Forensic Science International 283 (2018) 118–127

Contents lists available at ScienceDirect

Forensic Science International

journal homepage: www.elsevier.com/locate/forsciint

Effect of water immersion on multi- and mono-metallic VMD

Romain Steiner[1], Andy Bécue*

École des Sciences Criminelles, University of Lausanne, Building Batochime, CH-1015 Lausanne, Switzerland

ARTICLE INFO

Article history:
Received 21 August 2017
Received in revised form 17 November 2017
Accepted 10 December 2017
Available online 19 December 2017

Keywords:
Forensic science
Fingermark
Detection
Vacuum metal deposition
Contrast

ABSTRACT

The use of vacuum metal deposition (VMD) for fingermark detection has been known for almost 40 years. The technique is applicable on a wide variety of substrates and on wetted items. Several publications compare the relative efficiency of VMD (conventionally based on a successive vaporization of gold followed by zinc) with other detection techniques, or its ability to detect marks on difficult substrates, but few are known about the application of monometallic VMDs and about the impact of immersion on the detection performances. This study aims at partially filling that gap by offering a quantitative and qualitative glance at three VMD processes (*i.e.*, gold/zinc, silver, and sterling silver) applied to dry and wetted substrates. The impact of immersion on the detection process has been studied by using split marks (one half kept dry, the other one wetted). On immersed substrates, a modification of colour shades has been observed with monometallic VMDs (on all substrates considered) and of contrast with conventional VMD (on polyethylene). In terms of ridge details, a relatively good resistance of secretion residue towards immersion has been emphasized (in regards with VMD). This study provides original data, which will hopefully help getting a better understanding of the VMD detection mechanism.

1. Introduction

Vacuum metal deposition (VMD) is part of the currently available fingermark detection techniques [1]. It is mostly characterized by its versatility of application (*i.e.*, range of compatible substrates) and its efficiency, especially regarding difficult cases (*e.g.*, problematic substrates, adverse conditions). The technique is based on the vaporization of one or two metal(s) under vacuum, towards the item to be processed. Fingermarks becomes visible by the formation of a metallic film on the substrate (normal development) or on the secretion residue (reverse development), most likely due to a differentiated condensation mechanism. VMD was initially introduced in the forensic field in 1968 to detect fingermarks on paper [2], and was then optimized to be fully operational in the late seventies [3]. The conventional VMD process is based on the successive vaporization of gold and zinc ($VMD_{Au/Zn}$). Monometallic alternatives were also developed and offer the advantage of establishing a visible contrast in one step. They are complementary to $VMD_{Au/Zn}$ for they can develop fingermarks on substrates for which $VMD_{Au/Zn}$ results in poor performances. Monometallic VMDs can be based on silver (VMD_{Ag}) [4–8], copper (VMD_{Cu}) [8,9], aluminium (VMD_{Al}) [7,10], or palladium (VMD_{Pd}) [7], to cite a few.

In terms of contrast, $VMD_{Au/Zn}$-processed fingermarks will most likely results in transparent ridges opposed to a metal-coated substrate (Fig. 1a). This kind of contrast is not common in the field of fingermark detection, since detection techniques generally result in stained ridges (coloured or luminescent) opposed to a passive substrate. In some cases, $VMD_{Au/Zn}$ can result in fingermarks presenting ridges coated with a metal film. In that case, we speak of a "reverse" development, in regards with VMD. Finally, some processed fingermarks may present a normal contrast but no inner ridge details ("empty marks") – Fig. 1a. In this paper, the obtained contrasts (*i.e.*, normal or reverse) are qualified in regards with a conventional $VMD_{Au/Zn}$ result, that is, "coated substrate *vs.* transparent ridges". This distinction hardly applies to monometallic VMDs, which mostly result in coloured contrasts (Fig. 1b).

A strength of the VMD is its versatility of application, for it is compatible with an extended range of substrates (*e.g.*, porous, non-porous, metals, adhesives, wetted substrates) among which challenging ones, such as banknotes [9,11,12] or fabrics [5,13,14]. The use of VMD is compatible with "touch DNA" profiling [15,16] and it complements the conventional techniques as it can be introduced in detection sequences; even if no consensus does exist regarding its relative position with other techniques, especially cyanoacrylate fuming [12,17–19]. The technique nevertheless suffers from its cost (*i.e.*, a specific and costly equipment is

* Corresponding author.
E-mail address: andy.becue@unil.ch (A. Bécue).
[1] Current address: Centre for Forensic Science, University of Technology Sydney, Australia.

