A review of one-step fluorescent cyanoacrylate techniques

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Stewart, V. Deacon, P. and Farrugia, K.J. 2016. A review of one-step fluorescent cyanoacrylate techniques. *Fingerprint Whorld*. 41(162).

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Abstract

A review of recent research in the use of one-step fluorescent cyanoacrylate techniques is presented. Advantages and disadvantages of such techniques in comparison to two-step processes are discussed. Further studies and new experimental data are presented to aid this review: three one-step cyanoacrylate products (Lumicyano, PolyCyano UV and PECA Multiband) containing a fluorescent dye were tested to evaluate their effectiveness in developing latent fingermarks on polyethylene bags by means of a pseudo operational trial. The results were compared to the traditional two-step process of cyanoacrylate fuming followed by staining with ethanol-based basic yellow 40 (BY40). The study was conducted using sequential treatments of an initial fuming cycle, a second cycle and finally BY40 staining. Lumicyano™ and PolyCyano UV performed similarly before BY40 staining, with both providing good contrast and visibility under fluorescence. PECA Multiband, however, did not develop as many fingermarks and proved to be problematic for the fuming cabinet. Subsequent BY40 staining of fingermarks developed by all three one-step processes enabled the visualisation of new fingermarks.

Introduction

Cyanoacrylate fuming has proved to be very successful for the development of latent fingermarks on non-porous materials such as glass, plastic and metal. As certain components of a latent fingermark residue come into contact with the cyanoacrylate monomer vapour, a polymerisation reaction occurs along the ridges to produce a white polymer (Wargacki *et al* 2007). Cyanoacrylate will also react with many other stains composed of household products, oils, food and drink (Bandey 2008). Several studies (Wargacki *et al* 2008, Lewis *et al* 2001, Wargacki *et al* 2007) have investigated the underlying mechanism of the cyanoacrylate polymerisation reaction with latent fingermarks. Numerous studies (Mankidy *et al* 2006, 2008, Dadmun 2010, Paine *et al* 2011) have examined the optimum conditions for fuming i.e. 80% relative humidity (RH) and 120^{o}C temperature for evaporating cyanoacrylate. Other studies investigated the use of vacuum cyanoacrylate fuming where the evidence is sealed in a chamber (Watkin *et al* 1994, Yamashita 1994, Bessman *et al* 2005). Closer examination of the cyanoacrylate polymer found that its morphology differed when developed under atmospheric/humidity and vacuum conditions (figure 1), producing noodle-like and granular structures respectively. The small, granular bead structure can limit the scattering of light and hence reduce visibility of the polymer under white light. The main advantages of vacuum fuming are that it does not result in overdevelopment and that all surfaces of the article under examination (including those that are not directly exposed) are treated with fumes. The UK Home Office Centre for Applied Science and Technology (CAST, then called the Police Scientific Development Branch) investigated the use of vacuum cyanoacrylate fuming and concluded that the atmospheric/humidity process is superior; however another study in France reported the opposite results (Kent and Winefield 1996, Hebrard *et al* 1996). More recently, a pseudo-operational trial on plastic carrier bags comparing the two-step atmospheric and vacuum process in sequence with BY40 was in line with results from CAST that the atmospheric/humidity process is superior (Farrugia *et al* 2015).

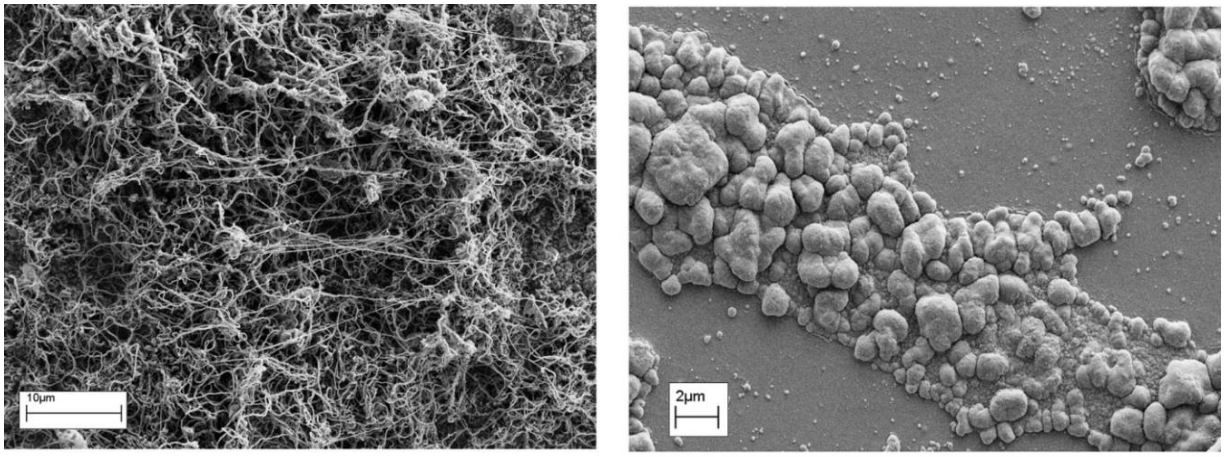


Figure 1 – Cyanoacrylate polymer morphology developed under (a) atmospheric and 80% RH and (b) vacuum conditions

The contrast between the developed cyanoacrylate polymer on the fingermark ridges and the substrate may be poor, so subsequent powdering or staining with a fluorescent dye is generally necessary. This is the basis of a two-step cyanoacrylate method where the articles to be examined are first fumed with cyanoacrylate then treated with a fluorescent dye. In the early 1980's Menzel (1980) and Menzel *et al* (1983) proposed the use of rhodamine 6G in methanol which is still in use in a number of countries today. Due to health and safety concerns related to the dye and solvent, CAST recommended the use of basic yellow 40 (BY40) as a suitable fluorescent dye in 1985 (Bleay *et al* 2012). There are many other fluorescent dyes that have been discussed in the literature, some of which are in use today, including basic red 14, safranine O, nile red and ardrox in addition to varying mixtures of dyes such as RAY (rhodamine 6G, ardrox and BY40) (Mazzella and Lennard 1995, Wilson 2010). CAST has carried out research on numerous and alternative fluorescent dyes; however, none of these are recommended due to health and safety concerns or due to inferiority to BY40. The only exception is the use of a water-based formulation of basic red 14 when required since this demonstrates stronger fluorescence than water-based BY40.

