Acid black 1, acid violet 17 and acid yellow 7

The reagents acid black 1, acid violet 17 and acid yellow 7 are used in the development of fingerprints contaminated with blood. The first two can be used on any type of surface, while the effective use of acid yellow 7 is confined to the enhancement of lightly contaminated fingerprints on non-porous surfaces. These blood reagents must be used as part of the sequential processing of blood-contaminated latent fingerprints (Figure 4.6), as they are not effective in developing those parts of a latent fingerprint in which only the usual constituents of sweat are present.

In the presence of proteins from blood or other body fluids, acid black 1, acid violet 17 and acid yellow 7 produce blue-black, vivid violet and yellow fluorescent images respectively. It should be noted that the blood reagent acid violet 17, but not acid black 1, may be used after the application of acid yellow 7 on non-porous surfaces. One or more of these blood reagents can be used for fingerprint enhancement at crime scenes if necessary (i.e. in those situations where it is not possible to send the evidential item or structure to the laboratory).

Fluorescence examination: the use of lasers and high-intensity light sources

Latent fingerprints may occasionally be observed to fluoresce when viewed, with appropriate viewing filters, under a laser or high-intensity light source. This inherent fluorescence is usually due to the presence of contaminants (such as grease, urine or coffee) in the sweat that forms the latent print (Section 4.1.4). Furthermore, latent fingerprints can be made to fluoresce by subjecting them to certain chemical treatments, for example spraying with zinc chloride solution after ninhydrin treatment and then viewing the prints under laser light. In some cases, it may be possible to make the background material fluoresce, thus showing up the fingerprint as a darker image. Iron arc lasers are still widely utilised for fingerprint visualisation but in more recent years a number of non-laser high-intensity light sources have been developed. These have some advantages over lasers, including greater portability.

Gentian Violet

Gentian Violet (also known as crystal violet) is a purple dye that stains the fatty components of sweat. It is particularly useful for developing latent fingerprints present on the adhesive surface of good-quality sticky tape, although it does not work well on Sellotape. It is also very effective on latex gloves.

Iodine fuming

Iodine fuming is one of the oldest techniques used to develop latent fingerprints but is currently used only rarely. It can be applied to practically any surface, both porous and non-porous (although the results usually show up best against a light-coloured background). When heated, iodine crystals undergo a process called sublimation whereby they change directly from the solid state to a gaseous one, without forming a liquid first. When latent prints are exposed to iodine vapour, a reaction may take place between the fumes and some component of the latent print to produce a yellowish-brown print. Importantly, the use of iodine fuming is not detrimental to the use of other, subsequent, visualisation techniques. Note that iodine-developed fingerprints are prone to fading but can be fixed with α-naphthoflavone solution, which gives a blue image.

Ninhydrin and/or DFO application

Ninhydrin (triketohydrindene hydrate) is an extensively used reagent for developing latent prints on porous surfaces, such as paper, cardboard, plasterboard or Artex. It is also effective in developing bloody fingerprints on most porous surfaces. A solution is made by dissolving ninhydrin crystals in a suitable solvent. In the United Kingdom, the recommended solvent from the Home Office is HFE 7100 but a number of other solvents have been developed for this purpose. The resultant solution is applied to the evidential object, often as a fine spray. The ninhydrin reacts with amino acids present in the perspiration component of the latent print to give a bluish-purple colour, known as 'Ruhemann's Purple'. This coloration can take up to several days, or possibly more, to develop but heat and increased humidity can accelerate the chemical reaction. Such conditions may be effectively provided by a humidifying oven, in which fingerprints can be developed in approximately two minutes. However, this treatment is not suitable for Artex, bare wood or plasterboard. These substrates are usually wrapped in black plastic and left until the fingerprints develop fully (usually after about ten days).

Once developed, ninhydrin-treated prints *may* be subjected to further enhancement, such as spraying with a zinc chloride solution, which makes the prints highly fluorescent, and then viewing them under an argon laser.

Another reagent that reacts principally with the amino acids present in fingerprints is the ninhydrin analogue DFO (1,8-diazafluoren-9-one). This produces a red-coloured fluorescent product, which needs to be viewed with a laser or high-intensity light source (thus necessitating the extra step of fluorescence examination). DFO may be applied to similar types of surface to those that may be treated with ninhydrin. If both reagents are used during the sequential processing of fingerprints, it is recommended that DFO be used first.

