Fingermark Visualisation Newsletter

November 2019

SPECIAL EDITION: POROUS PROCESSES AND CHARTS

IN THIS ISSUE

Marks captured during the pseudo-operational trial of Indandione (top) and Physical Developer (bottom).

INTRODUCTION

Dstl endeavours to provide the best possible advice on process sequences for a range of surfaces on which fingermarks may be developed. Porous surfaces have been a dominant focus of our research and development efforts over the past few years for various reasons. On the positive side, more sensitive chemical reagents have become available that have the potential to increase fingermark recovery rates. On the negative side, there have been issues with chemical availability caused by tighter environmental restrictions or inconsistency of supply. In order to at least maintain, and where possible improve, operational capability, Dstl (and formerly CAST) have investigated some of these issues. This involved international collaboration, academic engagement, extensive in-house research, development and full validation studies, enabling us to be in a position to provide comprehensive updated guidance to all UK operational laboratories on fingermark recovery on porous items.

This newsletter highlights some of the key changes that will be updated in the next (2nd) edition of the Fingermark Visualisation Manual (FVM). These include modified charts for a range of porous substrates, the release of the new Physical Developer formulation, and FVM-style processing instructions for Indandione (excluding Health and Safety: Labelling Solutions, which will be included in the FVM 2nd Edition).

If anyone would like further assistance with either of these processes then please contact us. We are keen for laboratories to bring these processes into operational use, so we can provide additional information or arrange a demonstration if necessary.

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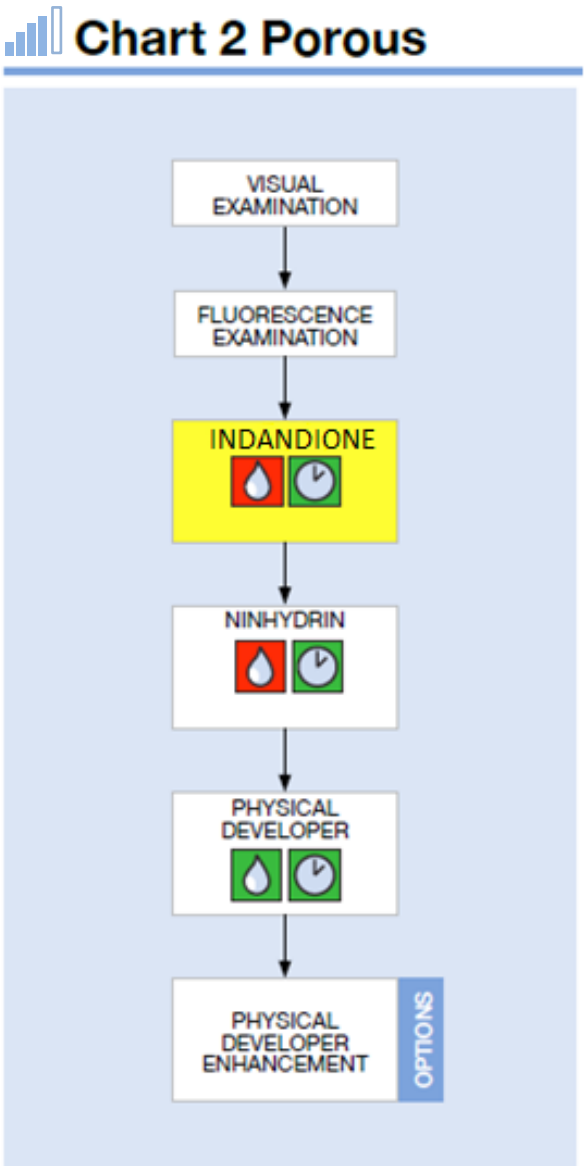
CHANGES TO SEQUENTIAL PROCESSING CHARTS

Indandione will be promoted from a Category B to Category A process in the next edition of the FVM. It will also be incorporated into the Charts in Chapter 4 as a direct replacement for DFO. This follows a full validation study spanning over several years and including an extensive laboratory trial and a pseudo-operational trial. Our work has consistently provided evidence that Indandione is a superior amino acid reagent to DFO. Specific details are outlined below.

Primary Chart

For 'Chart 2 Porous', Indandione replaces DFO as the single most effective process and the new sequence is shown below:



A modified primary chart: Chart 2 Porous

Secondary Charts

A broad range of porous substrates were used during the validation study, including (but not limited to):

- Light coloured matt
- Thermal
- Brown cardboard
- White glossy
- Printed paper and card
- Dark coloured matt

This provides enough evidence to replace DFO with Indandione in many of the secondary charts.

The following substrates and contaminants are also listed as secondary charts but these were not included in the validation study:

- Currency
- Untreated wood
- Painted surfaces
- Adhesives tapes
- Blood or grease contamination

However, both DFO and Indandione function similarly by reacting with amino acids and amine-containing compounds in fingermarks. For this reason, and the fact that Indandione outperformed DFO on all tested porous substrates, it is reasonable to believe that the same would be the case on other similar substrates. Thus, Indandione will replace DFO in *all* secondary charts. To mitigate any risk, maturity ratings will be set accordingly to reflect the level of data supporting the chart.

The Fate of DFO

DFO will be demoted to Category B with no critical changes to the process instruction. This will allow the information to remain available until UK laboratories fully transition across to Indandione. There is no known niche application for DFO so its use should only be considered if Indandione is not available.

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A INDANDIONE

Alternative names

IND; 1,2 IND; 1,2-Indandione; 1,2-Indanedione

Contents

Main Uses

✔	Latent	✘	Non-Porous
✔	Blood	✔	Semi-Porous
✘	Grease	✔	Porous

Key Information

- **Competent personnel** specialising in fingermark visualisation must be consulted if considering the use of this process.
- It is recommended that all sections are read prior to using this process for the first time.
- Full process details are given for **laboratory use** and additional considerations are given for **scene use**.

Process Overview

Indandione reacts with amino acids in latent fingermarks to give a fluorescent product. It also reacts with amine-containing compounds (mainly proteins) in blood.

It is a **chemical process** that involves the application of a solution to the item or surface followed by use of a specialist oven (if possible) to increase the speed of the reaction. The resultant mark is highly fluorescent and must be viewed using **Fluorescence Examination.**

Safety and Effectiveness Summary

The Process

- Indandione can be used safely and effectively in a laboratory using specialist equipment.
- The process can be used at scenes but there will be additional health and safety issues and the effectiveness may be variable.
- Precautions are required to mitigate the asphyxiate nature of the solvent.
- The effectiveness may be influenced by the method of applying the solution.
- The effectiveness is linked to the ability to control the temperature of the item or surface post-application.
- The process requires subsequent Fluorescence Examination to be effective.

The Item or Surface

- The process is most effective at developing both latent and bloody fingermarks on porous surfaces, although it can be used on semi-porous surfaces.
- Indandione is not effective on items or surfaces that have been wetted, even if they have been subsequently dried.
- It is effective on items or surfaces that have been soaked with petrol or paraffin.

