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REVIEW ARTICLE

Physical developer method for detection of latent fingerprints: A review

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Abstract: The physical developer technique is a means to detect fingerprints on dry and wet, porous items, including paper articles, clay-based products and adhesive tapes. The process involves an oxidation–reduction couple whereby a solution of an iron salt reduces aqueous silver nitrate to finely divided metallic silver. The technique derives its name from the photographic physical developer which, during processing of film rolls, undergoes a similar redox reaction. The physical developer reveals the fingerprints as dark gray or black images due to the adsorption of metallic silver particles on the fatty acid and lipid components of sweat residue.

Contents

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1. Introduction

A latent fingerprint is formed when the sweat pores of the papillary ridges leave a deposition of perspiration on a surface with which the finger has been brought into contact.[1] The Human body possesses the following three types of glands – *viz*. eccrine, apocrine and sebaceous, the secretions of which contribute to a fingerprint deposit.[2]

Eccrine glands are widely distributed throughout the body and are particularly numerous on the palms of hands and the soles of feet. These glands secrete a host of chemicals as fallout of metabolism and catabolism. Besides water content, eccrine sweat contains up to 1% of other substances of which inorganic salts constitute about one-half.[3] The other half consists of organic derivatives like, urea, creatinine, choline, lactic acid, sugars, uric acid, amino acids and proteins.[4]

The physical developer technique for detection of latent fingerprints is based on the interaction between lipids and fatty acid constituents of sweat residue, with colloidal silver particles.[5] Earlier it had been known that colloidal silver particulates have affinity for such organic derivatives.[6] Since these biomolecules are essentially insoluble in water, the physical developer can detect latent impressions on wet porous items as well.[7] Moreover, the insoluble, organic ingredients of sweat are stable for prolonged periods of time, as a result of which fingerprints that are several years old may be visualized by this technique.[8,9] The developed prints are dark gray or black in color.[10]

2. Mechanism

The basis of the physical developer technique is the *in situ* reduction of silver(I) ions to colloidal, elemental silver which, in turn, interacts with the organic constituents of the fingerprint residue and ultimately visualizes the impressions as dark gray or black ridges.[11] The same redox reaction is involved in the development of photographic films.[12,13]

The physical developer composition is a mixture of the following components.[14]

(a) An aqueous solution of silver nitrate.
(b) An iron(II) and iron(III) redox couple.
(c) An acid buffer, usually citric acid.
(d) A cationic detergent, usually *n*-dodecylamine acetate.

The iron(II) ions reduce silver(I) ions to metallic silver, and simultaneously get oxidized to iron(III) ions:

$$Ag^{+} + Fe^{2+} \rightleftharpoons Ag^{0} + Fe^{3+}$$

Due to the reversible nature of this reaction, the chances are that iron(III) ions may re-oxidize metallic silver to silver(I) ions. To overcome this problem, citric acid is added to the fingerprint composition. The structure of citric acid is shown in Fig. 1.

Citric acid complexes with iron(III) ions and removes these from the equilibrium system, thereby pushing the redox reaction in forward direction. It also brings down the pH of the composition. This is important since optimum results are obtained under mildly acidic conditions.

The finely divided metallic silver particles, formed as a result of the redox reaction are colloidal in nature. It is in this state that these adhere to the fatty acid and lipid constituents of latent fingerprint and visualize the impression. However, if the concentration of metallic silver increases beyond a threshold, the particles coalesce and precipitate out. The colloidal nature of silver particles is lost and the quality of developed fingerprints tends to fall.

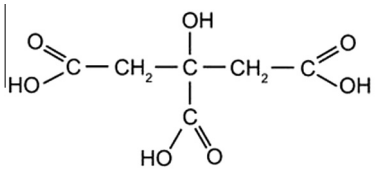

Figure 1 Structure of citric acid.

$$[CH_3(CH_2)_{10}CH_2NH_3]^{+}\ [CH_3COO]^{-}$$

Figure 2 Structure of *n*-dodecylamine acetate.

This problem is taken care of by incorporating a cationic detergent, usually *n*-dodecylamine acetate in the fingerprint composition. The structure of *n*-dodecylamine acetate is set out in Fig. 2.

The cations engulf silver particles, imparting a positive charge on to these. The positively charged particles repel each other, thereby averting the possibility of their coming close and condensing into a precipitate.[15] This phenomenon is called *peptization* and is symbolically shown in Fig. 3.

3. Pre-treatment of latent prints

The physical developer technique works very well on paper and paper products. However, the finished paper usually incorporates alkaline fillers and binders. These react with the physical developer composition and alter the concentration of its ingredients. It is therefore pertinent to neutralize the alkaline content of paper before attempting to develop fingerprints. This is carried out by giving an acid pre-wash to the paper sample.[16] Maleic acid, the structure of which is shown in Fig. 4, is commonly used for this purpose.

A solution containing 25 g maleic acid in 1 liter of water is prepared. The paper item is dipped in this solution for 5–10 min, till the bubbles cease to evolve. Thereafter, the procedure described in next section for development of fingerprints is followed.

Acetic acid[17] and malic acid[18] can serve as substitutes for maleic acids. Their structures are depicted in Fig. 4. However, chlorinated acids are unsuitable for neutralizing the alkali content of paper when physical developer technique of fingerprint detection is desired to be used. A pre-wash with dilute hydrochloric acid, for example, results in the formation of silver chloride which, almost instantaneously, decomposes into finely divided, black silver and darkens the background surface.[14]

4. Methodology

The following three solutions are required for detecting fingerprints by the physical developer method.[19]