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Technical Note

# Blood or not blood—That is the question. A non-destructive method for the detection of blood-contaminated fingermarks

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ABSTRACT

Working in crime scenes presents a challenge to the forensic scientist, as some surfaces, such as floors and walls, cannot be transferred to the lab for further development and must, therefore, be processed at the crime scene itself. Two main types of latent fingermarks may be encountered in crime scenes: amino acids based and blood contaminated. One of the most common reagents, which are able to develop both types of fingermarks on porous surfaces, is ninhydrin. As blood contaminated fingermarks may be crucial in connecting the suspect to the crime it is important to be able to distinguish between them and natural fingermarks. More than a decade of experience in crime scene investigations led to the understanding that there is a clear visual distinction between natural and blood contaminated fingermarks that are developed by ninhydrin. This study attempted to translate the visual difference into a mobile, non-destructive spectrophotometric method that can be used in crime scenes. Three independent spectrophotometric approaches were examined. The first showed a clear difference between the UV–vis spectra of the solution of blood and ninhydrin versus that of Ruhemann's purple. The second introduced another method in the solid phase to better simulate a real exhibit found in crime scenes. Once establishing the scientific foundation for the visible difference, a third technique for colour measurements was used in order to provide a potentially fast, quantitative, accurate and non-destructive field test for blood determination at the crime scene.

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## 1. Introduction

The importance of blood contaminated fingermarks in criminal investigations is indisputable, as they may indicate the involvement of a suspect in the crime. In order to obtain the best possible results, two essential requirements should be fulfilled: first, the determination of blood by a reliable method [1–8] and second, applying a sensitive and effective technique for developing a high quality fingermark. Several chemical tests are known for blood identification such as the commonly used phenolphthalein [9,10], and other peroxidase reagents that are catalyzed by the heme group [5,7] as well as some non-destructive light-source or spectroscopic tests [11,12]. Among the developing techniques are the widely used reagents for blood contaminated exhibits, divided according to the type of surface: porous [13–16] or non-porous [14,17,18]. Quite often in crime scenes, a need arises to also develop fingermarks on irremovable surfaces, such as floors and walls. Plaster walls, which are commonly found in crime scenes, are porous surfaces and, thus, suitable for development by ninhydrin (Fig. 1) [19]. The ninhydrin reacts with amino acids that are present in sweat as well as in blood [13,16]. Over a decade of experience by the authors in crime scene investigations led to an understanding that there is a clear visual distinction between natural and blood contaminated fingermarks, developed by ninhydrin (Fig. 2). However, this clear distinction is insufficient in a court of law for the determination of blood, and still requires a scientific method to support this observation. Nowadays, the operational tools available to the forensic scientists for the determination of blood contaminated fingermarks are chemical-based including the well-known Kastle–Meyer test [9,10] or the leuco-crystal violet (LCV) reagent [13,20]. However, all these methods may lead to false-positive results as well as being destructive as can be seen in Fig. 3[b], where the ninhydrin developed fingermark are washed away after applying the LCV reagent. Hence, it is strongly desirable to find a new scientific technique, which will enable an immediate, accurate, as well as non-destructive determination of blood in the crime-scene. In this study, the authors wished to harness this colour difference between natural and blood contaminated

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**Fig. 1.** Development of latent and blood-contaminated fingermark by ninhydrin on plaster walls in a crime-scene.

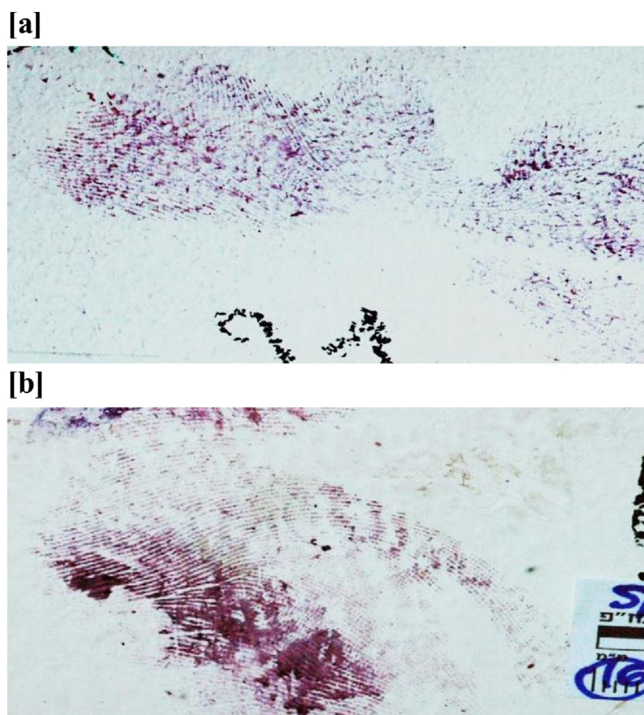

**Fig. 2.** Ninhydrin-developed fingermarks on a plaster wall: [a] latent natural fingermarks; [b] blood-contaminated fingermarks.