Integrated Use

Indandione may be detrimental to subsequent fingermark or forensic processing.

- See Chapter 4: Process Selection for information on its sequential use with other fingermark visualisation processes.
- See Chapter 7: Other Forensics for information on integration of fingermark and other forensic processes.

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Laboratory or Scene?

This page **only** gives an **overview** of **health and safety, effectiveness** and **practical issues** associated with the use of this process. Those responsible for deciding whether to process items in the laboratory or at the scene, e.g. crime scene managers or investigators, **must** consider in addition to the information below:

- the detailed process instructions; and
- other factors dictated by the investigation.

See **Chapter 2, Section 2.4,** 'Fingermark Evidence Recovery Planning'.

Indandione can be used both in the laboratory and at scenes, although it is safer, and generally more effective and practical to treat removable items with Indandione in a laboratory.

Health and Safety

The carrier solvent is a heavier-than-air asphyxiate and build-up of vapours must be avoided as it displaces air.

- **In a laboratory**, this is easy to achieve as processing can be carried out in an extracted fume cupboard.
- **At scenes**, there is a much increased risk of asphyxiate build-up where ventilation is variable and additional equipment, such as specialist RPE, may be required.

Effectiveness

Indandione produces consistently good results if used in the laboratory compared to at scenes where development may be variable. For scenes, it is not possible to follow all of the details as written in the process instructions, predominantly due to the environmental conditions required for optimal development, which can consistently be achieved and controlled in a development oven.

Practicality

This will depend upon the size of the item, or surface, to be treated and whether or not it can be readily removed to a laboratory.

- **In a laboratory**, the process has few practicality issues provided the item fits into the Indandione development oven. If the item does not fit in the oven, development can still occur at room temperature but may require several days to achieve optimal results.
- **At scenes**, application is less practical than in a laboratory due to: the added health and safety requirement during application; the longer processing times and associated scene monitoring; the added complexity of scene clean-up; the added complexity of creating optimal environmental parameters for effective **Fluorescence Examination**.

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Health and Safety

- Consult Chapter 3 for **general** information on **working safely** with Category A processes.
- Indandione may be carried out with no known hazards to health provided practitioners are trained and competent, if appropriate control measures are in place and the process is carried out as described in this Manual.
- Throughout the process instruction there may be reference to chemical hazards (e.g. *'residual processing chemicals on items are hazardous'*) and/or control measures (e.g. *'work within a fume cupboard'*). These are based on Dstl's local risk assessment (and Safety Data Sheets and must not be assumed to be appropriate in all situations, but are given as guidance only.

General Health and Safety Information

- The health and safety information provided throughout the Manual must be considered as guidance only: definitive health and safety policies, procedures and instructions must be provided locally.
- In providing the Category A process instructions it is assumed that:
  - the process will be carried out in a laboratory that can provide a safe working environment;
  - a responsible person will carry out a risk assessment before the process is carried out to include at least:
    - an assessment of the practitioner's competence to carry out the process;
    - a review of all the hazards associated with the use of the process, consulting relevant documents, such as Safety Data Sheets (SDSs), where necessary;
    - a review of all the hazards associated with the working environment, the item(s) and any contaminants present.
- All control measures identified will be put in place, including the wearing of appropriate PPE, and reviewed for their effectiveness.
- Where information is included for scene use of the processes, the considerations are over and above those for laboratory applications of the processes.

Hazards associated with Indandione

- Indandione is a **chemical** process.
- Practitioners will need to know the hazards associated with handling individual chemicals (from SDS) and the hazards associated with the process solutions or mixtures.
- Wear Standard PPE as a minimum.
- Some additional hazards associated with the process are identified below but those cited must not be regarded as exhaustive, nor the control measures prescriptive.

Additional hazard	Risk	Suggested control measures
Air depletion when preparing and using Indandione Working Solution.	Asphyxiation	• Prepare and apply Indandione Working Solution in an extracted fume cupboard. *HFE7100 is not absorbed by the activated carbon filters found in recirculating fume cupboards. It passes through them unaffected and unless the HFE7100 vapour is extracted from the laboratory it will displace the air from the ground up as it is much heavier than air.*
Nuisance odour from processed items.	Some individuals may experience watery eyes and sneezing.	• Examine treated items in a well-ventilated area or preferably on a down-draught bench.

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Equipment

Indandione requires the use of some process-specific equipment for the application of Indandione Working Solution and for creating the environmental conditions required for development.

If equipment is to meet the requirements as outlined below, it must be well maintained and, if appropriate, serviced regularly in accordance with the manufacturer's instructions. **General laboratory equipment** that may be required is outlined in Chapter 3.

Equipment	Requirements
Processing trough	A processing trough **must**: • be made of a material compatible with solvents used in the Indandione Working Solution, such as polypropylene. In addition, a processing trough **should**: • be of suitable length to accommodate the size of items being processed; • be shallow with a curved, corrugated bottom surface. *A processing trough that meets all of the above requirements allows Indandione Working Solution to be applied in such a way as to minimise wastage without compromising the effectiveness of the process. The curved, corrugated surface enables small quantities of solution to be used at one time, whilst preventing paper 'sticking' due to surface tension effects if the surface were smooth. Other designs can be used effectively, but they may generate additional waste Indandione Working Solution.*  *Examples of processing troughs produced for use with Indandione solutions.*
Indandione development oven	A Indandione development oven **must**: • maintain an air temperature at approximately 100 ± 5˚C within the oven whilst at equilibrium; • provide close control and rapid recovery of temperature across all shelves after items have been placed in the oven; • not have air flow so strong as to blow normal paper casework items around within the oven; • have a way of removing hot acetic acid fumes. In addition, a Indandione development oven **should**: • Have a working capacity sufficiently large enough to treat normal casework; • Have interior and shelves resistant to acetic acid vapour at 100˚C; • Incorporate a timer (external timers would suffice). • Have a way of monitoring items whilst in the oven.
Extraction for Indandione development oven (if required)	If required, extraction for a Indandione development oven **must**: • be a negative pressure exhaust system which provides a continuous extraction rate of between five and ten times the total volume of the oven per hour; • have extraction pipework that is be able to resist the temperature being used and acetic acid vapour at that temperature.

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Chemicals

This table lists chemicals that are required for Indandione.

Refer to supplier's Safety Data Sheet (SDS) for further information on specified chemicals.

See **Chapter 3 safe handling of chemicals** for general information.

