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Technical Note

Evaluation of one-step luminescent cyanoacrylate fuming

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ABSTRACT

One-step luminescent cyanoacrylates have recently been introduced as an alternative to the conventional cyanoacrylate fuming methods. These new techniques do not require the application of a luminescent post-treatment in order to enhance cyanoacrylate-developed fingermarks. In this study, three one-step polymer cyanoacrylates: CN Yellow Crystals (Aneval Inc.), PolyCyano UV (Foster + Freeman Ltd.) and PECA Multiband (BVDA), and one monomer cyanoacrylate: Lumikit™ (Crime Scene Technology), were evaluated against a conventional two-step cyanoacrylate fuming method (Cyanobloom (Foster + Freeman Ltd.) with rhodamine 6G stain). The manufacturers' recommended conditions or conditions compatible with the MVC™ 1000/D (Foster + Freeman Ltd.) were assessed with fingermarks aged for up to 8 weeks on non-porous and semi-porous substrates. Under white light, Cyanobloom generally gave better development than the one-step treatments across the substrates. Similarly when viewed under the respective luminescent conditions, Cyanobloom with rhodamine 6G stain resulted in improved contrast against the one-step treatments except on polystyrene, where PolyCyano UV and PECA Multiband gave better visualisation. Rhodamine 6G post-treatment of one-step samples did not significantly enhance the contrast of any of the one-step treatments against Cyanobloom/rhodamine 6G-treated samples.

1. Introduction

Cyanoacrylate (CA) fuming is the preferred laboratory technique for the detection of fingermarks deposited on non-porous substrates. In this technique, CA is vaporised and the fumes react with components from fingermark secretions forming a hard white polymer extending along the ridges of the fingermark [1]. Limitations arise with CA development due to the lack of contrast that occurs on light-coloured substrates, where white fingermarks can be difficult to visualise, and with the development of aged fingermarks, where transparency of the CA ridges is increased [1]. The contrast of developed fingermarks can be improved through post-treatment with luminescent stains which penetrate the CA development and become trapped within the polymer [2,3]. While contrast on non-porous substrates is generally improved, the use of post-stains is associated with a number of limitations: increased handling times [2]; absorption of stains into semi-porous substrates [4]; health and safety concerns associated with the use of hazardous chemicals during staining [5]; and the potential loss of integrity of the developed fingermark as well as the exhibit.

One-step luminescent CA fuming products incorporating a luminescent dye with CA have been researched since the early 1980s. However, it is only recently that a number of commercial products have become available including: CN Yellow Crystals (Aneval Inc.), PolyCyano UV (Foster + Freeman Ltd.), PECA Fluor Extra, PECA Multiband (BVDA), and Lumikit™ (Crime Scene Technology).

The initial report of a one-step luminescent CA was in 1993, when Weaver and Clary successfully produced luminescent fingermarks following co-sublimation of a styryl dye with CA monomer [6]. Weaver subsequently conducted work on the optimisation of CN Yellow, the first commercially available one-step luminescent CA. This product incorporates CA in a solid polymer form with yellow 43, a dye which was reported to show selectivity for CA-polymerised fingermark ridges [7]. Groeneveld et al. found that while CN-Yellow produced visible CA-developed fingermarks, luminescent contrast was poor [8]. CN-Yellow has since been superseded by CN Yellow Crystals. A review of the technical notes for the latter indicates that slow heating of the product may degrade the luminescent component [9].

More recently, PolyCyano UV and the PECA products have been developed and commercialised. Like CN-Yellow, these products are also in a solid polymer form and require a temperature of 230 °C to vaporise. The luminescent compound of PolyCyano UV and PECA formulations is *p*-dimethylaminobenzaldehyde (DMAB), which

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differs in concentrations from 5% in PolyCyano UV and up to 15% in PECA Fluor Extra and PECA Multiband [10–12]. In a study conducted by Takatsu et al., DMAB was reported to selectively bind to the CA polymer following a two-step enhancement process and could offer sufficient contrast on exhibits which were sensitive to solvents [13]. Previous studies conducted with PolyCyano UV on a number of non-porous surfaces have determined that its ability to develop fingermarks is similar to that of conventional CA [8,14,15]. However, in most cases, the luminescence of PolyCyano UV lacked intensity when compared to post-stains used following the fuming with Cyanobloom [14,15]. At the time of writing, no published research was available on either of the PECA products.