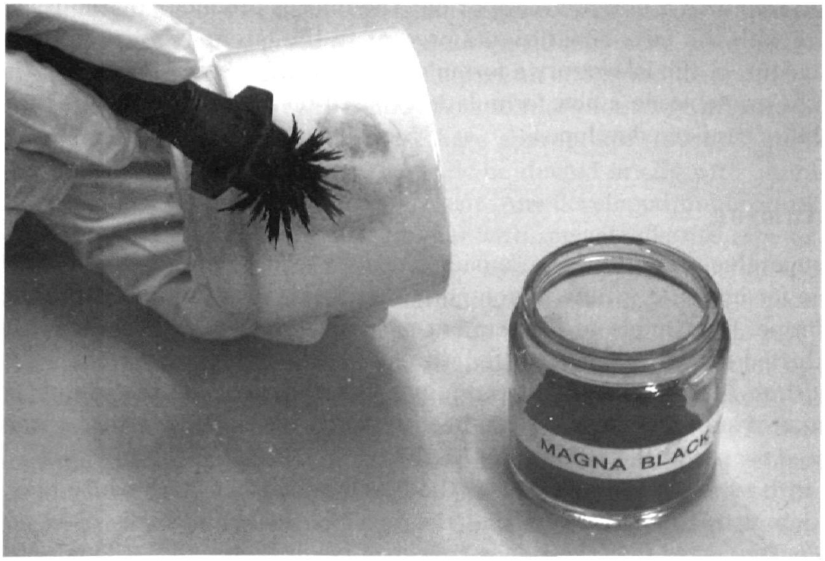
Physical developer (PD)

In the PD technique, a sequence of aqueous solutions is used to visualise latent prints on porous surfaces, especially paper, that have been wet. This procedure involves the immersion of the evidential object in a prewash solution of maleic acid (i.e. *cis*-butenedioic acid), followed by submersion in the PD working solution. This latter solution is composed of a mixture of a redox solution (an aqueous solution of ammonium ferrous sulphate, ferric nitrate and citric acid), surfactant solution and silver nitrate solution. After thorough rinsing in water and drying, the developed prints are photographed. The application of PD can often achieve results where other visualisation techniques have failed. As mentioned earlier, it is especially useful for paper that has been wet but is also effective on chip wrappers and materials soaked in petrol.

Powders

The application of powder to latent fingerprints is the most common visualisation technique in use today. It is suitable for hard, relatively smooth, non-porous surfaces, e.g. tiles and mirror glass, and works by adhering to any grease and/or dirt present in the print. In the United Kingdom, fingerprint powders are usually used at the crime scene when the objects under test cannot be submitted to the laboratory for appropriate treatment. In this situation, grey aluminium powder is generally applied, although black or white powder may sometimes be used instead. In the laboratory, coloured powders are used to enhance fingerprints that have been previously developed using superglue fuming (see later); they are very rarely used on undeveloped latent prints. Once an appropriate fingerprint powder has been selected for the surface under test, it is most commonly applied with a brush; synthetic fibre ones having largely superseded those composed of natural bristles.

As well as the various coloured powders, there are a number of other types of fingerprint powder available. For example, in some instances, e.g. on human skin and finished leather, the use of magnetic fingerprint powder is more appropriate for print development. A special device, known as a magnetic powder applicator, is used to apply magnetised powder to the surface in question without the need to touch it (Figure 4.5). The integral magnet removes excess powder from the print, leaving it clearly visible.



(Photograph by Andrew Jackson, Staffordshire University, UK)

Figure 4.5 The application of magnetic fingerprint powder

Fluorescent and phosphorescent powders (known collectively as luminescent powders) constitute another type of fingerprint powder. These are often applied to prints after they have been developed using other visualisation techniques. When exposed to laser or ultraviolet (UV) light, the luminescent powder emits light, thus enhancing the appearance of the developed print.

Radioactive sulphur dioxide

This technique has some use in detecting latent fingerprints on a number of different surfaces, including clean, fine fabric, adhesive tape and paper, although it is used very rarely. Briefly, radioactive sulphur dioxide gas (SO_2) is applied to the surface under test and reacts with the water component of any latent fingerprints present. These prints may be subsequently detected by autoradiography.