A one-step fluorescent cyanoacrylate process involves the use of a product that has a fluorescent dye (fluorophore) incorporated into the cyanoacrylate. In the early 1990s, Weaver and Clary (1993) reported one of the first instances of a one-step fluorescent cyanoacrylate process with the successful co-polymerisation of 3M styryl dyes with cyanoacrylate monomers. The one-step products are more expensive to purchase in comparison to the traditional two-step products but can reduce overall costs as casework can be processed more quickly (no dyeing and drying time) and there is no requirement for a dye tank and drying

space (cost of chemicals for dye and saving of lab space). The use of a liquid dyeing procedure on semi-porous surfaces generally results in excessive background staining and may interfere with subsequent DNA analysis (Bhoelai *et al* 2011). A one-step process offers the potential to address these issues; however, a pseudo-operational trial using Lumicyano on semi-porous materials such as food and cosmetic packaging revealed poor recovery of fingermarks on these surfaces (Farrugia *et al* 2014b). Around 2005, CAST investigated the co-polymerisation of cyanoacrylate and solvent yellow 43 that was heated to a temperature of 170 – 185^{o}C. The resultant fluorescence was weak; however subsequent staining with BY40 provided fluorescence that was 5-10 times brighter (Vaughn Sears, CAST, personal communication, 11/11/2015). Although not a one-step process, in 2012, Japanese researchers removed the use of solvents and reported the successful vapour staining of latent marks developed with cyanoacrylate using p-dimethylaminobenzaldehyde (DMAB) (Takatsu *et al* 2012). Furthermore, tagging of cyanoacrylate with fluorescent species has also been reported by Groeneveld et al (2014) . Over the last few years, there have been a number of commercial products marketed as a one-step fluorescent cyanoacrylate process e.g. Polycyano (Cyano UV, Foster and Freeman, U.K.), Lumicyano (Crime Scene Technology, France), PECA Multiband (BVDA), Fuming Orange and CN Yellow (Aneval, Inc., IL). For such products, fluorescence examination should be performed as soon as possible after fuming since the fluorescence of some products may decay over time, limiting the potential of such products in comparison to a two-step process. A number of these products require a temperature of 230^{o}C which may necessitate a conversion of older fuming cabinets to accommodate this increased temperature. However, newer cabinets provide hot plates that reach this temperature and beyond if required but heating cyanoacrylates to these temperatures may result in the production of hydrogen cyanide gas (Fung *et al* 2011).

Lumicyano

Lumicyano is a one-step fluorescent cyanoacrylate product which evaporates at the standard temperature of 120^{o}C. The developers of the product, reported that it is excited with UV or blue/green light and offers equal or better sensitivity to the two-step process (Prete *et al* 2013). Furthermore, the cyanoacrylate and the fluorophore are said to be unified and the dye is only found in conjunction with the polymer deposit (Prete *et al* 2013). The manufacturer stresses the importance of following the instructions provided with the product such as ensuring that the fuming cabinet is clean and that the recommended amount of product is fully evaporated (checked by weighing the amount of glue before and after fuming). The first

generation of the product was supplied as a 1% (weight/weight) pink solution of fluorescent dye in cyanoacrylate. A pseudo-operational trial on polyethylene bags using this 1% formulation, two-step cyanoacrylate/BY40 and iron-oxide powder suspension reported a similar number of detected marks by these techniques; however, the use of BY40 after 1% Lumicyano provided an additional 15% detection rate (Farrugia *et al* 2014a). In this trial, it was noted that the fluorescence decayed rapidly and completely after 1 week, even more so when the substrates were stored in daylight conditions. The fluorescence decay was also observed to deteriorate more quickly on certain substrates, such as glass, whereas aluminium foil retained fluorescence for several months (Prete *et al* 2013). It is recommended to perform fluorescence examination immediately after fuming with Lumicyano and when this is not possible, to store treated articles in a cool, dark, and dry place, ideally sealed in a brown paper envelope to prevent air circulation. The second generation of Lumicyano separated the cyanoacrylate and dye as Lumicyano solution and Lumicyano powder where the recommended optimum concentration of dye was 4% and later revised to the current 5% (figure 2). A further pseudo-operational trial using this formulation reported similar results to the previous trial; however, due to the higher dye concentration, the fluorescence lasted for at least 4 weeks when stored in the dark (Farrugia *et al* 2014b). For both generations of Lumicyano, it is possible to restore fluorescence by re-fuming the articles under examination and/or subsequent treatment with a fluorescent stain such as BY40. Such processes may result in additional marks being detected. A follow-up study (Farrugia *et al* 2015) reported the sequential process of Lumicyano fuming at atmospheric/humidity conditions followed by an additional Lumicyano fuming cycle at the same conditions. The second fuming cycle resulted in the detection of marks that were not observed during the first cycle.

Under vacuum conditions, for the two-step process of cyanoacrylate and dye, there is a possibility that the dye molecule does not adhere as efficiently to the granular beads (Kent and Winefield 1996). The use of vacuum conditions for one-step cyanoacrylate processes removes this limitation since the cyanoacrylate and the dye are co-fumed (figure 3). The double process for Lumicyano was repeated during pseudo operational trials on polyethylene bags where the first cycle was under vacuum and the second one was under atmospheric/humidity conditions. The first cycle (vacuum) yielded a low number of marks but this increased dramatically after the second cycle (atmospheric/humidity) suggesting that atmospheric/humidity conditions are superior and that the initial vacuum cycle does not affect the subsequent atmospheric/humidity fuming process (Farrugia *et al* 2015). It was also noted

that the fluorescence decay of Lumicyano was much faster under vacuum conditions in comparison to atmospheric/humidity conditions. Although, vacuum fuming may be inferior, its use in certain cases might be important since the cyanoacrylate fumes reaches all the areas of the article under examination, even those not directly exposed. Recent research (Farrugia *et al* 2015) has demonstrated that under vacuum conditions, marks can still be developed on plastic bags/items sealed in another plastic bag, and on CDs/DVDs stacked on top of each other. An operational example may include drugs packaging where the action of unwrapping one layer may damage fingermarks on further layers below.

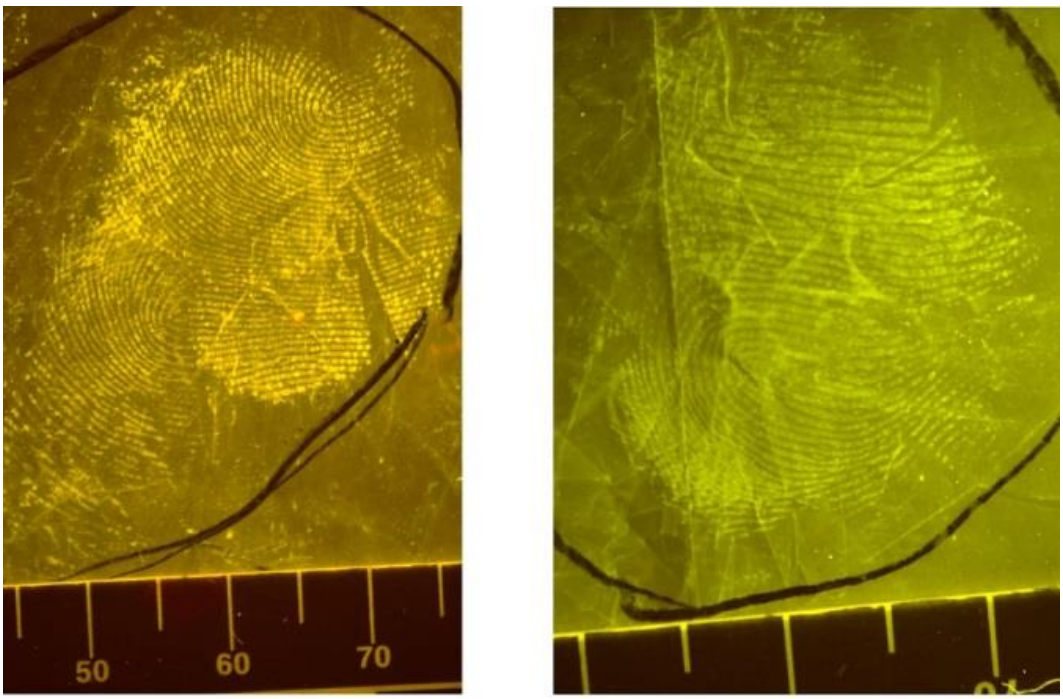


Figure 2 - A latent fingermark on a polyethylene bag developed with Lumicyano as viewed under blue/green light (orange filter) under (a) atmospheric/humidity and (b) vacuum conditions