Lumicyano™ was formerly available as a prepared solution of luminescent dye incorporated with CA. This has since been superseded by Lumikit™ which requires the combination of Lumicyano Powder™ dye ($C_4H_5ClN_4O$) and Lumicyano Solution™ in a two-step preparation process. Following preparation, Lumikit™ is fumed under the same conditions as that of conventional CA [16–18]. The manufacturers recommend a concentration of equal to or less than 5% w/w (powder to solution) prior to fuming [16]. Studies on both Lumicyano™ [4,19] and a 4% preparation of Lumikit™ [20] showed that the CA development under white light was comparable to that of conventional CA when the technique was applied to non-porous substrates. Farrugia et al. [19] found a similar rate of detection under luminescent lighting conditions, while it was also found that Lumicyano™ gave inferior luminescence to CA-developed fingermarks stained with basic yellow 40 (BY40) [4,20]. Further, semi-porous substrates treated with 4% Lumicyano™ resulted in inferior CA development compared to that of the conventional method [20]. However, post-treatment of 4% Lumicyano™ samples with BY40 revealed a further 30% of previously undetected fingermarks [20].

While one-step luminescent CAs offer the convenience of reduced handling and processing times, and show good potential for use on semi-porous substrates, they are associated with significantly greater costs than conventional CA fuming and staining reagents. The aims of this study were to evaluate the quality and performance of commercially available one-step luminescent CA fuming techniques (CN Yellow Crystals, PolyCyano UV, PECA Multiband and Lumikit™) in comparison to conventional CA fuming with a post-treatment of rhodamine 6G (R6G) and to evaluate the one-step luminescent techniques against each other. The manufacturers' recommended fuming conditions were firstly assessed to determine their compatibility with a commercial fuming cabinet. Comparisons of the different treatments on non-porous and semi-porous substrates were then performed. This study was conducted in accordance with the International Fingerprint Research Group guidelines [21].

2. Materials and methods

2.1. Materials and equipment

The control treatment consisted of fuming with the monomer CA: Cyanobloom (Foster + Freeman Ltd.), followed by staining with R6G working solution (R6G (Sigma–Aldrich); methyl ethyl ketone (Chem-Supply); isopropanol (VWR); deionised water) [22]. The one-step luminescent CAs evaluated in this study were polymer CAs: PolyCyano UV (Foster + Freeman Ltd.), CN Yellow Crystals (Aneval Inc.) and PECA Multiband (BVDA); and a monomer CA: Lumikit™ (Crime Scene Technology). The relative performances of these techniques were investigated on polyethylene bags (Woolworths Select Resealable Sandwich Bags), polystyrene cups (Woolworths Essentials Foam Cups) and glossy cardboard (Kleenex Facial Tissue box) surfaces (method described below).

A MVC™1000/D (Foster + Freeman Ltd.) fuming cabinet was used for all treatments in this study. Samples were imaged with a Nikon AF Micro Nikkor 60 mm lens and QImaging Peltier Cooling CCD Camera. Ultraviolet (UV) excitation and luminescent examination were performed using the Poliview IV (Rofin) with V++ Precision Digital Imaging System version 4.0 and Polilight PL500 forensic light source. A VSC6000 (Foster + Freeman Ltd.) was also used to image CA development on glossy cardboard and polystyrene for episcopic coaxial illumination.

2.2. Procedure

2.2.1. Fingermark collection and ageing

Three donors (one male, two females) were used in this study. Based on previous research, these donors were identified as either a weak, average or strong donor. Each donor provided three sets of natural, single fingermark depositions over three depletions on each of the test surfaces. Fingers were allowed to naturally recharge prior to the depositions onto each surface. For the comparison study, each set of the collected fingermarks was stored in the dark, under ambient laboratory conditions (21 °C/50% relative humidity (RH)) for either one, four or eight weeks. Following ageing, fingermarks were halved, with each half depletion series exposed to a different treatment. A total of 810 fingermarks were collected for the comparison study.

2.2.2. Fuming conditions

Samples were then exposed to the respective CA treatment for a maximum of 60 min, until sufficient development was observed or until it was deemed that no development or further enhancement could be achieved. Within three hours after sufficient fuming, Cyanobloom-treated samples were imaged under white light only, while other samples were imaged under the respective recommended luminescent conditions (Table 1) followed by white light. All samples were then left to cure for at least 18 h before being stained with a R6G solution (Table 2) and again imaged within three hours of staining at the recommended visualisation conditions for R6G [22]. Corresponding fingermark halves were digitally stitched using GNU Image Manipulation Program (GIMP). No further digital enhancements were performed on any of the imaged fingermarks. The CA treatment for each fingermark half was then directly compared to the treatment on the corresponding half and scored using the comparative scale shown in Table 3 [14,23].

Table 1
Fuming conditions for each treatment used in the MVC™1000/D CA fuming cabinet and visualisation conditions using the Poliview.

Conditions	Cyanobloom/R6G	PolyCyano UV	PECA Multiband	CN Yellow Crystals	Lumikit™
Temperature (°C)	120	230	230	230[a]	120
Mass (g)	0.5	0.6	0.2	0.6[a]	0.4[a] (5% w/w)
Humidity (%)	80	80	80	80	80
Visualisation (nm)	Ex = 490; Em = 555	Ex = 350; Em = 450	Ex = 440; Em = 505	Ex = 450; Em = 555	Ex = 350; Em = 555

[a] Values adjusted for use in this study.