Common Name	Alternative Name(s)	CAS	Number Grade
Indandione	1,2-Indandione, 1,2-Indanedione	16214-27-0	>99%
Acetic acid	Ethanoic acid	64-19-7	Analytical ≥ 99.7%
Ethyl Acetate	Ethyl Ethanoate	141-78-6	Analytical ≥ 99.7%
Methanol	Methyl alcohol	67-56-1	Analytical ≥ 99.7%
HFE7100	Methyl nonafluorobutyl ether; 1-Methoxynonafluorobutane	HFE7100 is only available as a mixture of two isomers. The isomers are inseparable but have essentially identical properties. Each isomer has its own CAS number (163702-08-7 and 163702-07-6). The isomeric mixture within HFE7100 does not have its own unique CAS number.	As supplied
Zinc Chloride		7646-85-7	Reagent Grade ≥ 98%

Solutions

Consult Chapter 3 for **general** information on **solution preparation**, **safe storage of chemicals, solutions and mixtures** (which includes information on **packaging and labelling**), **management of waste for disposal** of solutions and **guideline expiry periods**. This page gives additional information relevant to this process.

Solutions

Indandione Working Solution
- 0.25 g 1,2-Indandione
- 45 mL Ethyl Acetate
- 45 mL Methanol
- 10 mL Acetic acid
- 1 mL Zinc Chloride Stock Solution
- 1 L HFE 7100

Zinc Chloride Stock Solution
- 0.1 g Zinc Chloride
- 4 mL Ethyl Acetate
- 1 mL Acetic acid

Final solution ready for use is identified by a red border

1) Prepare solutions →
- a) Indandione Working Solution and Zinc Chloride Stock Solution must be prepared in an **extracted** fume cupboard.
- b) Pipettes (or other measuring equipment with an appropriate level of accuracy) may be required to measure small quantities of liquids.
- c) Ensure chemicals are added in the order listed. Indandione must be fully dissolved in ethyl acetate, methanol and acetic acid before the addition of Zinc Chloride Stock Solution and finally HFE 7100.
- d) Indandione Working Solution and Zinc Chloride Stock Solution are colourless.
- e) Solutions that are cloudy or with a **separate 'oily' layer** should not be used.

2) Label appropriately →
- a) Indandione Working Solution and Zinc Chloride Stock Solution should be labelled in line with the guidance in **Indandione Health and Safety**.[1]

3) Store appropriately →
- a) Indandione Working Solution has a guideline expiry date of 12 months if stored at room temperature.
- b) Solutions that are cloudy or with **separate 'oily' drops** on the top of the solution are a good indication that the solution has degraded and must not be used.

4) Dispose of appropriately

[1] *This information is to be determined and will appear in FVM 2nd Edition. Use DFO and Ninhydrin solution labelling pages from the FVM 1st Edition as guidelines.*

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Processing

Preparation

(1) Items	→	a) Carefully unpack and organise casework prior to pouring out the Indandione Working Solution.
(2) Work area	→	a) The Indandione Working Solution must be applied in an **extracted** fume cupboard.
(3) Equipment	→	a) The Indandione development oven must be pre-conditioned to a temperature appropriate to the item being treated. For common items, such as most papers and card etc. this is approximately 100˚C. b) Immediately prior to processing, pour the Indandione Working Solution into a suitable clean, dry vessel such as a **processing trough**. Small quantities should be used to minimise waste.

Processing

(4) Apply Indandione Working Solution	→	a) Draw the item through the Indandione Working Solution allowing excess to drain back into the trough. Alternatively, quickly immerse and remove the item. It is necessary only to wet the surface with the solution. Prolonged immersion is undesirable. b) Place item onto a suitable surface to 'dry' flat and horizontally within the fume cupboard. *A suitable surface could be thick, dry, single ply or bonded tissue.* ***Corrugated cardboard is not suitable**.* c) If it is not possible to immerse the item carefully, apply the solution with a soft brush. The surface must be 'wetted' evenly. d) If the item **turns grey/black** during processing see **Thermal Coating Removal** process instruction. e) Items contaminated with **blood** must be treated with utmost care so as not to damage fragile deposits of blood. Items should be treated by immersion. If this is not possible then the solution should be gently directed over the area to be treated using a wash bottle. f) Indandione Working Solution must be discarded if it changes in appearance (**turns cloudy**, forms **'oily' droplets**, or becomes contaminated). Provided there is no sign of contamination the trough may be replenished with fresh solution, but if changes in appearance occur, a clean dry trough must be used. There should be very little (if any) solution remaining in the trough at the end of the processing session, minimising wastage.
(5) 'Dry' item	→	a) Allow the solvent to completely evaporate from the item before removing from the fume cupboard.

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Processing continued

(6) Transfer item to a pre-conditioned Indandione development oven

(7) Remove item from Indandione development oven

→

a) The item may be placed on cardboard for transferring directly into the oven.
b) Minimise the time the oven door is open during transfer.
c) The item should be heated for at least 10 minutes.
d) Some items such as envelopes with plastic windows or plastic bottles with paper labels may be damaged at 100°C. Most plastics will tolerate a temperature of 50°C but samples of items should be tested if possible to determine the maximum temperature to which they can be subjected without damage. Items heated at less than 100°C may take **many hours to develop marks**.
e) Larger items that will not fit into the development oven can be left at room temperature for at least 24 hours to allow mark development. However, optimal mark development is best achieved using a development oven at 100°C for 10 minutes.

(8) Examination

Primary: Fluorescence Examination[2]

Secondary: Visual Examination

→

a) Items should be examined in a well-ventilated area, preferably on a down-draught bench.
b) Extraneous fingermarks may develop if items are handled after processing.
c) Fluorescent marks are coloured orange. Visible marks are coloured pale pink.
d) The item may be examined as soon as cool enough to handle.
e) Most fingermarks are expected to develop during treatment, although further development may occur with time.
f) Indandione-developed fingermarks may fade over time so it is important to image all fingermarks found immediately.
g) The item should be kept in the dark if awaiting additional development or imaging.
h) There are many non-destructive **optical processes** that can be considered when examining and imaging marks in addition to Visual Examination and Fluorescence Examination, particularly for low-contrast marks or marks on dark or patterned surfaces.
i) Mark up viable fingermarks appropriately and capture image.
j) After examination, items can be re-treated if necessary, but this is only worthwhile if there is very little background development.

[2] *Nominal excitation and emission ranges are similar to DFO, and this is shown in the supplementary information section. Therefore, FVM 1st Edition DFO guidelines for wavelength selection (5.FE.10) can be referred to when selecting light sources and viewing filters.*

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Post-Processing

Consult Chapter 3 for **general** advice on **packaging**, **storage**, **disposal or return of items**, and **management of waste for disposal** of equipment, chemicals, solutions and mixtures. This page gives additional information relevant to this process.

Processed item		
(1) Residual processing chemicals	→	a) Items treated with Indandione may emit a nuisance odour comprising of acetic acid vapour. Its concentration is likely to be below the workplace exposure limit.
(2) Cleaning processed items	→	a) It may not be possible to return items to their original state. If possible, items may be thoroughly wiped or washed with soap and water.
(3) Disposal or return of processed items	→	a) Residual processing chemicals that cannot be removed during cleaning are non-hazardous so items can be discarded with ordinary waste or returned to the owner.
Equipment and Chemicals		
(4) Disposal of used Indandione Solution	→	a) Used Indandione Working Solution must not be poured back into a container for re-use at a later date as the effectiveness and solution lifetime are significantly reduced.