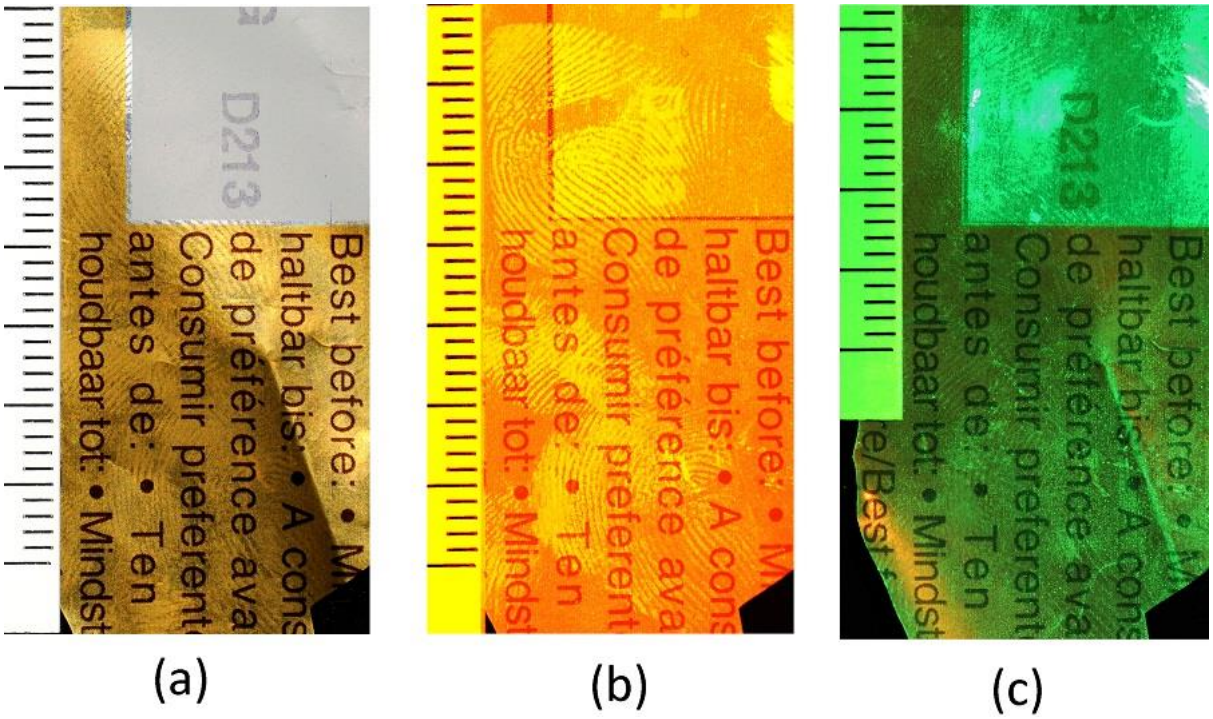
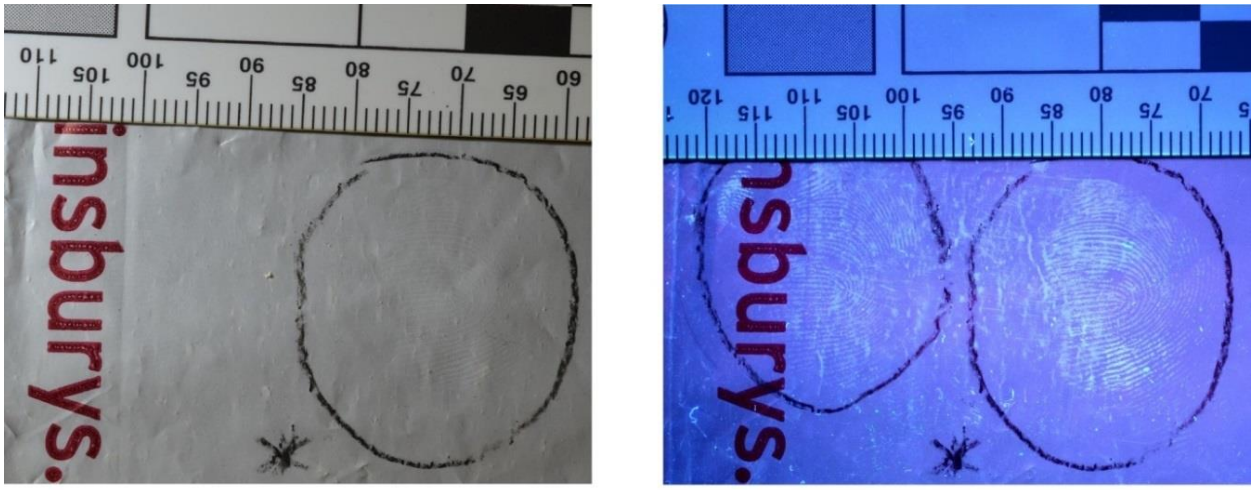


Figure 3 - Latent mark enhanced on a chocolate wrapper with Lumicyano 4% under vacuum conditions: (a) observed under white light; (b) observed under blue-green light (orange filter); (c) subsequent BY40 staining observed under violet-blue light (yellow filter) (Farrugia *et al* 2015).[1]

[1] Reprinted from Forensic Science International, 257, Farrugia, K.J., Fraser, J., Friel, L., Adams, D., Attard-Montalto, N., Deacon, P., A comparison between atmospheric/humidity and vacuum cyanoacrylate fuming of latent fingermarks, 54-70, Copyright (2015), with permission from Elsevier

PolyCyano UV

This product is a solid powder of polymerised cyanoacrylate with the UV reactive dye DMAB where a temperature above 208°C is required to completely vaporise the powder back to its monomer form and liberate the fluorescent dye. The manufacturer recommends a temperature of 230°C and 60% - 90% RH. Figure 4 shows an example of a latent fingermark developed with Polycyano UV; however, the use of a UV excitation dye may result in background fluorescence that can limit the contrast between the latent mark and the substrate. An evaluation of Polycyano in comparison to the two-step cyanoacrylate process demonstrated that the one-step process yielded a comparable quality of enhanced fingermarks (Hahn and Ramotowski 2012). Another study (Chadwick *et al* 2014) of Polycyano in Australia reported similar results; however, it was argued that the higher cost and weaker fluorescence do not justify its implementation as an alternative technique to the two-step process. Nonetheless, the same study reported that the use of Polycyano in sequence with rhodamine 6G provided better development and contrast than either the one or two-step processes alone.



