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Studies on the development of latent fingerprints by the method of solid–medium ninhydrin

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ABSTRACT

A new series of fingerprint developing membrane were prepared using ninhydrin as the developing agent, and pressure-sensitive emulsifiers as the encapsulated chemicals. The type of emulsifier, plastic film, concentration of the developing agent, modifying ions and thickness of the membrane were studied in order to get the optimized fingerprint developing effect. The membrane can be successfully applied to both latent sweat fingerprints and blood fingerprint on many different surfaces. The sensitivity of the method toward the latent sweat fingerprint is 0.1 mg/L amino acid. The membrane can be applied to both porous and non-porous surfaces. Fingerprints that are difficult to develop on surfaces such as leather, glass and heat-sensitive paper using traditional chemical methods can be successfully developed with this membrane.

1. Introduction

The fingerprint is one of the most important evidences of crime scene. In most cases, the fingerprints on many types of surface are invisible. The study of fingerprint developing methods is always one of the hot topics in the forensic science area. The traditional used fingerprint development methods are chemical processes. Commonly used chemicals for fingerprint development on porous surfaces are ninhydrin [1,2] and 1,8-diaza-9-fluorenone (DFO) [2–4]. There have been a number of improvements to the ninhydrin development method such as treatment with divalent metal ions [5,6], freeze-treatment with liquid nitrogen and treatment with laser or visible light [7]. In 1997, a new fingerprint developing agent, 1,2-indanediones was reported by Ramotowski et al. [8].

Most of the previous studies focus either on the synthesis of the ninhydrin-similar chemicals or the post-treatment after fingerprint development. With the improvements of these processes, the sensitivity has increased. Ninhydrin is a successful reagent for developing latent fingerprints on porous surfaces and has sufficient sensitivity for real-life application. However, there are several limitations to using ninhydrin, such as background coloration, dissolution of the printing ink and its flammable characteristics. In 1974, a most remarkable breakthrough in optimizing the formulation of the ninhydrin reagent was reported by Morris. They described an improved ninhydrin reagent based on another nonpolar solvent, Freon 113, or CFC113. This formulation is nonflammable, nontoxic, and doesn't dissolve ink on documents [9]. In 1997, a formulation that appeared to satisfy all the requirements for fingerprint work was based on the work of Hewlett and Suzuki, which uses the solvent HEE7100 as the carrier [10,11]. This provides a safe and effective replacement to Feron 113 in the ninhydrin process. However, solid–medium ninhydrin method can overcome these disadvantages, by avoiding the need for the ninhydrin development cabinet, developing fingerprints more quickly detecting fingerprints on both porous and non-porous surfaces.

In this work, a new fingerprint development method was studied which involves the stabilization of ninhydrin in a membrane, together with the encapsulated chemicals. A new series of fingerprint developing membrane (FDM) were prepared and applied to many different surfaces. The membrane's preparation and application are reported in this article. It is a non-destructive fingerprint development method.

2. Experimental

2.1. Materials and chemicals

The pressure-sensitive emulsifiers were used as the encapsulated chemicals. Three kinds of water-soluble pressure-sensitive

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emulsifier: general emulsifier, combined emulsifier and reacting emulsifier were used and were self-prepared in our laboratory. Liposoluble pressure-sensitive emulsifier was from Changchun Chemical Institute of Chinese Academy of Science. Dichlorodibutyltin was used as the organic tin compound and was supplied by Chinese Northeastern Normal University. Ninhydrin and other chemical pure reagents were purchased from Tianjin Chemical Institute. The separating papers were obtained from The Seventh Paper Plant in Beijing.

2.2. Preparation of the FDMs

The water-soluble FDMs were prepared by spreading the parent mixture solution of the developing agent (ninhydrin) and water-soluble pressure-sensitive emulsifier (polyvinyl alcohol) on polypropylene film. Similarly, the liposoluble FDM was prepared by using the mixture of ninhydrin and liposoluble pressure-sensitive emulsifier (polyacrylic). The liquid membrane obtained was then dried at 70 °C for 5 min and covered with the separating paper ready for use. The membrane was spread out in a controlled manner to a thickness of 10–20 μm.

In order to color the enhanced fingerprint, 1% dichlorodibutyltin was added as the organic Sn compound to the parent mixture solution of the ninhydrin and emulsifier, to get the modified FDM.