Scene Use

If a decision has been made to apply Indandione at a scene, a number of **additional considerations** need to be taken into account over and above those given for laboratory use. The recommendations below cannot be prescriptive since every scene will be different and:

- Each must be subject to a local risk assessment and will require control measures to mitigate any risks identified before work can be carried out **safely** and in compliance with the requirements of the Health and Safety at Work Act (1974);
- Different approaches may be needed to make the process as **effective** as possible within the constraints of the scene;
- Present a range of **practical** issues that need to be overcome.

This page **must** be read in conjunction with the laboratory process instruction.

See **Chapter 2, Section 2.4**, 'Fingermark Evidence Recovery Planning' and **Chapter 3, Section 3.1 – Laboratory or scene use of Category A processes** for other general information.

For health and safety, consider:

- minimising the risk of asphyxiation by reducing the hazard by:
  - ensuring adequate ventilation of the processing area, e.g. by opening doors and windows;
  - limiting the area treated and restricting the amount of Indandione Working Solution used by targeted application;
  - providing additional PPE to protect practitioners, such as breathing apparatus and oxygen monitors;
  - **not spraying solutions**;

If even relatively small quantities of HFE7100 are used and the vapours are allowed to build up in a confined space, lack of oxygen will cause those in close proximity to feel faint then blackout and asphyxiate.

- what additional packaging and labelling will be needed for transporting the solutions (made in the laboratory) to the scene;
- what residual hazard might be present when returning to a scene to inspect for fingermark development.

For effectiveness, consider:

- how Indandione Working Solution can be evenly applied to larger items and non-removable horizontal and vertical surfaces;
- how to raise temperature without damaging items, surfaces and fingermarks;
- how to protect surfaces from direct sunlight after treatment.

For practicality, consider:

- Access to the areas to be treated;
- The additional time, staffing and costs of applying the process at the scene, including:
  - Transport costs;
  - Additional equipment to make the process safe and effective and to minimise mess, e.g. breathing apparatus, oxygen monitor, heaters;
    - If using breathing apparatus there is a requirement for two staff to be present during application; one must be away from the treatment area, in fresh air and able to monitor that supplied air is fresh and the other is safe;
  - Keeping the scene isolated for the time it takes for fingermarks to develop; this may be many days unless it is possible to increase temperature;
  - Scene clean-up, which may involve washing and sealing surfaces followed by complete redecoration.

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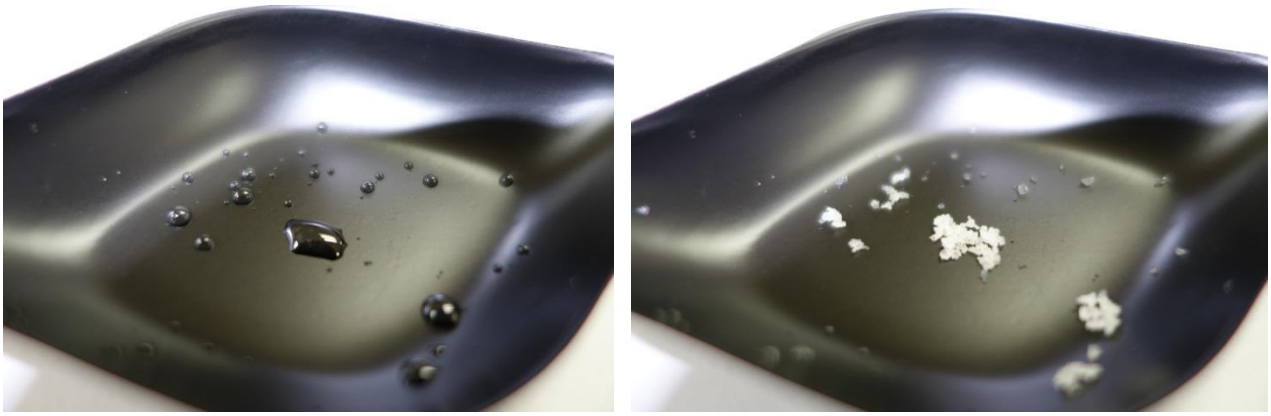
Changing State of Zinc Chloride

Recognition

The Zinc Chloride powder quickly forms a liquid when left in the air.



Zinc Chloride weighed out incorrectly (left) and correctly (right).

Cause	Effect	Prevention	Correction
The Zinc Chloride is left out for too long when weighing and absorbs water from the air causing the chemical to dissolve.	Zinc Chloride Stock Solution will be contaminated with water, leading to the formation of water ("oily") drops, and a less effective solution.	Ensure that: • Zinc Chloride is purchased in small quantities to reduce water absorption from the air; • Chemicals are not used past their expiry date • The zinc chloride bottle is quickly resealed.	There are no corrective measures.

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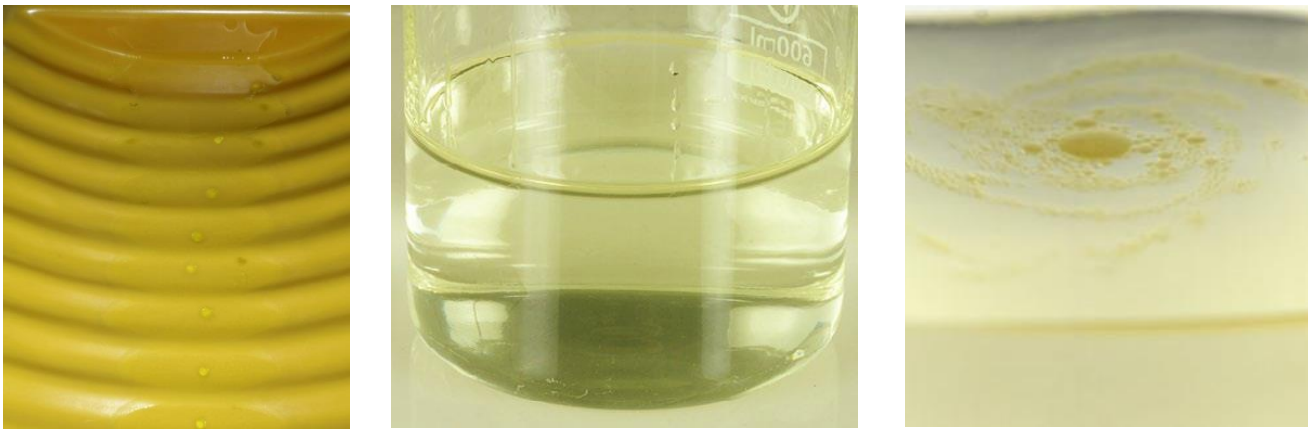
Separate Layer or Droplets on the Surface of Indandione Working Solution

Recognition
A separate layer and/or 'oily' droplets have formed on the surface of the Indandione Working Solution.