(a) (b)

Figure 4 – A latent fingermark on a polyethylene bag developed with Polycyano UV and viewed under (a) white light and (b) UV fluorescence

PECA Multiband

This one-step fluorescent cyanoacrylate from BVDA appears to still be under development although there are a number of international websites marketing this product. Samples of the product were given out to delegates during a number of conferences in 2015 such as the 41st Fingerprint Society Educational Conference. There is currently a small number of studies (Khuu *et al* 2016) reporting its effectiveness. The product is a yellow powder of polymerised cyanoacrylate with the fluorescent dye 4-dimethylaminocinnamaldeyhde (DMAC). The use of DMAC and its associated fluorescence (without the use of cyanoacrylate) has also been reported for the detection of latent fingermarks (Sasson and Almog 1978, Brennan 1996, Lee *et al* 2009) and urine (Rhodes and Thornton 1976, Ong *et al* 2012, Farrugia *et al* 2012). Fuming conditions for PECA Multiband require a hot plate temperature of 230°C with 80% RH where 1.6g of product per cubic meter is recommended by the manufacturer. This product is marketed with the advantage of using varying excitation wavelengths ranging from 365 to 555nm which can be useful to limit background fluorescence from different substrates (figure 5).

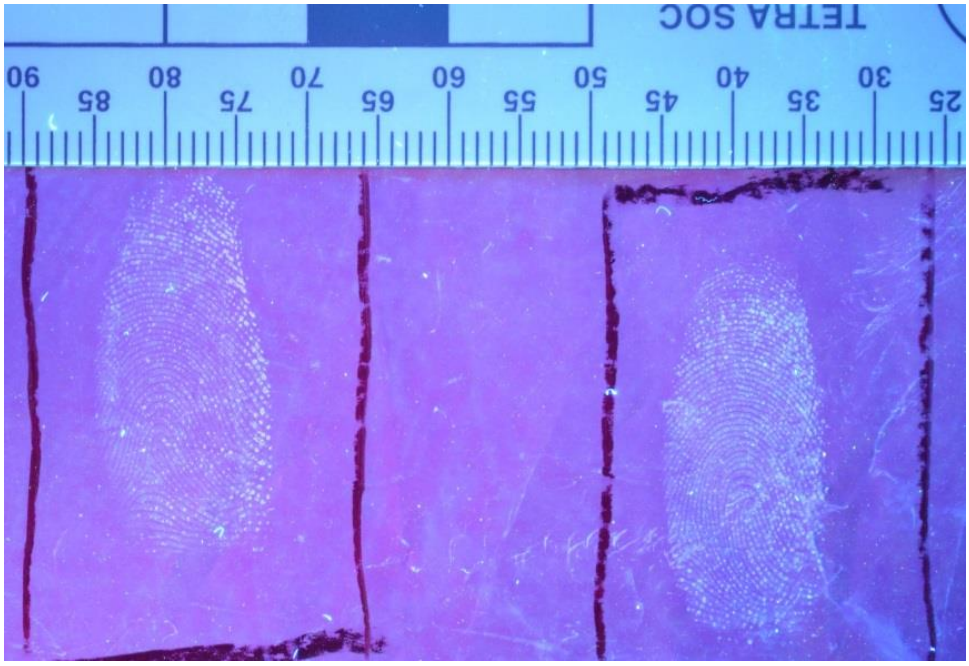


Figure 5 - Latent fingermarks on a polyethylene bag developed with PECA Multiband as viewed under UV light and UV filter

A comparative study of one-step fluorescent cyanoacrylate processes

A study was conducted to investigate and compare the effectiveness of three one-step fluorescent cyanoacrylate processes and the two-step process of cyanoacrylate in sequence with ethanol-based BY40 for the detection of latent marks on polyethylene bags by means of a pseudo-operational trial. Previous work has demonstrated the potential advantages of a double fuming process with Lumicyano and hence this study follows on with this procedure and other one-step products. The advantages of a one-step process are highlighted in this study; however, further research is required before such treatments are widely accepted within the forensic community.

Materials and Methods

Sample Preparation

One hundred plastic carrier bags were collected from friends, family and colleagues, with care taken not to collect too many from the same source. All bags were numbered and their details recorded; such as brand, plastic type and colour (table 1). Each bag was cut open, quartered and labelled with the relevant process in a pseudo-operational trial; A, B, C or D and bag number (figure 6). The process sequence was rotated clockwise for each bag to avoid bias to a particular process. The quarter sections were compiled by process (A,B…) and the first 25 of each process treated until all 100 bags for that process had received the first treatment. Treatments continued in batches of 25 in this manner until all sequential treatments were complete.