Small particle reagent

This reagent is composed of molybdenum disulphide (MoS_2) particles suspended in a solution of detergent. Small particle reagent may be applied to exhibits either by dish or spray application. The molybdenum disulphide particles adhere to the fatty components of any latent fingerprints present, forming a grey deposit. Small particle reagent is principally recommended for use in wet conditions outdoors or on waxy or polystyrene surfaces but, in practice, is usually not as effective as other appropriate development processes.

Solvent black 3 (Sudan black)

Solvent black 3 may be used to develop latent fingerprints on a number of non-porous substrates, such as metals and plastics, and is especially effective when these surfaces are covered with a film of grease or oil. The images produced by the reaction of this dye with the fatty constituents present in the latent fingerprints are blue-black in colour. In the laboratory a formulation of this dye based on ethanol is used, but for the crime scene a new formulation (based on methoxypropanol) with lower flammability has been developed.

Superglue fuming

Fuming with superglue vapour (ethyl cyanoacrylate) is a relatively recent technique that is suitable for use on a variety of non-porous surfaces, such as rubber, metals and electrical tape. It is simple to perform but potentially very hazardous. It must therefore be carried out in a chamber fitted with a suitable extraction system, such as internal carbon filters. Although originally a laboratory-based technique, a portable version of superglue fuming has been recently developed by Foster and Freeman Limited for use at the crime scene itself.

Treatment with superglue vapour causes the development of a hard white polymer on some latent fingerprints. Note that the negative image is usually used for identification purposes, so that the ridges appear in black (Figure 4.4). This polymerisation of the superglue, believed to be catalysed by the water content of the fingerprint, is effective in conditions of 80 per cent relative humidity, atmospheric pressure and room temperature (taking only a few minutes to develop). The rate of development can be accelerated further by heating the superglue to approximately 120 °C to encourage its evaporation. The active circulation of the air within the chamber used for fuming will also speed this process up. Most items subjected to superglue fuming are subsequently stained with a fluorescent dye, such as Basic Yellow 40, followed by fluorescent examination. This further enhancement helps to maximise the number of fingerprints developed.

Vacuum metal deposition

Vacuum metal deposition involves the evaporation of a metal, usually zinc or gold (or a combination of both), and its deposition, under vacuum, as a thin film on the latent print. It is particularly useful for the detection of latent prints on non-porous surfaces that are smooth, such as plastic packaging materials, e.g. polythene, glass, and photographic prints and negatives.

During the processing of a crime scene (Chapter 2), small items suspected of bearing latent fingerprints, which are suitable for chemical treatment, are packaged by SOCOs and sent to the in-force chemical enhancement laboratory (CEL). Here, highly trained, specialist laboratory staff select the most appropriate visualisation technique for each of the items submitted. In some cases, it may be necessary to apply more than one technique before a print is adequately developed. Therefore, the operator must be aware of the sequence in which different techniques can be applied in order to maximise the chances of success. Illustrative flow charts for the sequential processing of latent fingerprints on different types of surfaces are given in the *Fingerprint development handbook* (see Further reading), two examples of which are shown in Figures 4.6 and 4.7. Consideration must also be given to the possible effects of the different visualisation techniques on other types of forensic evidence that may be present. After suitable development, photographic images are sent to the Fingerprint Bureau for comparison and identification.

There will be items at the crime scene that are too large or otherwise unsuitable for submission to the CEL. If these have appropriate (ideally non-porous, smooth and reasonably flat) surfaces, they may be dusted *in situ* with aluminium powder to reveal any latent fingerprints present. Any developed fingerprints may then be photographed before being lifted either with special adhesive tape or with gelatine lifters. Gelatine lifters are flexible pads, approximately 1 mm thick, composed of a layer of low-adhesive gelatine sandwiched between a backing sheet and a plastic cover sheet. In use, the cover sheet is removed and the gelatine pad applied to the surface in question. Once the print is lifted, it is preserved either by replacing the cover sheet or by covering the gelatine with clear sticky-backed plastic. Gelatine lifters can be cut to the required size and are particularly useful where the surface bearing the print is uneven. After labelling, lifted prints are sent to the in-force Fingerprint Bureau, where they are input into NAFIS (Section 4.1.3). It should be noted that it is not possible for lifted fingerprints to undergo any further chemical enhancement. However, their clarity may be improved by the use of digital imaging.