https://doi.org/10.1016/j.forsciint.2017.12.020

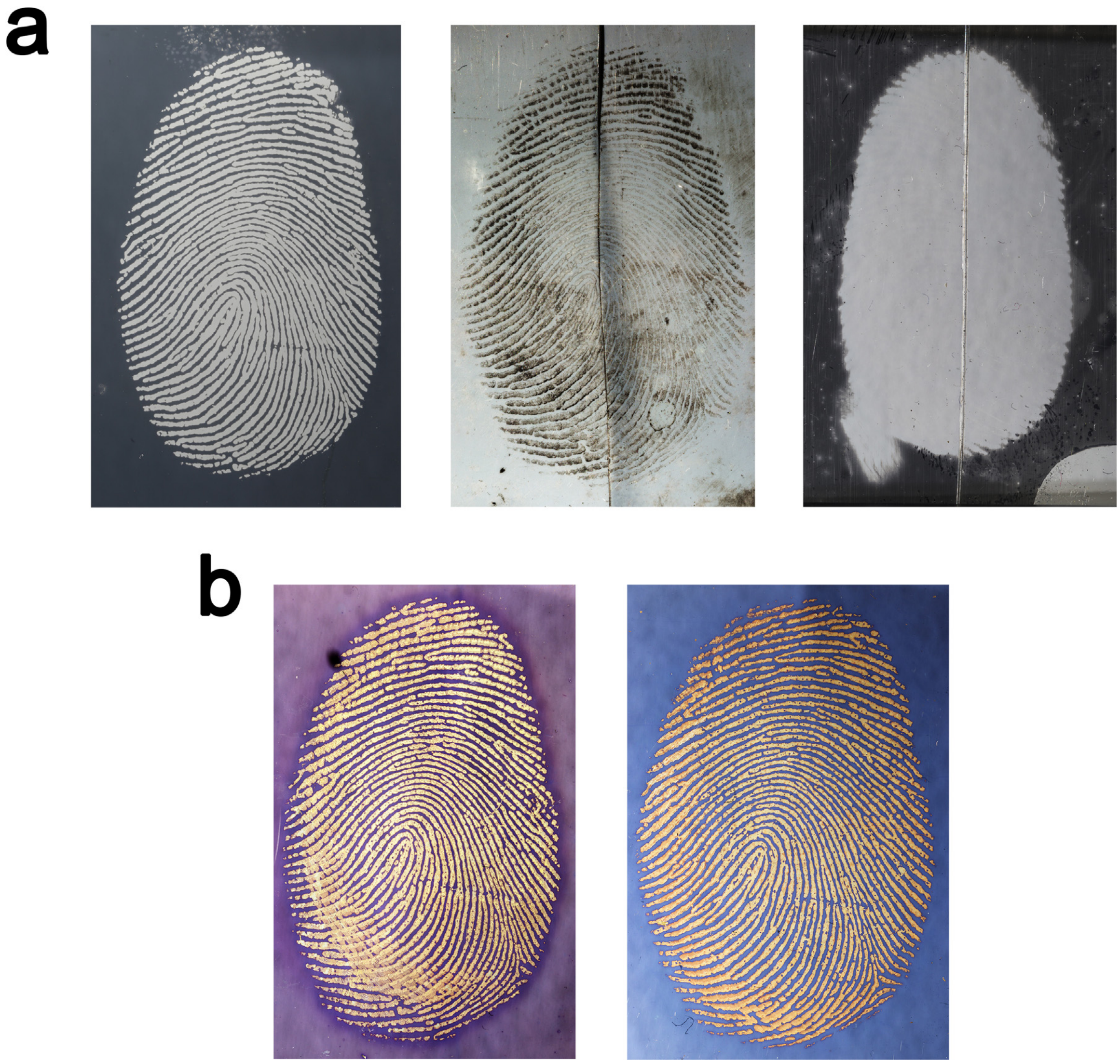

Fig. 1. (a) Illustration of the three main results obtained with $VMD_{Au/Zn}$ – from left to right: normal contrast (substrate = glass), reverse contrast (substrate = polyethylene), and hollow mark (substrate = polyvinylchloride); (b) example of colour shades that may result from the application of monometallic VMDs: VMD_{Ag} (substrate = glass) and $VMD_{Sterling}$ (substrate = polyvinylchloride).

required), the necessity to gain experience with its handling before obtaining acceptable detection results, and a detection mechanism which remains partially understood [20,21]. This results in substantial variations of efficiency according to the substrate composition, especially polymers/plastics and surface treatments [19,20,22–24]. Guidelines and best practice recommendations can be provided to users but they don't overcome all these difficulties [17,19,25]. Research in the field of VMD is consequently a valuable source of information for people willing to gain a better understanding of the technique.

This study originated from a detection course we organized about mono-/bi-metallic VMD. During this course, a hand mark (fingers and palm) was left on a PVC plastic sheet that was then briefly and partially immersed in water (half the substrate remained dry). Once dried, the whole plastic sheet was processed with VMD_{Ag}. As a result, half of the hand mark appeared with yellow/blue colour tones (dry half) while the other half appeared with blue/purple tones (wetted half). This change of colour upon immersion has not been reported in the literature yet, to the authors' knowledge. Some research has been performed on wetted items processed with $VMD_{Au/Zn}$ [26], but no systematic study regarding the impact of immersion or the use of monometallic VMD in this context. This contribution consequently aims at exploring this phenomenon and providing original data that may help getting a better understanding about the intrinsic VMD detection mechanism.

2. Materials and methods

2.1. Substrates and fingermark collection

Three non-porous substrates were chosen: white polyethylene (PE containing 50% recycled material; official state garbage bag), transparent polyvinylchloride (HiClear PVC; GBC), and glass (microscopy slides; VWR). Fingermarks were collected from three donors who were asked to leave natural marks [27]. Natural marks were exclusively used in this study, to offer a more realistic approach since secretions are not artificially enriched with sweat or sebum. The only recommendations that the donors received were to act normally, at the exception of washing their hands (prohibited 30 min before the deposition). To allow a direct comparison (*i.e.*, Situation A *vs.* Situation B), halved marks were used. For that, fingermarks left on plastics (PE and PVC) were cut after deposition; for glass, donors were asked to leave fingermarks