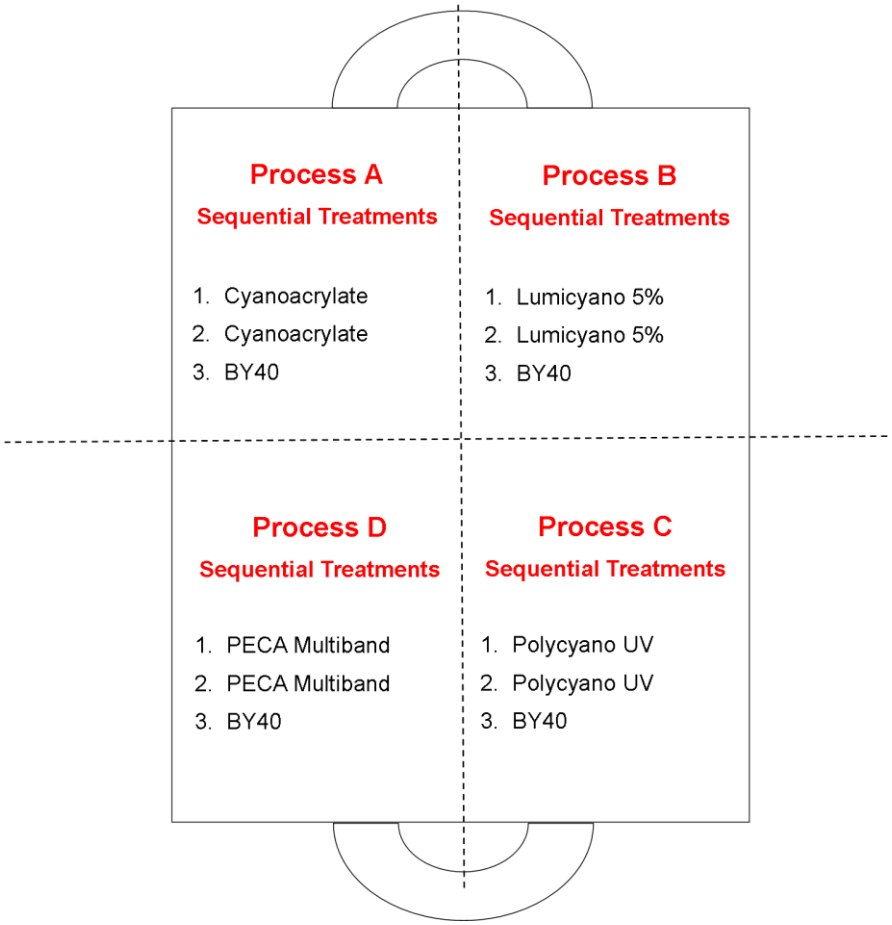


Figure 6 - Bag division by process with treatment information

Table 1 – List of PE bags used in the study

Bag Number	Brand	Type of Plastic	Colour(s)
1	Morrisons	100% recycled	Green/red/yellow
2	Tesco	HDPE	White/blue/red
3	Morrisons	Recycled	White/green
4	Co-op Food	HDPE	White/black
5	Sainsburys	100% recycled	Cream/red
6	n/a	n/a	White
7	ASDA (BFL)	100% recycled	Green/white/yellow
8	Tesco	HDPE	White/blue/red
9	Tesco	100% recycled	Blue/white
10	Tesco	100% recycled	Cream/multi-coloured
11	M&S	100% recycled	Green/blue
12	n/a	Recycled	White/black
13	Tesco	HDPE	Green/blue/red
14	Morrisons	100% recycled	Green/red/yellow
15	ASDA	Recycled	White/green
16	Scotmid Co-op	n/a	Black/multi-coloured
17	Tesco	HDPE	White/blue/red
18	Scotmid Co-op	Recycled	White/blue
19	Ness	n/a	White/red/blue
20	Scotmid Co-op	Recycled	White/blue
21	Tesco	HDPE	White/blue/red
22	Morrisons	100% recycled	Green/red/yellow
23	Spar	Recycled	Green/red
24	Scotmid Co-op	Recycled	White/blue
25	M&Co	50% recycled	Black/white
26	Tesco	HDPE	White/red/blue
27	ASDA (BFL)	100% recycled	Green/white/yellow
28	ASDA	Recycled	White/green
29	M&S	100% recycled	Cream/red/blue
30	ASDA (BFL)	100% recycled	Green/white/yellow
31	Tesco	HDPE	White/blue/red
32	Morrisons	Recycled	Green/red/yellow
33	Tesco	HDPE	White/blue/red
34	M&S	n/a	Green/white
35	Sainsburys	100% recycled	Cream/red
36	Tesco	HDPE	White/blue/red
37	Oasis	n/a	Pink/white
38	Beyond words	n/a	White/black
39	Tesco	HDPE	White/blue/red
40	Sainsburys	100% recycled	Cream/red
41	Aldi	Recycled	Multi-coloured
42	ASDA (BFL)	100% recycled	Green/white/yellow
43	M&S	100% recycled	Green/blue
44	Tesco	HDPE	Green/blue/red
45	Poundland	100% recycled	Brown
46	Vans	LDPE	Clear/red/blue/black
47	Tesco	HDPE	White/red/blue
48	Tesco	HDPE	Yellow/red/blue
49	Apple	n/a	White/silver
50	Tesco	HDPE	White/red/blue
51	Tesco	HDPE	Green/blue/red
52	Boots	LDPE	White/blue
53	Tesco	HDPE	Green/blue/red
54	Boots	HDPE	White/blue
55	Tesco	100% recycled	Blue white
56	Tesco	HDPE	White/blue/red
57	Dobbies	33% recycled	White/pink

58	Scotmid Co-op	Recycled	White/blue
59	XXL All sports Ltd	LDPE	Black/green/white
60	Tesco	HDPE	Yellow/blue/red
61	Morrisons	Recycled	Green/red/yellow
62	Spar	Recycled	Green/red
63	Iceland	HDPE	White/red
64	Tesco	HDPE	Yellow/blue/red
65	McColls	n/a	White/blue
66	Scotmid Co-op	Recycled	White/blue
67	Tesco	HDPE	Yellow/blue/red
68	Co-op food	HDPE	White/black
69	n/a	n/a	White
70	Tesco	HDPE	Blue/red
71	Oxfam	100% recycled	Green/white
72	ASDA (BFL)	100% recycled	Green/white/yellow
73	Tesco	HDPE	Green/blue/red
74	ASDA	Recycled	White/green
75	Tesco	HDPE	White/blue/red
76	M&S	100% recycled	Green/blue
77	Tesco	HDPE	Yellow/blue/red
78	Sainsburys	100% recycled	Cream/red
79	Tesco	HDPE	White/blue/red
80	M&S	100% recycled	Green/blue
81	Morrisons	Recycled	White/green/yellow
82	Tesco	HDPE	White/blue/red
83	Spar	Recycled	Green/red
84	Sainsburys	100% recycled	Cream/red
85	Tesco	HDPE	White/blue/red
86	M&S	100% recycled	Green/blue
87	Morrisons	Recycled	White/green/yellow
88	Tesco	HDPE	White/blue/red
89	Sainsburys	Recycled	Orange/red
90	M&S	100% recycled	Green/blue
91	Morrisons	Recycled	White/green/yellow
92	Tesco	HDPE	White/blue/red
93	ASDA	Recycled	White/green
94	ASDA	Recycled	White/green
95	Iceland	HDPE	White/red
96	ASDA	Recycled	White/green
97	Morrisons	Recycled	White/green/yellow
98	ASDA	Recycled	White/green
99	ASDA (BFL)	100% recycled	White/green/yellow
100	ASDA	Recycled	White/green

Cyanoacrylate Fuming Processing

All articles were fumed with the relevant cyanoacrylate product using an Air Science Safefume CA60T fuming cabinet with a volume of approximately 1.5m^3. All fuming cycles were performed at atmospheric pressure and 80% RH. The hot plate temperature and the cabinet's relative humidity were verified, and calibrated where necessary, by means of a digital thermometer/thermocouple (RS 206-3738) and a humidity meter (Fluke-971). For process **A** (two-step cyanoacrylate/BY40), 4.0g of cyanoacrylate was weighed with a 40 minute fuming cycle and a hotplate temperature of 120^{o}C. For process **B** (Lumicyano 5%), 0.2g of Lumicyano powder was added to 4.0g of Lumicyano cyanoacrylate solution to make

a 5% concentration with a 40 minute fuming cycle and a hotplate temperature of 120ºC. For processes **C** (Polycyano UV) and **D** (PECA Multiband), 2.0g and 2.4g of powder was weighed respectively with a fuming cycle of 60 minutes and a hotplate temperature of 230°C for both processes. The weight of each product was monitored before and after fuming. After the first fuming cycle with the appropriate process, all sections were fumed again with the same technique for a double process before subsequent staining with BY40 (figure 5). The number of latent marks detected (visual and fluorescent) after each process was recorded. Any prints developed with continuous ridge detail and an area greater than 64 mm^2 were counted, as per CAST guidelines for pseudo-operational trials (Sears *et al* 2012). In addition and after the second process, marks found from the first process were assessed for over development, by assessing whether the ridge detail recorded from the first fuming cycle was of the same quality. The BY40 solution was prepared by dissolving 2g of BY40 in 1L of ethanol. Bag sections were submerged in the BY40 solution for 15-20 seconds before rinsing off the excess dye with running tap water and allowed to dry (Centre for Applied Science and Technology (CAST) 2014).