Indandione working solution with 'oily' droplets/layer floating on the surface

Cause	Effect	Prevention	Correction
The separate layer and/or 'oily' droplets is actually water. Water and HFE7100 are immiscible so when Indandione Working Solution becomes contaminated with water a two-phase solution is formed. The specific gravity of water is less than that of HFE7100 so it is the water that floats, but has the appearance of 'oil floating on water'. This can occur when water gets into the solution.	Indandione is considerably more soluble in the water phase than the HFE phase and it becomes more concentrated there. Therefore, the Indandione Working Solution becomes less concentrated than intended. As a consequence: • processed marks may appear more weakly fluorescent and weak fingermarks may be missed; • processed fingermarks may be blurred as the amino acids within fingermarks are water soluble and if the water layer comes into contact with amino acids they will dissolve or be diffused from ridge; • the 'oily' layer can be transferred and leave stains which may obscure fingermarks.	Ensure that: • acetic acid, ethyl acetate and methanol of ≥99.7% are used; • all equipment is thoroughly dried before use. In addition, some porous items, especially thermal coated papers, naturally have a high water content as they absorb water from the air, especially on humid days. In this case, preventing the layer or droplets from forming may prove difficult, but the use of small fresh quantities of solution will help.	There are no corrective measures. Dispose of solutions appropriately. **Note:** Do not filter two-phase Indandione Working Solution. Although it may remove the 'oily' layer or water phase it leaves a Working Solution that contains much less Indandione as it dissolved within the water phase and therefore will have been removed along with it.

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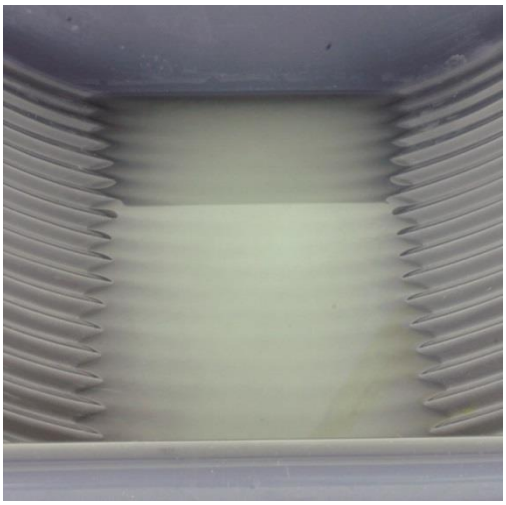
Cloudy Working Solution

Recognition



Indandione Solution prepared incorrectly (left) and a tray containing cloudy working solution (right).

Cause	Effect	Prevention	Correction
Cloudy Indandione Working Solution occurs when the dissolved Indandione or Zinc Chloride separates from the solvent - a process known as precipitation. This can be caused by: adding chemicals in the wrong order when making up the working solution; evaporation of the solvent; contaminants present in papers or the processing trough promoting precipitation of Indandione or zinc chloride.	Indandione Working Solution will contain less Indandione or Zinc Chloride than intended. Processed fingermarks may be less fluorescent and may be missed as a result.	Follow the instructions in the solution section and add the chemicals in the correct order. It is difficult to eliminate this problem when processing, but steps can be taken to ensure that the solution lasts as long as possible. Reduce the time the Working Solution is in the trough prior to treatment which minimises the opportunity for solvent evaporation. Unpacking and organising casework prior to pouring out the Indandione Working Solution will help. Minimise the volume of solution poured into the trough at a time to reduce wastage.	There are no corrective measures. Dispose of solutions appropriately. Note: Do not filter cloudy Indandione Working Solution as this removes precipitated Indandione or Zinc Chloride reducing its concentration in the Working Solution and resulting in weaker fluorescing and fewer marks being developed.

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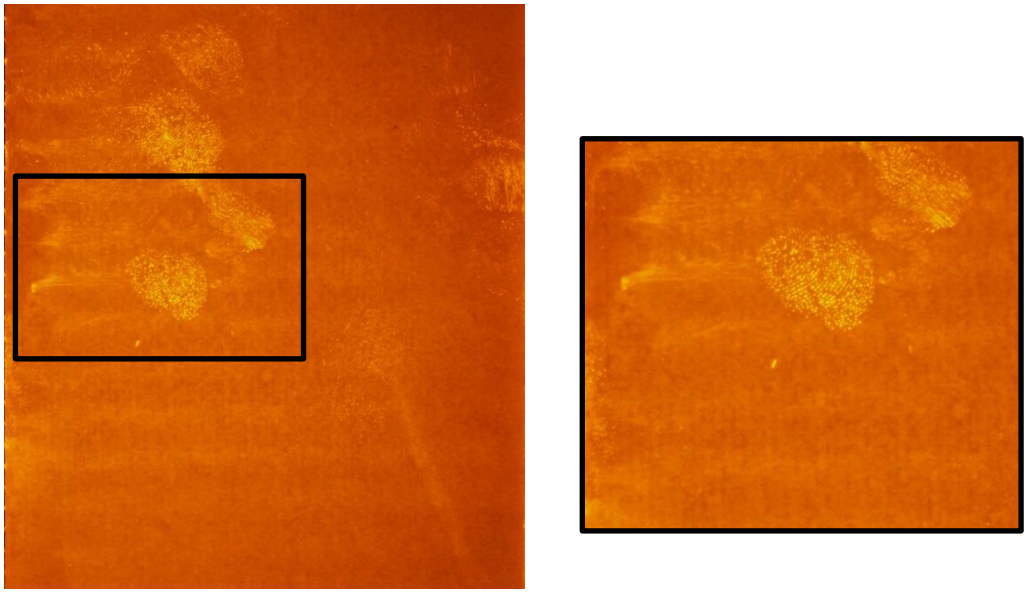
Localised Areas of High Background Development

Recognition
White writing paper treated with an amino acid reagent showing localised areas of high development.



White writing paper showing localised areas of high development.

Cause	Effect	Prevention	Correction
Evaporation of solvent occurs at an uneven rate across the surface, locally increasing amino acid reagent concentration and consequently increasing background development in regions where evaporation occurs more slowly.	Localised areas of high background development may obscure weakly developed fluorescent marks.	Ensure that: • Processed items are allowed to dry horizontally where possible; • Processed items are allowed to dry on soft surfaces with uniform surface texture, e.g. absorbent tissue instead of rigid corrugated cardboard.	There are no corrective measures.