fingermarks to their advantage by proposing the application of colour spectrophotometry as a neat solution for the above challenge. Three independent spectrophotometric methods were used: The first attempted to confirm the observed colour difference by UV–vis measurements in solution, while the second measured the reflectance in the solid state. In the third experiment, a colour measurement technique was proposed for examining the potential for a future fast, accurate and non-destructive field device for blood determination at the crime scene.

## 2. Materials and methods

Most of the chemicals were purchased from Bio-lab, Israel, unless stated otherwise. Glycine was purchased from BDH (Pool, UK). HFE 7100 was purchased from 3 M,

Blood was voluntarily donated by the one of the authors for the exclusive use in this experiment in 4 mL sterile test tubes (BD Vacutainer) with EDTA to prevent blood-clotting.

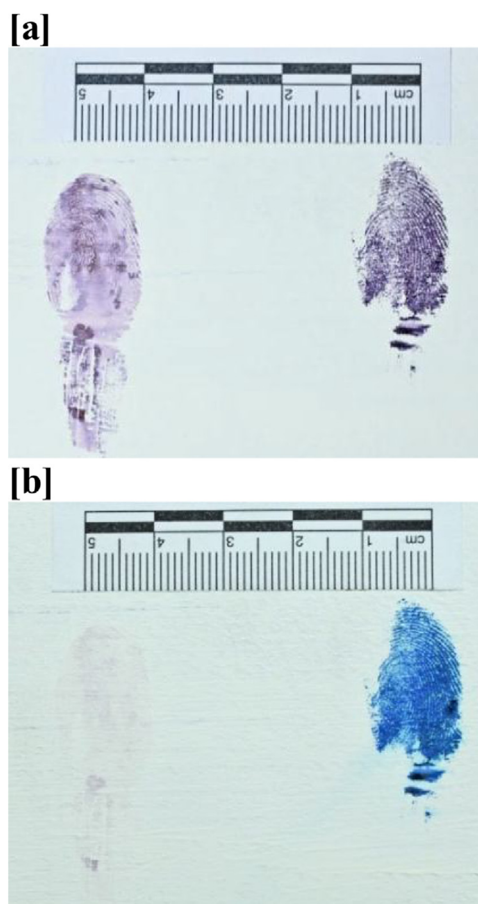

**Fig. 3.** A latent natural fingermark (left) and a blood-contaminated fingermark (right) on a plaster wall surface after development with: [a] ninhydrin; [b] ninhydrin followed by Leuco crystal violet.

### 2.1. Experiment I

A dilution of 1:400 of blood in distilled water was prepared using an automatic pipette (Genex Beta 100–1000 μL). 0.5% Ninhydrin solution was prepared by dissolving 1.5 g of ninhydrin in 300 mL of distilled water (Solution A). A 1:400 solution of blood and ninhydrin was prepared by adding 2 mL of a dilution of 1:200 of blood in distilled water to a 2 mL of Solution A. The UV–vis measurements were performed on a Shimadzu UV-1800 UV-spectrophotometer.

### 2.2. Experiment II

0.01 M solution of glycine was prepared by dissolving 37.5 mg of glycine in 50 mL of distilled water and added drop-wise onto a white copier paper (80 gsm) and allowed to dry overnight. A solution of blood in distilled water (50% w/w) was added drop-wise onto a white copier paper (80 gsm) and allowed to dry overnight. The deposition of blood-contaminated fingermarks was performed first by soaking a sterile medical pad with blood, followed by placing the finger on the pad and then depositing the fingerprints onto a standard white copier paper (80 gsm). The development was performed 24 h after the deposition. The ninhydrin solution contained 5 g of ninhydrin, 2 mL ethyl acetate, 5 mL acetic acid, 45 mL ethanol, 1 L HFE 7100[15]. Development of the samples was carried out by dipping the paper in the solution and drying overnight in a fume-hood. Colour measurements of the samples were carried out using a DataColor 650 instrument from Data Color (Lawrenceville, NJ, USA).

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