Visualisation and Photography

Developed marks with of an area greater than 64mm^2 were counted as recommended by CAST in pseudo-operational trials (Sears *et al* 2012). All treated items were observed under white light and under fluorescence as soon as possible to avoid possible fluorescence degradation from the three one-step fluorescent cyanoacrylate processes. Fluorescence examination was performed using a recently serviced Mason Vactron Quaser 2000/30 (light source is a 300W Xenon arc lamp with a light output power of 4W in the 400-600nm band and a 2m liquid light guide) and a 50W Labino SuperXenon Lumi Kit (peak excitation of 325nm). The distance and angle of the light source from the substrate varied through the study depending on how weakly/strongly the mark fluoresced. Lumicyano (process B) was viewed under a blue/green excitation source at 468-526nm and a 529nm viewing filter. PolyCyano UV (process C) was observed with long wave UV (peak excitation of 325nm) and viewed with a UV face shield for UV protection. PECA Multiband (process D) was observed under multiple excitation sources: 400-469nm (476nm viewing filter), 468-526nm (529nm viewing filter), 473-548nm (549nm viewing filter) goggles and under UV light. BY40, the final treatment in the sequence for all sections, was observed with a blue light excitation source (400-469nm) and viewed with a 476nm viewing filter. Visualisation of BY40 was

carried out the day after staining once the bags were dry. Fingermarks were photographed using a Nikon D5100 camera, fitted with a 60mm micro Nikkor lens and the appropriate viewing camera filters as per the viewing goggles. The same light sources were used for the examination and photography of fingermarks.

Results and Discussion

Figure 7 summarise the number of marks observed with the different cyanoacrylate processes where the number of marks (visual and fluorescent) was recorded at each stage. The total number of fingermarks detected by the two-step CA/BY40 was 120 marks which includes the double fuming process (treatment 2), albeit only an additional 8 fingermarks. After the double process and fluorescent examination, Lumicyano developed a total of 108 fingermarks PolyCyano UV developed 115 fingermarks and PECA Multiband 96 fingermarks. The use of BY40 after all processes in this study detected a higher number of more marks. Although a significant number of additional fingermarks were detected after the second fuming cycle for all three one-step products, none of the marks developed during the first cycle appeared to be overdeveloped after the secondary fuming (figure 8).

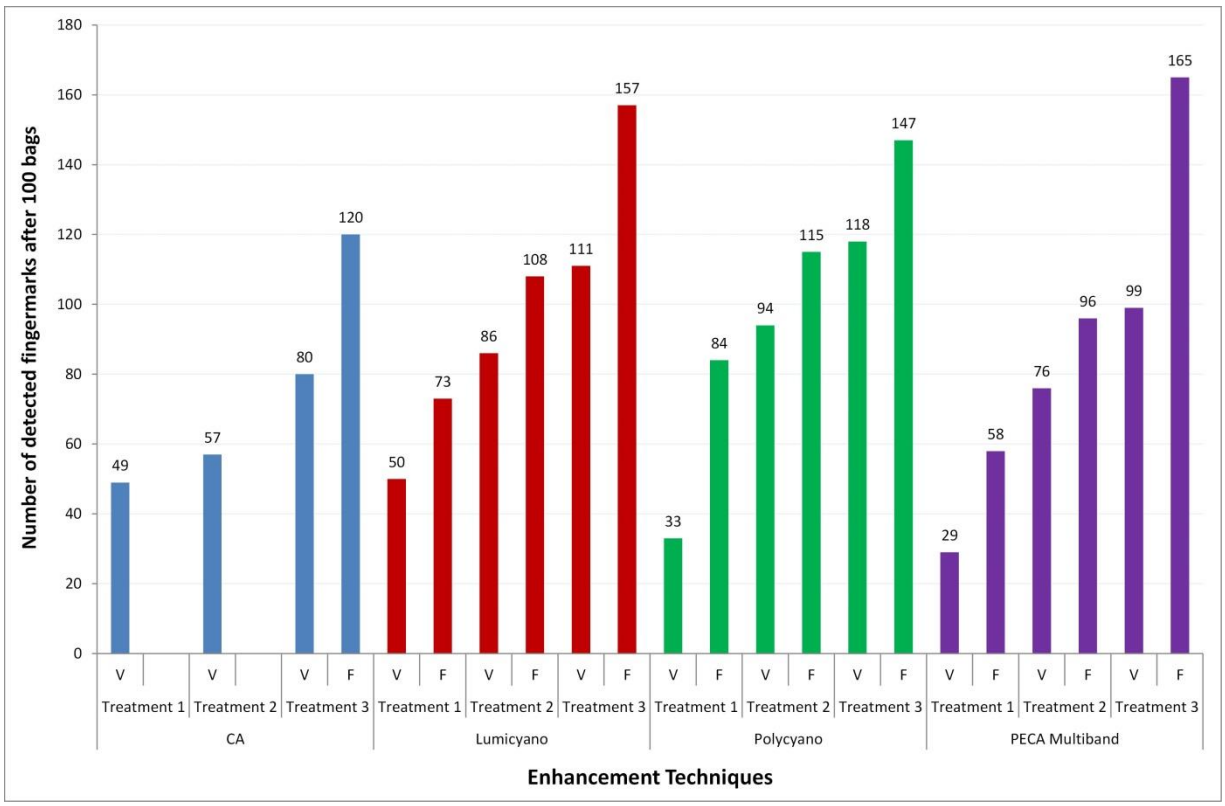


Figure 7 - Number of fingermarks developed by each process after each treatment under white light (V) and fluorescence (F)

