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A preliminary investigation into the use of alginates for the lifting and enhancement of fingermarks in blood

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ABSTRACT

Recent studies have reported the use of alginate in the lifting and subsequent enhancement of footwear marks in blood. A study was set up to assess the use of such a method in the treatment of fingermarks in blood on a variety of porous, non-porous and semi-porous surfaces. Other variables included ageing of the fingermarks in blood and the application of chemicals prior to or post-alginate lifting. All different variations were compared to direct chemical treatment of the substrate. The results demonstrated that alginate is not compatible with certain substrates (e.g. glass and tile). On substrates that were compatible with alginate (e.g. fabric and paper), the enhanced fingermarks on the alginate cast and the enhanced fingermarks on the post-alginate substrates appeared, overall, inferior compared to direct chemical enhancement without the use of alginate. A further variation using water-based protein stains directly mixed with the alginate appeared to provide enhancement directly on the substrate as well as simultaneous lifting and enhancing the fingermarks in blood on the alginate cast.

1. Introduction

Alginate casting is commonly used in the field of dentistry for casting a patient's mouth and/or jaw [1]. Alginate is generally supplied as a powder, to which water is added and mixed before application and setting. The typical composition of the powder is 11–16% sodium or potassium salts of alginic acid (originates from brown seaweed and is the main reactive ingredient that forms a solution with water to form a gel), 11–17% gypsum ($CaSO_4.2H_2O$ — provides the Ca^{2+} ions that cross-link the alginate chains), 1–3% trisodium phosphate (controls the setting time), and 65–75% inert fillers (allows for easy manipulation) [2,3]. Research [3–5] has demonstrated that alginate provides a good medium for lifting blood marks since it binds permanently to the blood to retain most of the detail. A proposed mechanism is that the blood is partially solubilised by the water in the alginate mixture upon application, and then retained when the cast sets [3]. Other similar substances (e.g. dental stone, Mikrosil® and polyvinylsiloxane) have been investigated to assess if they have similar capabilities; however, alginate was the only suitable substance for the lifting of blood marks from the substrates tested (concrete, fabric and human skin) [4]. A major drawback of alginate casting is that the casts shrink quickly over time and therefore immediate photography is recommended after enhancement. Several studies [3,5,6] have compared a range of alginate brands and all concluded that GC Aroma Fine Dust III gave superior results. Alginate has proven to be unreactive with blood enhancement techniques such as leuco crystal violet (LCV) and acid black 1 (AB1), allowing chemical enhancement of the lifted blood mark on the alginate [4,5]. In addition, the original blood marks appear to remain intact and largely unchanged, which shows the alginate's non-destructive nature although other studies demonstrated that subsequent enhancement of footwear marks directly on fabric items after alginate lifting was not successful [6]. Two recent studies [3,6] are in agreement that acid black 1 (AB1) provides superior enhancement of the blood marks lifted on the alginate cast when compared to LCV whilst DFO did not provide any enhancement.

The aim of this study was to assess the capability of GC Aroma Fine Dust III alginate in the lifting and subsequent enhancement of fingermarks in blood (in situ and on alginate cast) on a variety of porous, non-porous and semi-porous surfaces.

2. Materials and methods

The initial substrates selected for this study included glass, tiles, leaflets, white paper, dark denim and black polycotton. The alginate selected for this study is GC Aroma Dust Fine III. The fingermarks in blood were lifted with alginate casting and a comparison of two enhancement techniques was carried out on the alginate casts. The fingermarks in blood on the original surface post-alginate lifting were then treated with one of three enhancement techniques depending on the colour of the original surface. Fingermarks in blood were also placed directly on the surfaces and treated with one of two enhancement techniques (depending on the colour of the original surface) only (no alginate casting). A comparison of all three methods (alginate casting followed by subsequent enhancement; enhancement of the original surface post-

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alginate lifting; and enhancement only) was established to determine the most effective technique. The effect of ageing on the enhancement of the fingermark on each surface was investigated using four different ageing periods: 1, 7, 14 and 28 days. The sensitivity of each method was assessed through the use of depletion series'.

The enhancement techniques carried out on both the alginate cast and the original surface post-alginate casting were the protein stain acid black 1 (AB1) and the peroxidase reagent leuco crystal violet (LCV). If the original surface was dark in colour, the fluorescent protein stain acid yellow 7 (AY7) was applied instead of AB1. The same methodology was applied for depletion series' treated with the enhancement technique alone (no alginate casting).

2.1. Preliminary work

Preliminary work with the alginate casting material proved that the initial ratio of alginate powder to distilled water needed to be altered from 33.6 g of GC Aroma Fine Dust III mixed with 80 mL distilled water (as per manufacturer guidelines) to 33.6 g of alginate mixed with 90 mL distilled water [6]. This ratio provided a better consistency and provided enough material to cast a depletion series of 10 fingermarks in adjacent two columns of five. Furthermore, preliminary work proved the alginate to be ineffective on the non-porous surfaces tested in this experiment (glass and tile) and these were therefore substituted with two new substrates (cardboard and clear plastic bags).