2.3. Fingerprint developing

Prior to laying down the fingermarks a grooming procedure developed for this study was carried out. This was intended to mimic natural behavior and minimize variability due to exogenous sources. The grooming procedure was as follows: (1) hands were washed three times thoroughly with soap; (2) fingers were then gently wiped across the forehead; (3) latent fingermarks were deposited onto the substrates with good quality. 100 sebaceous fingermarks from ten healthy donors aged from 20 to 40 were collected on different paper types, such as print papers, heat-sensitive papers, news papers and leather. The images were taken with a Nikon D 80 digital camera and a Nikon 60 mm60F/2.8D Macro Lens.

The latent fingerprint samples were left for 30 min before being covered with the FDM and tightly pressed for a few minutes after which development had occurred. The time needed to the develop the fingerprint is dependent on the aging of the fingerprint. Older fingerprints need more time to develop. The developing time could be shortened by using UV or sun light irradiation, or heating with a flatiron (70–110 °C) or hot water bottle. The heating time with a flatiron should not be longer than 30 s. In this article, the 100–110 °C flatiron was used to accelerate fingerprint development. The development should be checked every 3–5 s to avoid darkening the background due to the excessive heating.

The sensitivity of this process was tested using the following procedures. For the sweat fingerprint, aqueous glycine solutions of different concentrations (0.005, 0.01, 0.05, 0.5, 1.0 mg/L) were added dropwise to thin layer chromatographic plates, which were then kept in room conditions for 1 h before development with the FDM. For the latent blood fingerprint, human blood was diluted with distilled water before being inked on the print-paper. The FDM was then used to develop this.

3. Results and discussion

3.1. Study on the FDM preparation

3.1.1. Screening on the encapsulated chemical

Three kinds of water-soluble pressure-sensitive emulsifier: general emulsifier, combined emulsifier and reacting emulsifier were screened as the encapsulated chemical to get the optimized water-soluble FDM. All the FDMs performed well at developing the latent fingerprints but each effect the background differently. Then the water-soluble FDM with the reacting emulsifier, and liposoluble FDM were chosen for the following studies.

3.1.2. Selection of the plastic film

There is no other need for the plastic film other than the softness, transparency, extending strength. In this study, polypropylene film was used. The surface of the plastic film must be treated with the electric corona to get satisfactory adsorpstion.

3.1.3. The concentration of the developing agent (ninhydrin)

The optimization of the concentration of the fingerprint developing agent has been well studied by many other researchers [12–15]. It was found in this study that the concentration of the developing agent ninhydrin in the parent mixture solution needs to be controlled at 0.5–2.0% (w/v). Concentrations lower than 0.5% would decrease the sensitivity and concentration higher than 2.0% would destroy the stability of the liquid membrane. Concentrations higher than 10% cause background to darken during development.

3.1.4. Effect of the modifying ion

The divalent Zn^{2+} and Cd^{2+} ions are traditionally used to enhance the effects of fingerprint development. In this study, introducing modifying ions into the water-soluble membrane would accelerate the inner and external transportation of the developing agent in the liquid membrane. The homogeneous dispersion of the ions in the liposoluble membrane could not be obtained due to their low solubility. The organic Sn compound (dichlorodibutyltin) was used as a modifying agent. Users should wear suitable protective clothing, gloves and eye protection, and avoid release into the environment. A good result was obtained as shown in Fig. 1. A similar color could be obtained using either the organic Sn compound or Zn^{2+} ion. The combination of the Sn organic compound with the fingerprint developing agent gives the better effects. And furthermore, the fingerprint development process is much simpler.

3.1.5. Controlling of the thickness of the liquid membrane on FDMs

The thickness of the liquid membrane has an important influence on the fingerprint development. The agents in the thick membrane are difficult to transport to the samples and would get no developing effects on the latent fingerprints. A thinner membrane has less agents resulting in poorer development. In this study, it was found that the optimized thickness of the liquid membrane is 10–15 μm. The dissolved solid content in the parent

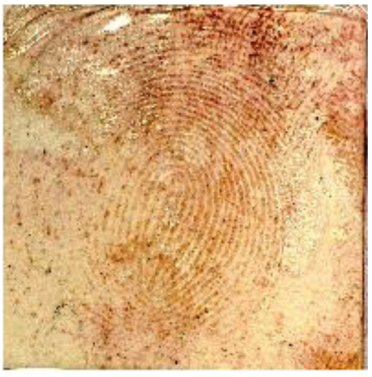

Fig. 1. Fingerprint on print-paper enhanced using Sn modified FDM. (Natural Fingerprint left on paper for 10 days).