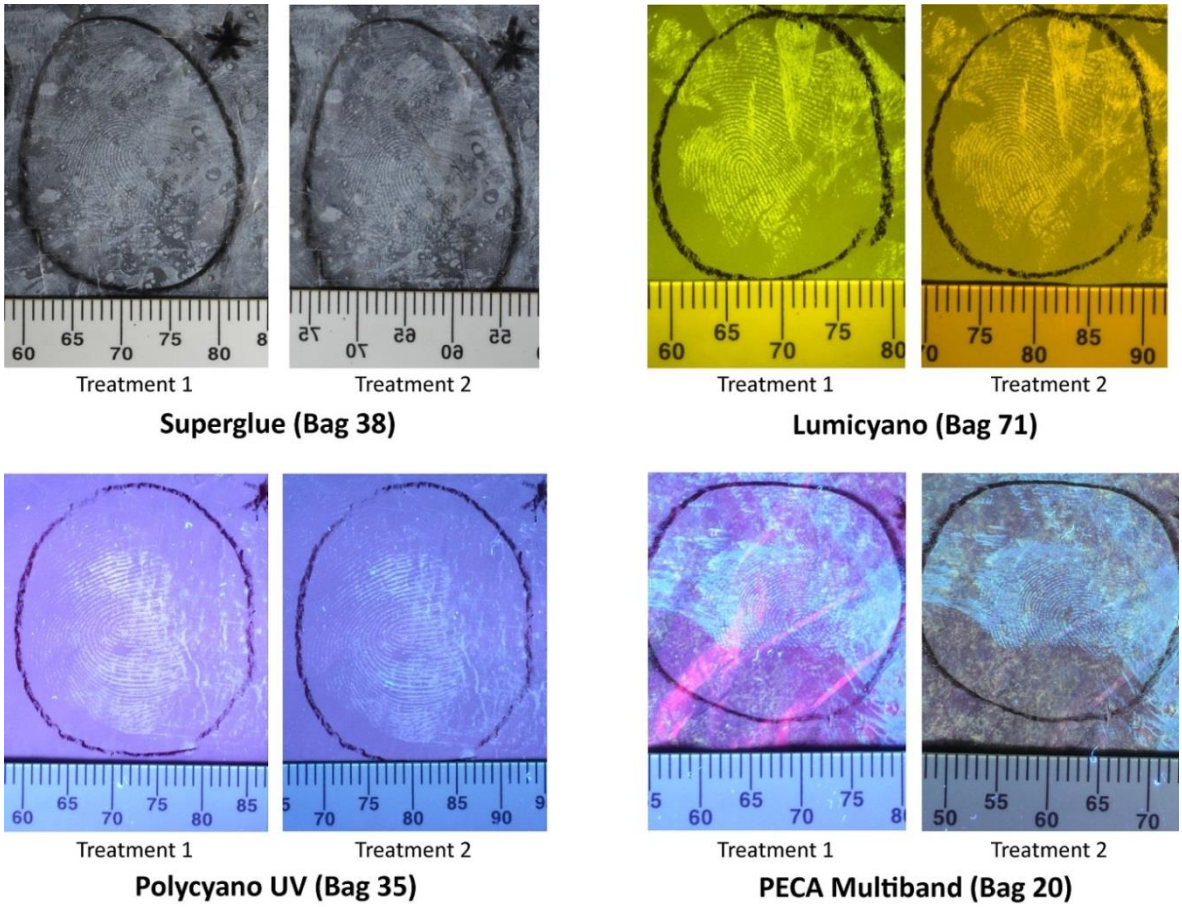


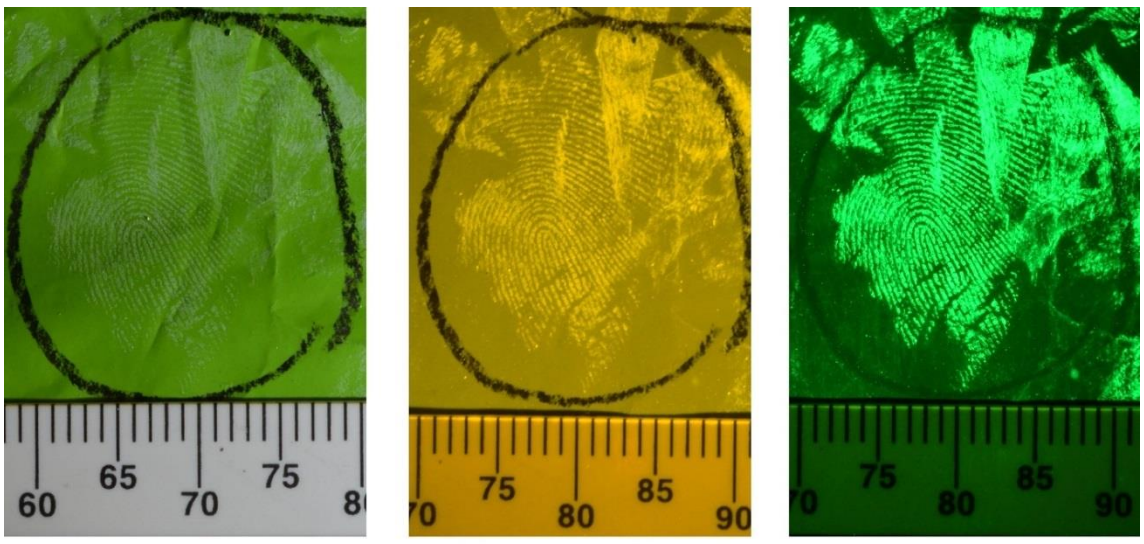
Figure 8 – The same latent mark going through two fuming cycles

Re-fuming of marks in a second process can result in an enhanced fingermark where the initial cycle may not have deposited enough cyanoacrylate polymer material. There are several possible explanations for this. One study (Farrugia *et al* 2015) noted that the Lumicyano polymer develops on top of the previously developed ridge detail (z plane) rather than laterally (x-y plane), which explains why weak development after one cycle may be further developed with a second cycle. Another study (Groeneveld *et al* 2014) reported that the Lumicyano polymer appears to have a "slightly better developed polymeric nanofiber morphology in comparison with the traditional method". Further research is required to understand the double fuming process and whether the one-step cyanoacrylate deposits are attracting further cyanoacrylate component, dye component or a combination of both. For the conventional two-step cyanoacrylate, Lumicyano and Polycyano, there was no obvious

leftover product visible in the foil dish after the fuming process; however, for PECA Multiband there was an average of 25% w/w leftover partly burnt product in the foil dish. This may be due to PECA Multiband rapidly decomposing prior to evaporation.

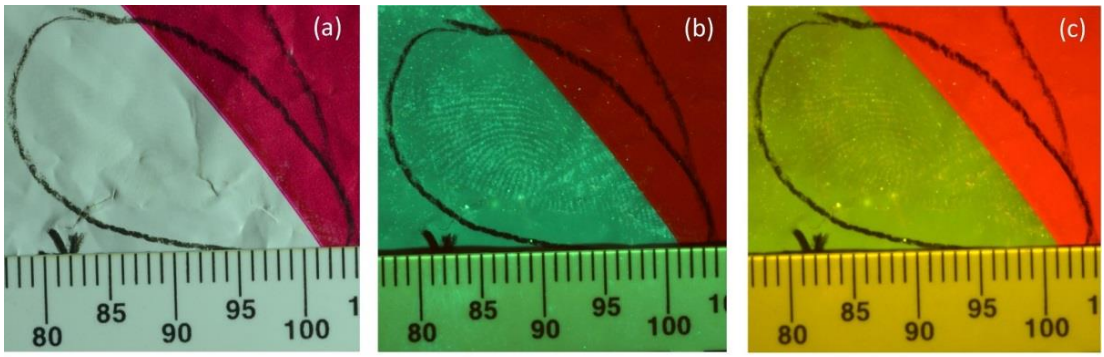
Fluorescence examination

Lumicyano, PolyCyano UV and PECA Multiband yielded similar levels of fluorescence brightness. All articles under examination were observed as soon as possible to avoid any potential fluorescence degradation. The fluorescence observed with the final BY40 treatment was far brighter in comparison to the fluorescence of all three one-step products, which allowed for easier visualisation and the detection of additional marks (figure 9). Another study (Khuu *et al* 2016) reported that the two-step cyanoacrylate process with Rhodamine 6G staining provided better contrast than the one-step fluorescent processes and that rhodamine 6G post-treatment of one-step treated marks did not significantly enhance the contrast further. After testing a number of different types and colours of bags with PECA Multiband, it quickly became obvious that the best contrast and visualisation was achieved by means of UV lighting (figure 10). Furthermore, PECA Multiband powder residue was visible on the majority of the bags which resulted in background fluorescence. There are health and safety issues with regards to the prolonged use of UV-A (315-400nm); however, UV-B (280-315nm) and UV-C (100-280nm) are even more damaging as well as destructive to DNA. The use of Quaser high-intensity sources has so far proved non-destructive to DNA at all wavelengths for up to 30 minutes exposure (Bowman 2005).