2.2. Preparation of substrates

Plastic bags, leaflets and 80 gsm white paper were obtained locally, each from the same source and batch. Square pieces of cardboard were cut from a large cardboard box to ensure all cardboard samples were from the same source. 1 m^2 of black polycotton fabric and a pair of dark blue denim jeans were acquired and cut to include in the study. Some substrates (clear plastic bags and leaflets) had areas of different colour (due to patterns and/or writing) and therefore to achieve consistency, the fingermarks were applied to the same sections of the substrate.

2.3. Preparation of fingermarks in blood

10 mL of lysed horse blood (at room temperature) was poured into a Petri dish. The donor coated their right index finger in the blood before dabbing the finger twice (about two seconds per dab) on chemical free blue paper towel to remove the excess blood. The deposition pressure of each fingermark in blood was not controlled in this study; however, the donor was instructed to attempt to keep a constant pressure in the process. Three replicates of each depletion series were prepared on each substrate for each ageing period. Each depletion series was prepared in two columns: fingermarks 1–5 were planted in the first column followed by fingermarks 6–10 in the adjacent column.

One of these three depletion series was treated with alginate, with the alginate cast being subsequently enhanced with AB1 and the original post-alginate surface treated with AB1 (or AY7 if the substrate was dark in colour). The second of these three depletion series was treated with alginate, with the alginate cast being subsequently enhanced with LCV and the original post-alginate surface treated with LCV. The third depletion series was then treated with AB1 directly without the use of alginate (or AY7 if the substrate was dark in colour). This process was then repeated for each of the four ageing periods (1, 7, 14 and 28 days) and each of the six substrates (black polycotton, denim, cardboard, leaflets, paper, and plastic bags). During each ageing period, the fingermarks in blood were stored on an open bench in the laboratory at room temperature.

2.4. Control samples

The positive control tests involved treating a depletion series of 10 fingermarks in blood for each ageing period (1, 7, 14 and 28 days) on each of the individual surfaces for each of the techniques (AB1, AY7 and LCV). The negative controls involved applying alginate to each of the substrates where no blood was present on the surface.

2.5. Alginate casting

The alginate was prepared for each required sample by vigorously mixing 33.6 g of alginate powder to 90 mL distilled water in a plastic beaker for 30 s. The mixture was then applied to the substrate as quickly as possible using a plastic spatula ensuring a consistent layer is produced. A plastic bag was then placed over the top and light pressure was applied (to ensure good contact between the alginate and the substrate). The alginate was then left for two to three minutes to set and dry before removal from the substrate. For paper samples, the alginate had to be removed two minutes after application as longer time periods caused the paper to rip and tear during removal of the cast. All alginate casts were left to dry overnight before chemical treatment.

2.6. Preparation and application of enhancement techniques

2.6.1. Protein stains [7]

Fixative solution — the fixing solution was necessary to fix the blood marks (prior to applying the protein stain) by precipitation. 5-Sulfosalicylic acid dihydrate (23 g, Acros) was dissolved in 1 L of distilled water using a magnetic stirrer. Items to be treated were left in solution for at least five minutes.

Staining solution — the relevant protein stain (AB1 or AY7, 1 g, BVDA) was stirred for at least 30 min in acetic acid (50 mL, Fisher), ethanol (250 mL, Fisher) and distilled water (700 mL) using a magnetic stirrer. Items to be treated were left in solution for at least 10 min.

De-staining solution — a solution of acetic acid (50 mL, Fisher), ethanol (250 mL, Fisher) and distilled water (700 mL) was used to wash off the excess dye.

2.6.2. LCV [8]

5-Sulfosalicylic dihydrate (10 g, Acros) was dissolved in 3% hydrogen peroxide (500 mL, Fisher). Sodium acetate (3.7 g, Acros) was then added, followed by leuco crystal violet (1 g, Acros) and stirred until completely dissolved using a magnetic stirrer. The solution was then transferred to an Ecospray® unit and applied via short bursts of spraying. All samples were left to dry in the fume hood prior to photography and grading.

2.7. Photography and fluorescence

A Nikon D5100 digital SLR camera with an 18–55 mm lens was used to photograph all samples before and after enhancement. Fluorescence observation for AY7 and LCV was performed by means of a Mason Vactron Quaser 2000/30 connected to an Integrated Rapid Imaging System (IRIS) and Crime-lites®. For items treated with AY7, fluorescence was observed by exciting with a blue excitation source (band pass filter 385–509 nm 1% cut-on and cut-off points respectively) and viewed with a yellow/orange long pass 510 nm filter (1% cut-on point) whereas for items treated with LCV, fluorescence was observed by using a green/yellow excitation source (band pass filter 503–591 nm 1% cut-on and cut-off points respectively) and viewed with a red long pass 593 nm filter (1% cut-on point).

2.8. Alternative alginate preparation

Further tests were conducted where the staining solutions (both AB1 and AY7 were tested) were mixed with the alginate powder in