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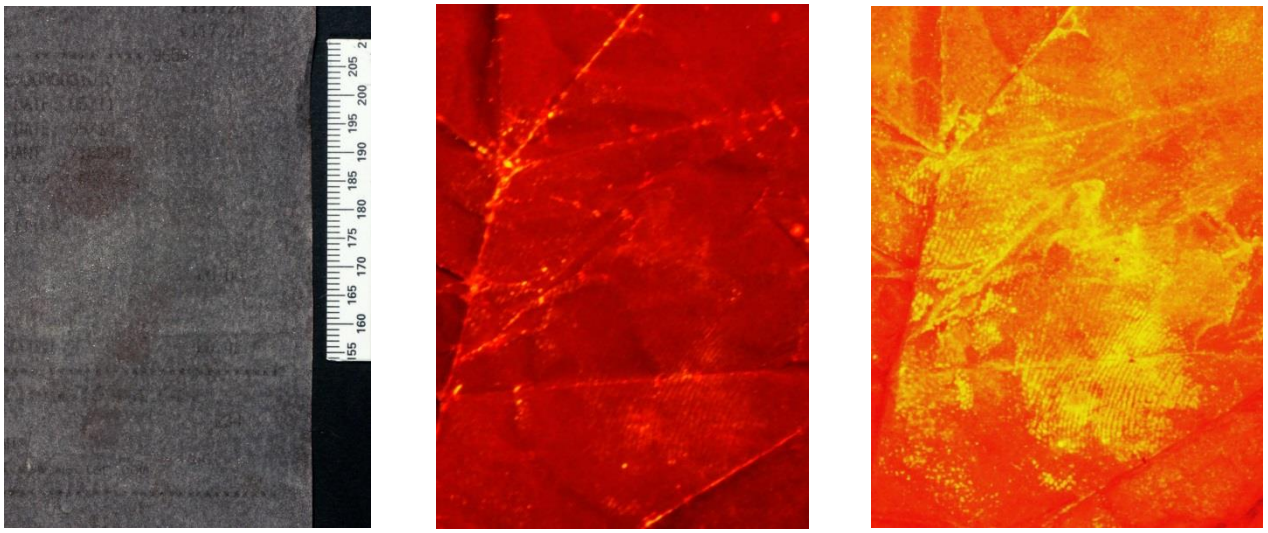
Blackening of Thermal Receipts

Recognition
A black coating has appeared on thermal receipts after processing with an amino acid reagent.



A receipt processed with an amino acid reagent showing (left) blackening post-processing, (centre) the fluorescence from the blackened receipt, and (right) the fluorescence from the receipt which has been washed to remove the blackening.

Cause	Effect	Prevention	Correction
The black coating is caused by chemical and physical interactions between the thermal layer within the receipt and the process. In particular, acetic acid in the amino acid reagents working Solution and high temperature within the oven causing blackening.	The black layer can absorb excitation and emission light during **Fluorescence Examination**. This reduces the contrast of developed marks, making them difficult to see and they are likely to be missed.	Ensure that: • the receipt is treated by the **Thermal Coating Removal** process prior to treatment with amino acid reagents; • Items are imaged prior to use of the pre-dipping method as text will be removed by the solvent.	It is possible to treat with the Thermal Coating Removal process to remove the black coating after amino acid reagents have been used. However, pre-dipping is the preferred method for the removal of thermal coatings from receipts.

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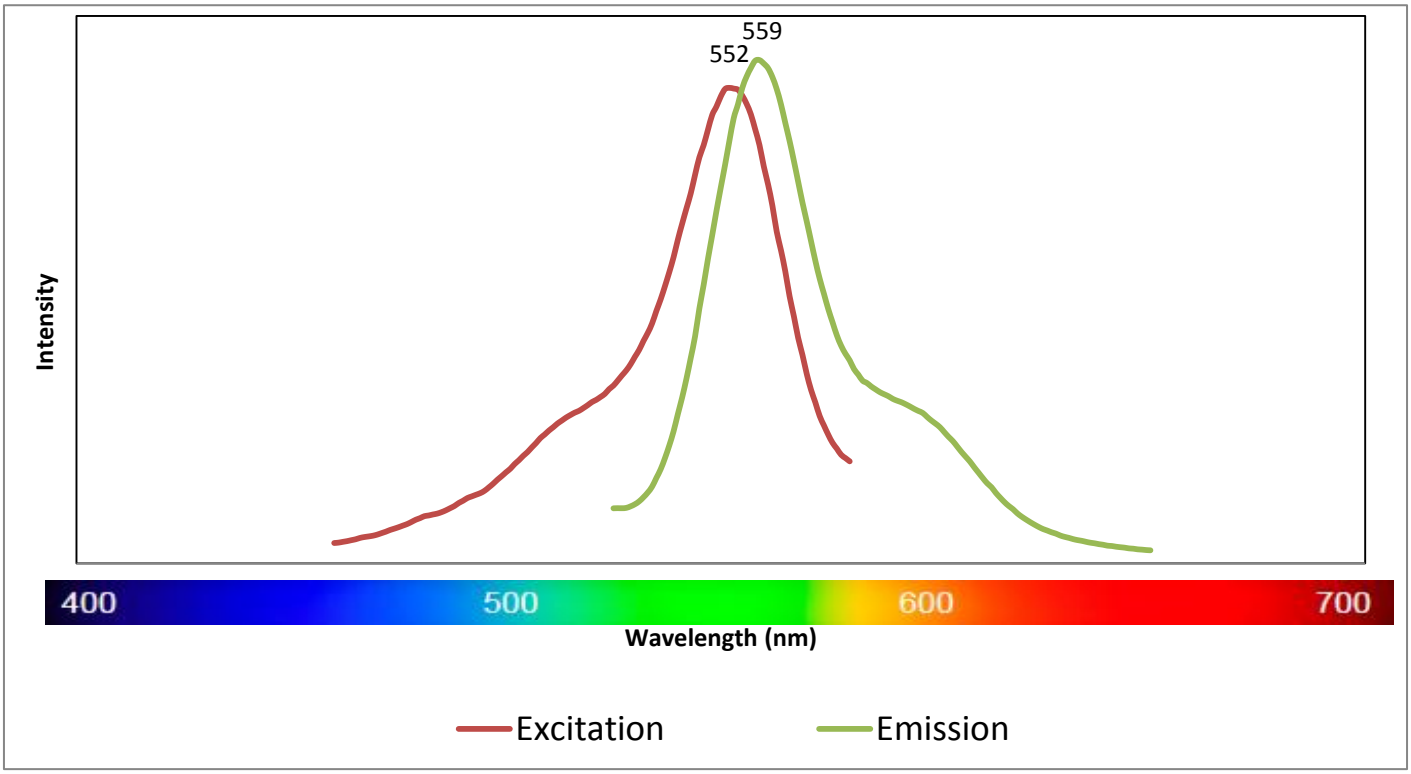
Theory

Indandione is chemically similar to Ninhydrin and it is believed that the chemical reacts with amine groups contained in amino acids and possibly other components in fingermarks. It follows a reaction pathway similar to Ninhydrin to produce a pale pink coloured product analogous to 'Ruhemann's purple' known as 'Joullié's Pink'.

The pale pink product may be faintly visible but fluoresces bright orange when excited by wavelengths in the green region of the spectrum. This is shown by the excitation and emission spectra of L-Alanine when processed by Indandione, and can provide an initial reference for establishing a suitable light source.[3] However, the spectrum is very similar to diazafluoren-9-one, and therefore similar light sources can be used.

