Vacuum Vaporization Technique for Latent Fingerprints Development on Thermal Papers using Lawsone Natural Products

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Abstract. The vacuum vaporization technique is widely used to develop of visualized latent fingerprints on substrate surface for forensics investigation. In this study, we reported the first utilization of lawsone in the vacuum vaporization technique. The lawsone was sublimation in vacuum and showed the detected latent fingerprints on thermal papers. The method involves hanging the thermal paper samples 5, 10, 15 cm above a heating source with dispersed lawsone solids in a vacuum chamber. The optimized condition for lawsone sublimation are 50, 100, 150 mg with low-vacuum (0.1 mbar) and vaporizing temperature at 40-60°C. The sample fingerprints were left for 1, 3, 7 and 30 days before examination comparison between lawsone and fingerprint ink pad using an Automated Fingerprint Identification (AFIS). The resulted showed that using 100 mg lawsone sublimation on thermal paper at the range of 10 cm evidenced the clear, detectable minutiae which can be used for visualization and identification of latent prints without the background black staining known. Thus, thisstudy might be interested application for developing latent fingerprints as a solvent free technique and non-hazardous materials.

1. Introduction

The vacuum vaporization is a technique of thin-film deposition in which the metals were brought into the gas phase by thermal sublimation and deposited to the surface of substrate for a thin film. This process is widely used in the semiconductor, microelectronic and optical industries. Currently, this technique is applied for visualized latent fingerprints as known as Vacuum Metal Deposition (VMD) [1-4]. For example, gold was deposited on polyethylene substrates to develop fingerprints [5], copper and gold can deposit on the polymer banknotes to visualize latent fingerprints [6] and gold/Zinc VMD was also successful to visualized the fingerprints on fabrics [7]. Moreover, the organic chemicals were also succeeded to develop latent fingerprints instead of metals e.g. the use of solid ninhydrin used develop the latent fingerprints on porous surface [8]. Thus, the organic chemicals that can undergo thermal sublimation and visualization are of interest to study for the vacuum vaporization. Lawsone is a naphthoquinone natural products from the leaves of *Lawsonia inermis* has been used as a skin and hair dye as its reacts with amino acids of keratin. The lawsone solution can also react with latent fingerprint deposits on paper surfaces to show purple-brown impressions of ridge details which are also photo luminescent [9]. Detection of latent fingerprints on thermal paper is an

increasing problem in criminalistics, because thermal paper prevails on the credit card receipt market, ATM paper and etc. Thermal papers show background black staining on the heat-sensitive front side when treated with conventional techniques like ninhydrin in petroleum ether or DFO solution. Consequently, fingerprints and information on the receipt will be destroyed. Thus, the fingerprint detection on thermal paper using the lawsone sublimation under reduced pressure was investigated. As the solvent free technique and ambient temperature, the thermal papers as evidence for forensics investigation will not be ruined. The optimization of the vacuum deposition parameters (quantity of lawsone, distance between sample holder and heating source, vaporization source and vacuum pressure) to development of latent fingerprints on thermal papers was also reported.

2. Materials and method

2.1. Instrument and chemical

In this study, the thermal evaporation equipment was used. This equipment produces a vacuum system in low-vacuum range (0.1 mbar). The heating source is tungsten dimple boat placed in vaporization source, that connected with high current (10 - 200 A) power supply. Thermocouple used for detect the temperature and pressure observed by active pirani gauge and controller from Edwards Limited. 2-hydroxy-1,4-Naphthoquinone (lawsone) purchased from TCI Chemicals. The new thermal paper purchased from Tesco.

