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Review article

Composition of fingermark residue: A qualitative and quantitative review

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ABSTRACT

This article describes the composition of fingermark residue as being a complex system with numerous compounds coming from different sources and evolving over time from the initial composition (corresponding to the composition right after deposition) to the aged composition (corresponding to the evolution of the initial composition over time). This complex system will additionally vary due to effects of numerous influence factors grouped in five different classes: the donor characteristics, the deposition conditions, the substrate nature, the environmental conditions and the applied enhancement techniques.

The initial and aged compositions as well as the influence factors are thus considered in this article to provide a qualitative and quantitative review of all compounds identified in fingermark residue up to now. The analytical techniques used to obtain these data are also enumerated.

This review highlights the fact that despite the numerous analytical processes that have already been proposed and tested to elucidate fingermark composition, advanced knowledge is still missing. Thus, there is a real need to conduct future research on the composition of fingermark residue, focusing particularly on quantitative measurements, aging kinetics and effects of influence factors. The results of future research are particularly important for advances in fingermark enhancement and dating technique developments.

Contents

1. Introduction

The composition of skin and perspiration originating from the eccrine secretory glands has already been studied extensively for medical and dermatological purposes [1–6]. However, the

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information provided in these studies is not sufficient for the forensic scientist working in the field of fingermarks. In fact, the chemical composition of fingermark residue differs qualitatively and quantitatively from the general chemical composition of sweat, because it contains a complex mixture of compounds coming from different glands and not exclusively from the eccrine ones. Numerous contaminants can also be present such as cosmetics, food residue or drugs and their metabolites. Furthermore, in practice, a forensic scientist will never collect fingermarks right after deposition. Therefore, chemical, physical and biological alterations over time will also affect the fingermark residue left on surfaces during a crime and hence modify its initial composition.

Many forensic studies have thus been carried out in order to gain a better knowledge about the precise nature of fingermark residue and its modification over time. These studies concentrated on the chemical characterization of fingermarks, but focused on three distinct objectives:

(1) The development and/or the improvement of enhancement techniques [1,7–35].
(2) The development of fingermark dating techniques [13,14,20,21,36–49].
(3) The capacity to distinguish between people using their personal characteristics (e.g., age, gender) [8,50–52] as well as extrinsic components found in their fingertip secretions (e.g., drugs) [7,9,53–62].

Despite these numerous studies, there has been no recent overview covering the chemical composition of fingermarks since the last review was published in 2001 [17]. Therefore, the present article aims to provide an up-to-date review of the literature regarding the qualitative and quantitative analysis of compounds identified in fingermark residue. Recent developments and improvements in analytical instrumentation and increasing interest on this topic during the last decade have lead to a better understanding of fingermark chemistry. This paper will thus begin with a preliminary definition of fingermark composition and then continue with a detailed description of the compounds identified in fresh fingermark residue originating from different sources (initial composition). The aging of fingermarks will then be considered (aged composition), as well as the variability of the composition due to influence factors. Finally, perspectives in the field of chemical analysis of fingermark residue will be outlined.

2. Fingermark composition

Numerous analytical techniques have been proposed and tested to elucidate fingermark composition, resulting in an expensive and complex combination of analytical procedures. However, despite the large amount of research carried out on this topic, advanced knowledge has not been achieved yet, mainly because of the technical difficulty of the needed analyses. In fact, determining the composition of fingermark residue is an analytical challenge because of its complex and multifaceted nature, which can be described as a system evolving between different states over time as follows:

(1) *The initial composition*: This corresponds to the transferred fingermark residue immediately after the contact between the finger and a substrate. All compounds having been identified in fingermark residue are taken into consideration.
(2) *The aged composition*: This corresponds to the evolution of the initial composition over time. Products emerging over time in fingermark residue are also considered.

The two states of the chemical composition of fingermarks are highly variable, because of numerous *influence factors*. When considering fingermark composition, it is therefore necessary to take into account the combination of initial and aged compositions, as well as the role of influence factors (Fig. 1).

The complexity of the fingermark composition is well illustrated by the difference in effectiveness of fingermark enhancement techniques applied on fresh or old fingermarks. For example, the efficiency of physical developer is known to be higher on aged fingermarks than on fresh ones [63]. While this observation highlights the fact that the composition between fresh and aged fingermarks significantly differs, no fundamental knowledge about specific compounds responsible for this difference is available yet. Among other things, such knowledge would help understand reaction pathways of enhancement techniques, such as physical developer. Differences in the enhancement quality between adult and children's fingermarks were also observed. In fact, enhanced fingermarks of children seem to be generally of poorer quality than those of adults, due to chemical differences of fingermark residue [16,25,64,65]. The age of the donor is thus one example of influence factors affecting the chemical composition of fingermarks and making it complex (see Section 2.3 for more details).

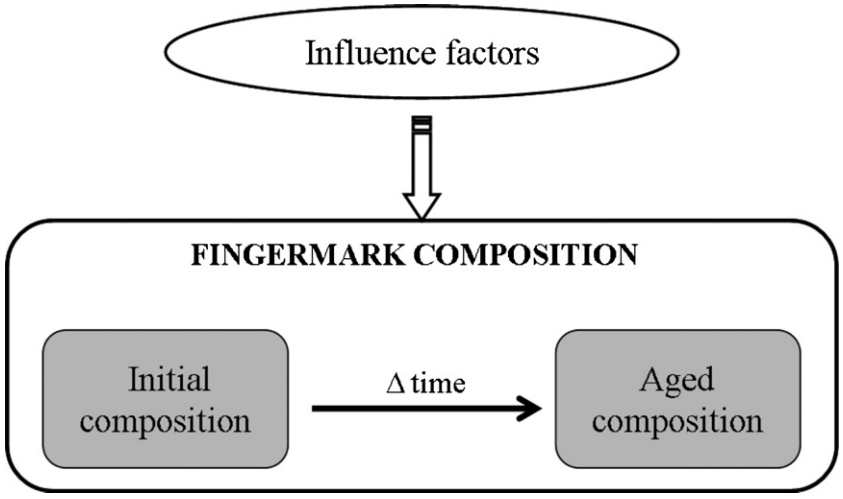

Fig. 1. Schematic representation of the composition of fingermark residue being affected by influence factors and containing two different states: (1) the initial composition and (2) the aged composition.