The inclusion of both methanol and zinc ions in the formulation increases the fluorescence of developed marks. They promote the initial reaction with amines and zinc ions have been found to stabilize a critical reaction intermediate compound so that the reaction can proceed to Joullié's Pink. It is also thought that some constituents of paper, in particular cellulose, may assist with catalysing and stabilising some of the early intermediates and possibly the final product.

The rate of reaction between Indandione and amines is increased considerably by heat but will still proceed at normal room temperature, although more slowly, making Indandione useable at scenes of crime, provided the scene can be blacked out so the fluorescence can be seen more effectively.



Excitation and emission spectra measured for 1,2 indandione reacted with L-alanine on a substrate of filter paper.

[3] *The spectra presented is for the analysis of 1,2 indandione reacted with L-alanine. There may be some variation in the exact spectra of fluorescence from realistic items due to variability in conditions.*

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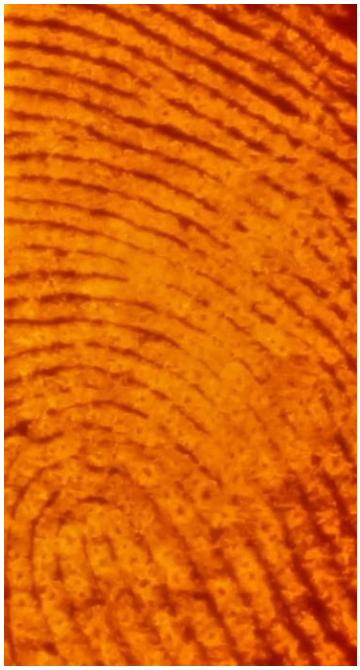
Blood and some other body fluids such as semen and vaginal fluid contain a high concentration of proteins, which are made up from amino acids so these will also react strongly with Indandione. However, the haem group in haemoglobin strongly absorbs both the excitation and emission light so it is generally only productive to treat light deposits of blood with Indandione.

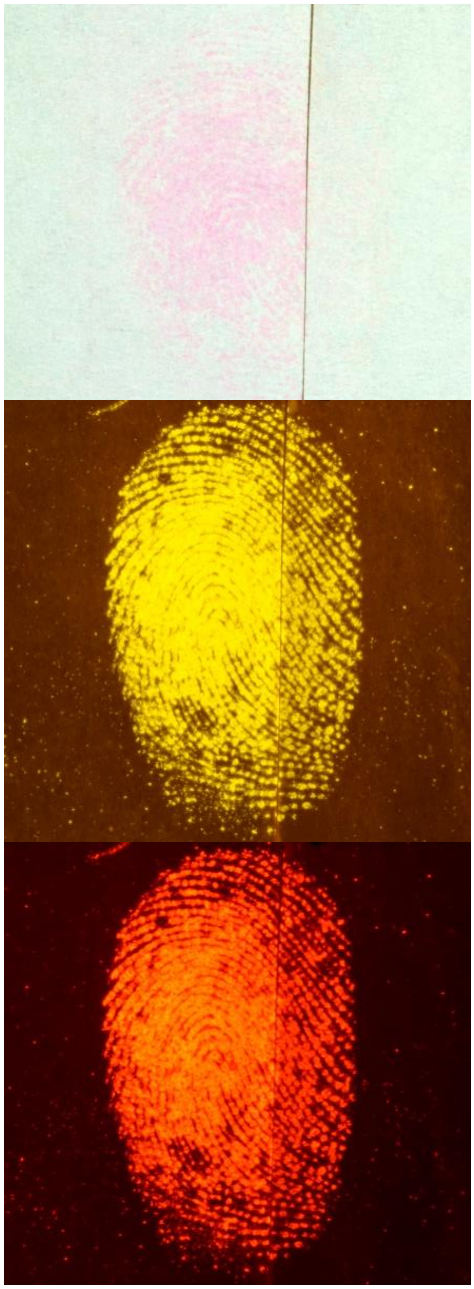
Ninhydrin and Indandione

Ninhydrin and Indandione are both 'amino acid reagents' and Indandione is the most sensitive. However, Ninhydrin is used in sequence after Indandione as it finds additional marks. There are several theories for this.

1. There may not be sufficient Indandione to completely react in a 2:1 ratio with all amino acids present.
2. That Ninhydrin reacts with a wider range of amino acids than Indandione and also some non-amino containing compounds.
3. The reaction between Indandione and some amino acids may not proceed to completion.



A close-up of a mark visualised with Indandione



The same mark visualised using different wavelengths of light: White light showing the Joullié's Pink colour (top); Blue-Green (460-510 nm) illumination and OG550 nm viewing filter (middle); Green (490-560 nm) illumination and OG590 nm viewing filter (bottom).

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A NEW PHYSICAL DEVELOPER FORMULATION

Our March 2019 newsletter reported promising results of a new formulation of Physical Developer (PD). In this new solution, we have replaced one of the reagents in the stock detergent (Synperonic N) with Decaethylene glycol mono-dodecyl ether (DGME). Vaughn Sears (now retired ex-CAST staff) found the detergent DGME and led on the validation work. While comparisons were going on at CAST, we shared our formulation and results with Leicester University who were looking at the mechanism for how Physical Developer works. The validation work is now complete and the results show that the new Physical Developer formulation works as effectively as the current Fingermark Visualisation Manual (FVM) (1st Edition) formulation. Therefore, we now encourage practitioners to transition across to the new formulation as soon as possible.

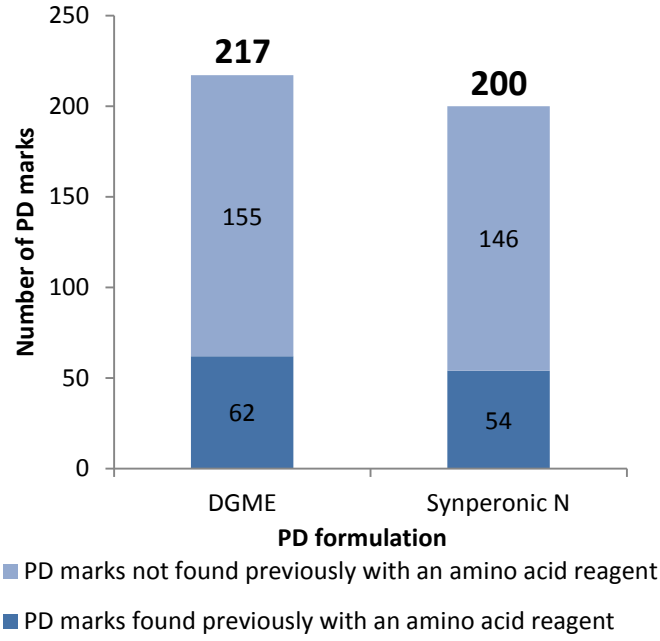
Pseudo-Operational Trial Results

The final stage of the Physical Developer validation was a pseudo-operational trial. This study compared the new formulation to the current FVM formulation using approximately 660 realistic paper and cardboard samples. These items had been treated previously with DFO or Indandione (IND) followed by Ninhydrin as part of the validation studies for the new Indandione.