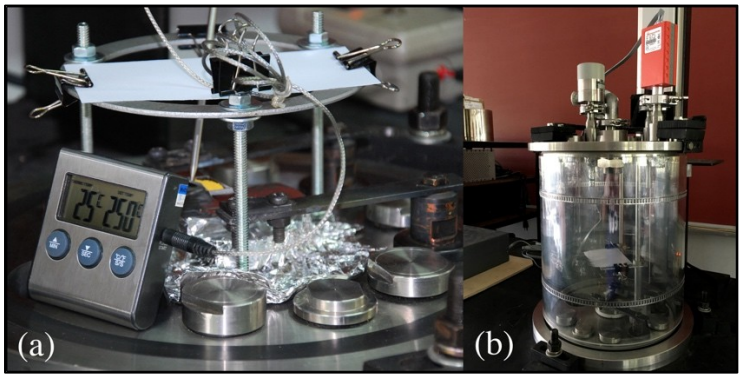

Figure 1. A composition of experimental equipment (a) and when chamber covered it (b)

2.2. Experiment

Sample preparation: Fingerprints were deposited upon the surface of each new thermal paper by one male donor. The fingertips along the forehead and side of nose were briefly wiped onto the thermal papers for the sebaceous fingerprints. The thermal papers were kept in the envelopes for 1, 3, 7 and 30 days after deposited.

Experimental procedure and data collection: Lawsone was put in a tungsten dimple boat and placed in the vaporization source. A deposited thermal paper was placed on the holder and covered on vaporization source. The thermocouple was placed in the lawsone boat for temperature measurement and covered all with glass chamber. Once the vacuum inside the chamber reached 0.1 mbar, the source boat temperature was raised by applyied high current (30 A) until the lawsone was vaporized to the gas phase. This process took about 3-5 minutes and vaporization temperature was in the range of 40-60 °C. When the gas phase of lawsone deposited on the thermal paper surface, the lawsone reacted with fingerprint and appeared the yellow sign of fingerprints on the substrate. A deposited thermal paper was taken out from the chamber and photographed using a Nikon D5100 digital camera for 2 light conditions (white light and Ultraviolet light). The photos in Ultraviolet (UV) light condition were analyzed by Automated Fingerprint Identification System (AFIS) for numbered the minutiae and the results were discussed.

2.2.3. Optimization the parameter

Quantity of lawsone: The quantity of lawsone (50, 100 and 150 mg) was studied for the optimal amount of lawsone for developing the clear latent fingerprints. The amount of lawsone used was estimated from the size tungsten dimple boat. The sample papers were folded parallel and centered of the vaporization source.

Distance between sample and vaporization source: The distance between sample and heating source is important for vacuum vaporization technique. In this study, three distances (5, 10, and 15 cm) were compared for the optimal ranges for the clear latent fingerprints.

Aged of fingerprints: In the study, the development fingerprints were deposited on thesurface of thermal paper different the ages to test the efficiency of this application. After deposited the finger on thermal paper, the fingerprints were absorbed onto the papers. Thus, the longer time passed, the fingerprints were hardly to develop. The age of fingerprints studied were collected for 1, 3, 7 and 30 days.

3. Results and discussion

3.1. Quantity of lawsone

For 50 mg of lawsone batches were studied. It showed clear yellow fingerprints on surface of thermal paper when photographed in white light. When photographed in UV light, brown-yellow fingerprints were visualizing. The numbers of minutiae after processing in AFIS have 97 points. It more than to personal identification (that result can be seen in Figure 2). For 100 mg lawsone batches, the clear darken-yellow fingerprints were shown, while the 150 mg lawsone used, the more darken-yellow fingerprints were appeared but the fingerprints were uncleared as the lined patterns were too squeezed and hardly identified (Figure 3).