(From Bowman, 2005)

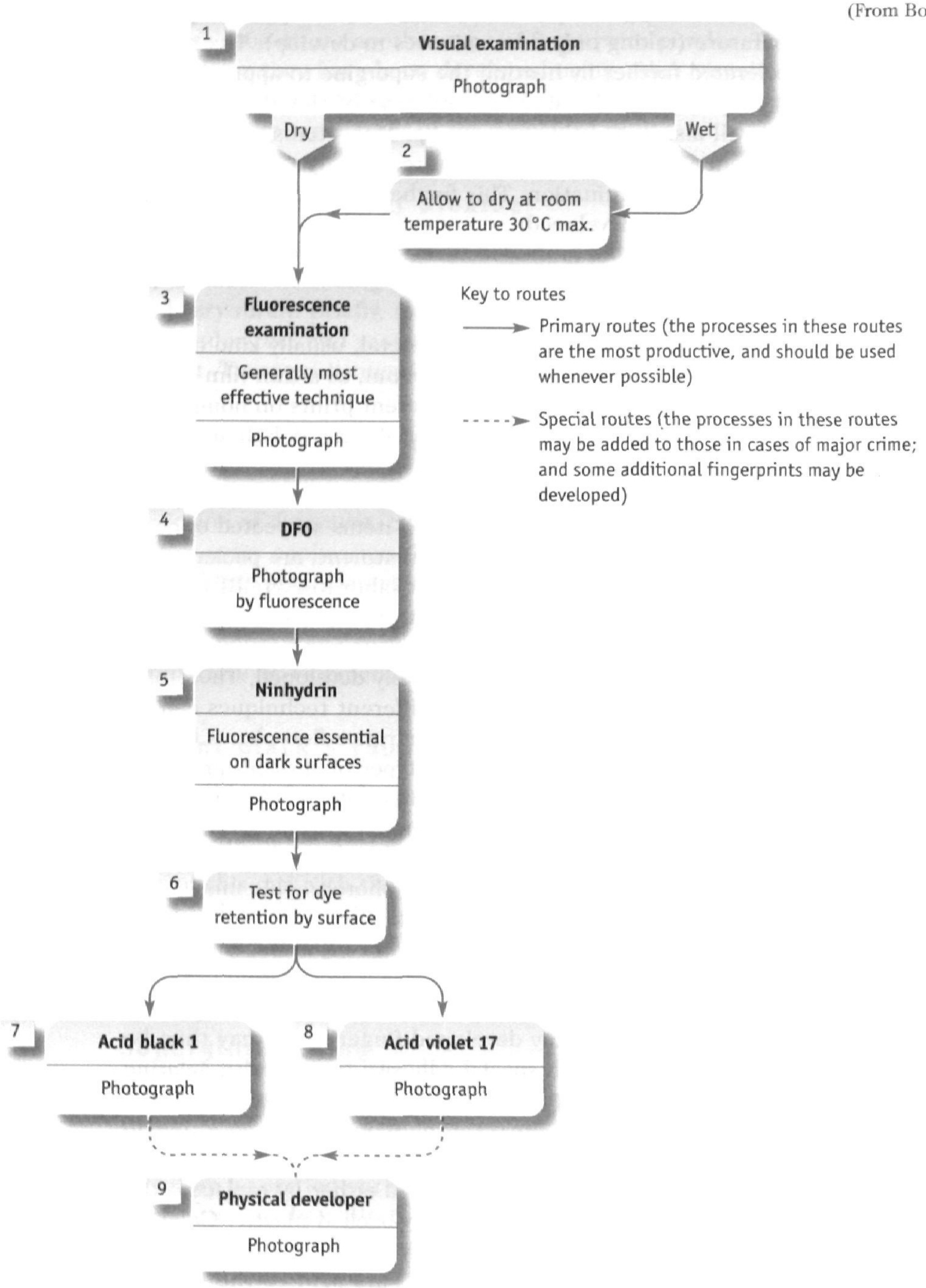
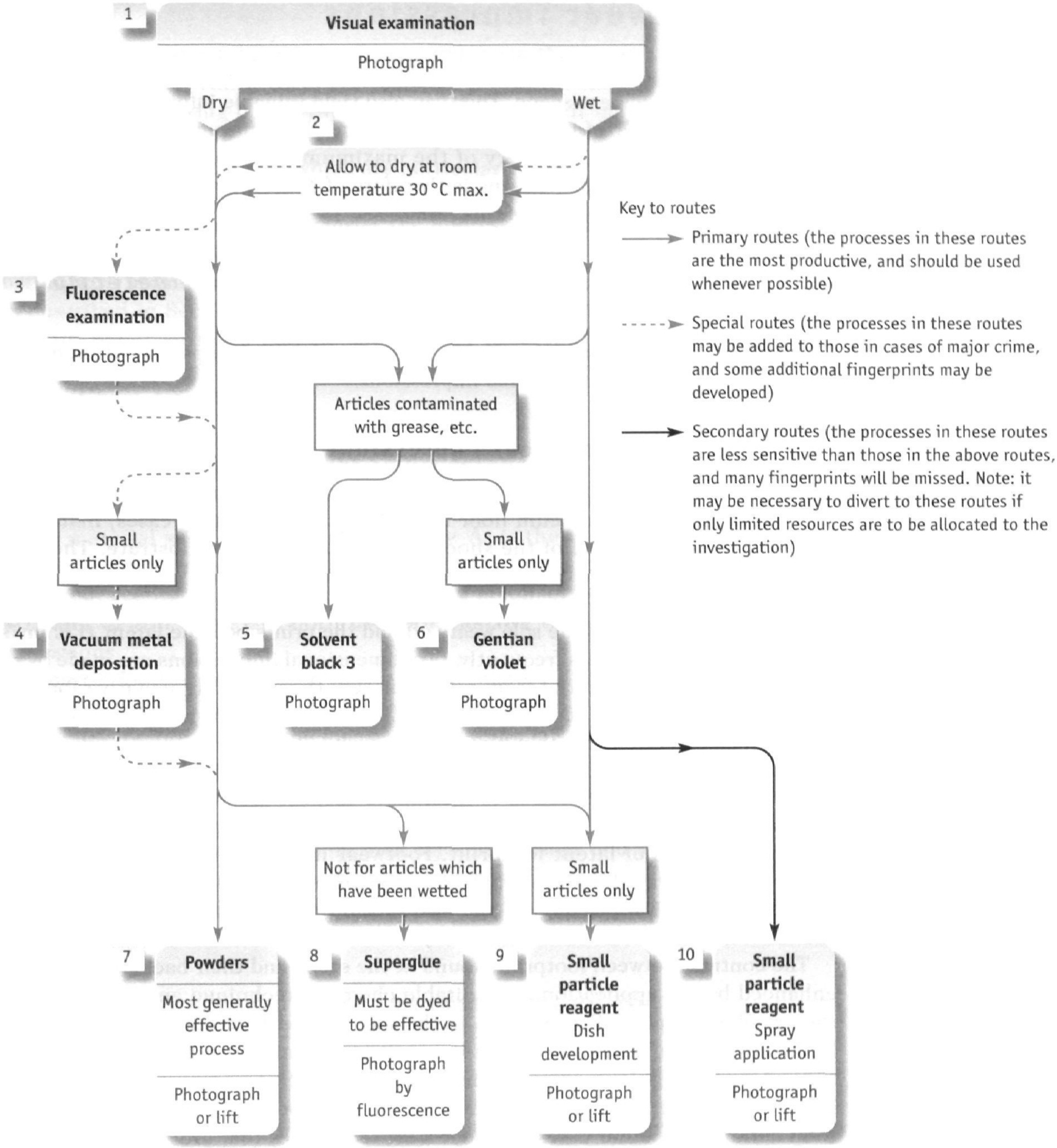


Figure 4.6 The sequential processing of latent fingerprints in blood on porous surfaces
Note that these recommendations were made based on best possible documented trials available at the date of publication



(From Bowman, 2005)

Figure 4.7 The sequential processing of latent fingerprints on smooth, non-porous surfaces (e.g. glass, paint or varnish and hard plastic mouldings)

Note that these recommendations were made based on best possible documented trials available at the date of publication