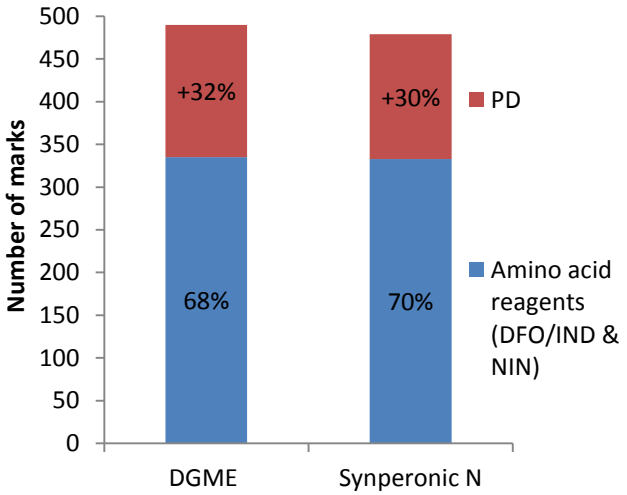
Each sample was treated with one of the two Physical Developer formulations and any developed marks that had an area of clear ridge detail greater than 64 mm^2 were counted and photographed. The study showed similar performance with the new Physical Developer formulation developing 217 marks and the current FVM formulation developing 200 marks. This data is represented in the top graph in the next column.

The graph also highlights the benefit of Physical Developer in a sequential process after amino acid reagents. Of the 417 marks developed by Physical Developer (both formulations), 301 of these were unique to Physical Developer and would have been missed had the sequence stopped at Ninhydrin.

To demonstrate this point, the bottom graph shows the data from both the amino acid *and* Physical Developer pseudo-operational trials. It clearly shows the added benefit of Physical Developer at the end of a sequence as 30-32% additional marks were developed on top of those found with the amino-acid sequence.



A graph showing the total number of Physical Developer marks visualised in the pseudo-operational trial consisting of 660 items pre-treated with amino-acid reagents.



A graph showing the number of marks developed at the two stages of the processing sequence

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Fingermarks visualised by the new DGME-based PD (left) and the Synperonic N PD formulation (right)

Stock Detergent Solution Availability

Within the UK, a comparative operational trial is sometimes carried out as a final-stage check that the new method is performing as expected. However, supplies of the Dstl issued stock detergent solution have been depleted during the course of the validation studies at CAST/Dstl meaning it is not possible to supply operational laboratories for such testing. Dstl consider the risk of implementing this modified Physical Developer formulation without such a trial as extremely low because: (1) it is an end-of-sequence process; (2) the alternative is to not use Physical Developer at all which will lose a considerable number of marks (as demonstrated in the graphs on the previous page).

Dstl will continue to supply the Synperonic N stock detergent solution for casework until the new formulation is brought into use or until supplies diminish (whichever is sooner). It is anticipated that we will supply stock detergent until March 2020, coinciding with the closure of our Sandridge-based laboratory, but the supply may stop sooner if demand is high; consequently, so getting the new formulation in use in your laboratory should be a priority. The new DGME formulation enables you to purchase the reagents directly from chemical suppliers and prepare the new solution in-house.

Physical Developer Process Instruction

The FVM contains full process instructions for Physical Developer in Chapter 5, and these can be followed for the new formulation. Important changes are:

Chemicals

Details of both detergents required to prepare the stock detergent solutions are provided in the table. Although the FVM does not normally provide details of specific suppliers, it will do so if critical to the process. In this case, the Pfaltz and Bauer n-Dodecylamine acetate was the only reliable product that CAST/Dstl was able to locate worldwide. If other suppliers are identified, appropriate testing must be carried out to ensure that the product is fit-for-purpose.

Common Name	Alternative Name(s)	CAS Number	Grade
Decaethylene glycol mono-dodecyl ether	DGME	9002-92-0	Lab Grade
n-Dodecylamine acetate	Laurylamine acetate	2016-56-0	Lab Grade*

*n-dodecylamine is available from Pfaltz and Bauer (although a US chemical company, its products can be bought via UK distributors).

A table showing changes to chemicals within the Physical Developer process instruction

The DGME reagent is in the form of a semi-solid and is often received in a bottle with a narrow neck. We have found it easier to gently heat the chemical in order to transfer it to a container with a larger opening.

Image of the DGME reagent showing it as a semi-solid

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Solutions

The new formulation is given below. For clarity, the highlighted changes show the differences to the current FVM formulation.

Solutions

Maleic Acid Solution
25 g Maleic acid
1 L Water

Physical Developer (PD) Working solution
900 mL Physical Developer Redox Solution
50 mL (Change from FVM) Physical Developer Stock Detergent Solution
50 mL Silver Nitrate Solution

Physical Developer Redox Solution
30 g Iron (III) nitrate nonahydrate
80 g Ammonium iron (II) sulphate hexahydrate
20 g Citric acid anhydrous
900 mL Water

Physical Developer Stock Detergent Solution **(Change from FVM)**
1.25 g Decaethylene glycol mono-dodecyl ether
1.5 g n-Dodecylamine acetate
1 L Water

Silver Nitrate Solution
10 g Silver nitrate
50 mL Water

The new physical developer formulation

Our studies have shown that the solution is stable at lower temperatures (tested down to 15°C) and we will be removing the requirement that solutions must be kept above 17°C. However, it is still good practice to operate at room temperature.

The FVM states the guideline expiry date for the working solution is five days. However, the new formulation should be used on the day of preparation as the effectiveness drops off over time. The guideline expiry date of the new stock detergent is 12 months.

During chemical treatment, it was observed that the processing time of items in the new formulation was similar, if not slightly quicker (typically in the range of 15-20 minutes).

The reformulation and validation work on Physical Developer is currently being drafted for journal publication. It is anticipated that these papers will be published in 2020 and full references will be provided when available.

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CONTACT US

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Note: Dstl's email system does not send out-of-office replies to non-Dstl accounts. To avoid delay to enquiries that are time-critical, please ensure that the central mailbox is used in preference to individual staff mailboxes.

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Publications

Past newsletters and the Source Book v2.0 (second edition) can be found on the following website: https://www.gov.uk/government/collections/centre-for-applied-science-and-technology-information#fingermark-documents

For sales of the Fingermark Visualisation Manual (FVM) please contact Clare Polley, Official/Library Channel Sales Manager, Williams Lea Tag, WLT (Clare.Polley@wlt.co.uk)

Home Office Commissioning Hub

This fingermark visualisation research has been funded by the Home Office. If you have a new work requirement that you would like the Dstl team to explore, please contact the Home Office Commissioning Hub, who are responsible for tasking Dstl on behalf of the UK Home Office & Law Enforcement; their email address is CommissioningHub@homeoffice.gov.uk.