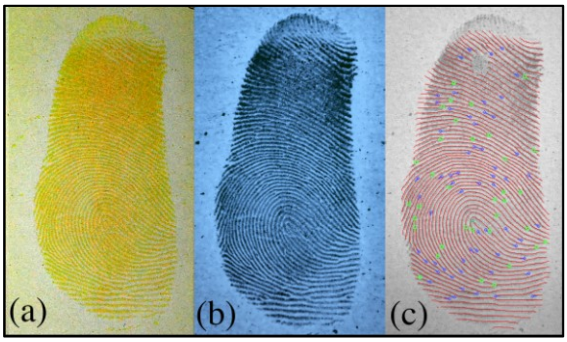

Figure 2. The fingerprints of 100 mg lawsone, photographed in white light condition (a), UV light condition (b) and counted of minutiae in AFIS (c)

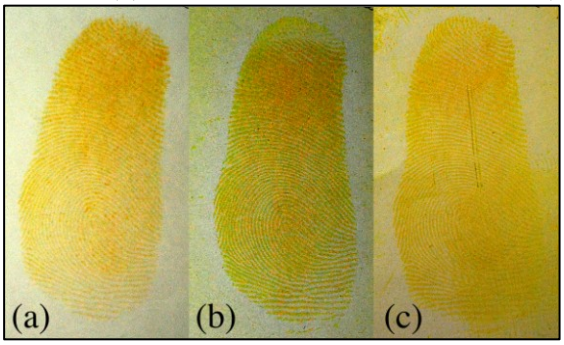

Figure 3. The fingerprints of 50 mg (a), 100 mg (b) and 150 mg (c) lawsone

3.2. Distance between sample and vaporization source

The result showed that the longer range have fader fingerprints than the shorter range. The optimal range is 10 cm. It has clear fingerprints and most efficiency for personal identification. That result can be seen in Figure 4.

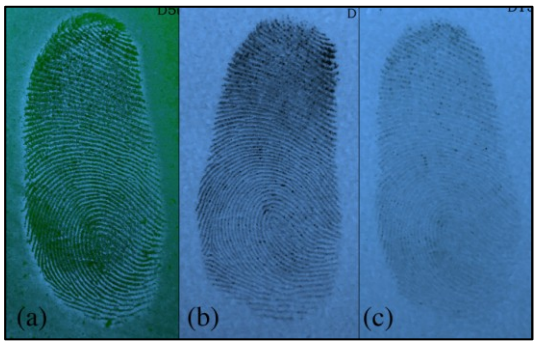

Figure 4. The fingerprints (in UV light) of distance between sample holder and vaporization source of 5 cm (a), 10 cm (b) and 15 cm (c)

3.3. Age of fingerprints

The age of evidence impacted the efficiency of criminalistics. For the studied of 1, 3 and 7 days of fingerprints left on the thermal papers, these showed the more effective clear fingerprints and have number of minutiae from AFIS much better than personal identification. Surprisingly, the 30 days' fingerprints also showed a clear sign of fingerprints. Thus, these results showed that the more efficiency of this application for development latent fingerprints on thermal papers and the results can be seen in Figure 5.

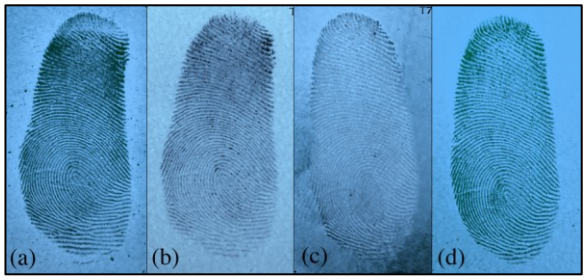

Figure 5. The fingerprints (in UV light) of age 1 day (a), 3 days (b), 7 days (c) and 30 days (d) of fingerprints

4. Conclusions

This study showed that fingerprints on thermal papers are more effectively developed using lawsone natural products with vacuum vaporization technique. The sample fingerprints were left for 1, 3, 7 and 30 days later before examination. The result showed that using 100 mg lawsone sublimation on thermal paper at the range of 10 cm under low-vacuum (0.1 mbar) evidenced the clear, detectable minutiae which can be used for visualization and identification of latent fingerprints without the background black of thermal paper. These results of fingerprints were depended on a deposition of fingertips. This study might be interested in the application for developing latent fingerprints as a solvent free technique and non-hazardous materials.

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