(a) (b) (c)

Figure 9 - Enhancement of a latent mark on a plastic bag with Lumicyano and observed under (a) white light (oblique lighting); (b) blue/green light (orange filter) followed by treatment with BY40 and observed under (c) violet/blue light (yellow filter)



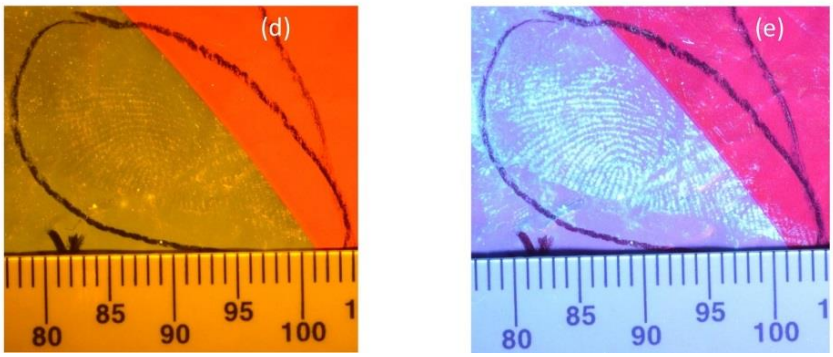


Figure 10 - A latent fingermark on a polyethylene bag developed with PECA Multiband as viewed under different excitation wavelengths (a) white light; (b) blue light (yellow filter); (c) blue/green light (orange filter); (d) green light (orange filter); (e) longwave UV (UV filter)

Maintenance issues

The use of PECA Multiband resulted in a number of issues since a yellow/orange powder residue was left on the inside of the fuming cabinet, in the circulation fans, filters and the humidifier fan which required thorough cleaning that was time consuming (figure 11). This powder also clogged up the humidifier wick, which meant that unless the water was changed and the wick thoroughly rinsed after each PECA cycle the humidity would take an abnormally long time to reach 80%. The wick also had a shorter lifespan as a result of the PECA fuming cycles. The use of Polycyano UV also resulted in similar problems but this was to a much lesser degree when compared to PECA Multiband. There were no powder problems with Lumicyano since the product consists of a powder that dissolves in cyanoacrylate; however, there was some pink staining on the cabinet walls that needed scrubbing in between cycles.

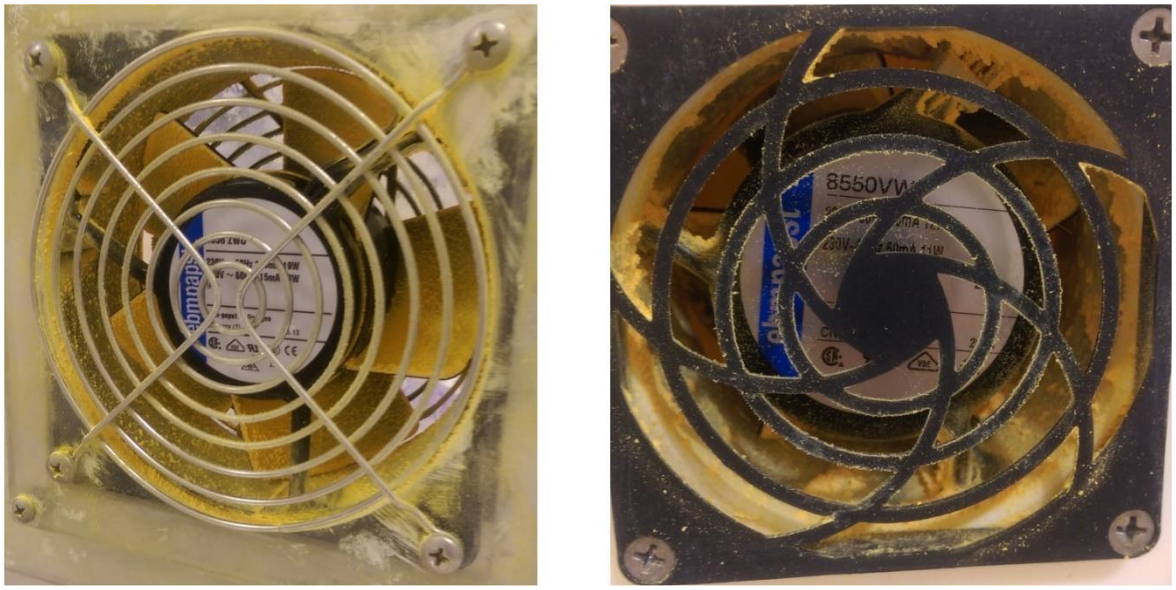


Figure 11 - PECA Multiband powder residue problems in fuming cabinet components

Conclusion

The main advantages of a one-step process are the reduction of processing times in urgent cases by avoiding the dyeing procedure as well as the drying time after rinsing off the excess dye. Nonetheless, for certain one-step processes, the cleaning time of the fuming cabinet can negate any time saving in comparison to the two-step process. There is also space saving aspects since a dyeing tank and drying areas are not required. Furthermore, the absence of solvents can potentially reduce interference with subsequent DNA analysis and other forensic evidence such as body fluids and inks in an effort to maximise the recovery of different types of evidence.

One-step fluorescent cyanoacrylate techniques provide an alternative to the two-step process with the added advantage of more marks being detected by re-fuming. The increased detection rate after this secondary cycle may be explained by the targeting of the cyanoacrylate/dye to previous deposits of cyanoacrylate and/or dye; however, this requires further research to fully understand. The minimal, increased detection after a double fuming process using traditional cyanoacrylate of the two-step process was not significant. Subsequent BY40 staining after the two fuming cycles of the one-step process then resulted in an increased detection rate to the two-step process.

Terry Kent stresses the importance that "we are not seduced into giving up well-tried and documented methods by superficial attraction of a 'new technique' until we have reliable data" (Kent 2010). There is no doubt about the advantages of a one-step fluorescent cyanoacrylate process; however, extensive further research by the forensic community is required to improve the category C status of these processes in the Fingermark Visualisation Manual.

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