

Further Pseudo-Operational Trials with the Lumicyano Double- and Co-Fuming Process for the Detection of Latent Fingermarks

Kevin J. Farrugia
Danielle Hunter
Clarice Wilson
Stef Hay
Paul Sherriffs
Paul Deacon

This is the peer reviewed version of the following article:
Farrugia, K.J. et al(2019) Further Pseudo-Operational
Trials with the Lumicyano Double- and Co-Fuming
Process for the Detection of Latent Fingermarks, which
has been published in final form at
<https://doi.org/10.1111/1556-4029.14140>.

This article may be used for non-commercial purposes in
accordance with [Wiley Terms and Conditions for Self-
Archiving](#).

Further pseudo-operational trials with the Lumicyano double and co-fuming process for the detection of latent fingerprints

Journal:	<i>Journal of Forensic Sciences</i>
Manuscript ID	JOFS-19-300.R1
Manuscript Type:	Technical Note
Keywords:	forensic science, cyanoacrylate, superglue, fingerprint, latent mark, fluorescence

1
2
3 Further pseudo-operational trials with the Lumicyano double and co-
4 fuming process for the detection of latent fingerprints
5
6
7
8
9

10
11
12 **ABSTRACT**

13
14 This study presents a number of pseudo-operational trials on plastic bags investigating the
15 double and co-fuming process of a one-step fluorescent cyanoacrylate (Lumicyano™) with
16 comparisons to the two-step process with basic yellow 40 (BY40) staining for the detection of
17 latent fingerprints. The results demonstrate that both the Lumicyano solution and dye
18 contribute to the increased detection of latent fingerprints during the double fuming process
19 (trial 1). Co-fuming the Lumicyano solution and dye separately (at a concentration of 8%) but
20 simultaneously was less effective than 8% Lumicyano (trial 2). Co-fuming Lumicyano 8% and
21 an additional 8% Lumicyano dye by weight was more effective than Lumicyano 8% (trial 3),
22 possibly due to increased fluorescent material deposition during co-fuming allowing for better
23 visualisation. The use of BY40 after Lumicyano resulted in a considerable increase of detected
24 fingerprints. luorescence
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40

41
42 **KEYWORDS**

43 Forensic science, cyanoacrylate, superglue, fingerprint, latent mark, fluorescence
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

1
2
3 One-step fluorescent cyanoacrylates have a number of potential advantages such as a decrease
4
5 in processing time and the absence of solvents helps to reduce interference with subsequent
6
7 DNA analysis and other forensic evidence. Examples of one-step fluorescent cyanoacrylates
8
9 include Lumicyano, Polycyano, CN Yellow, Fuming Orange and PECA Multiband in addition
10
11 to other fluorescent cyanoacrylates synthesised in the laboratory (1-8). Although such products
12
13 have a number of advantages, their fluorescence is generally weaker and can degrade with time.
14
15 The subsequent use of a fluorescent stain, such as basic yellow 40 (BY40) and Rhodamine 6G
16
17 will often reveal additional new detections of latent marks (9). Fluorescent cyanoacrylates, with
18
19 the exception of Lumicyano, require a temperature of 230°C. The use of higher temperatures
20
21 for evaporating cyanoacrylates may require cabinet modification and produce toxic hydrogen
22
23 cyanide gas (10).
24
25
26
27

28
29 A study (3) investigating the sequential double process of Lumicyano fuming, whereby items
30
31 are fumed followed by another fuming cycle, reported that the second fuming cycle resulted in
32
33 the detection of marks that were not observed after the first fuming cycle. This increased
34
35 detection rate was due to a break between the two fuming cycles rather than due to the double
36
37 amount of cyanoacrylate/dye and fuming time. In 2005, the UK Home Office Centre for
38
39 Applied Science and Technology (CAST) investigated the co-polymerisation of cyanoacrylate
40
41 and solvent yellow 43 that was heated to a temperature range of 170–185°C. The resultant
42
43 fluorescence was weak; however, subsequent staining with basic yellow 40 provided
44
45 fluorescence that was 5-10 times brighter (Vaughn Sears, CAST, personal communication,
46
47 11/11/2015).
48
49
50
51

52
53 This current study aims to follow up on previous pseudo-operational trials (3) on plastic
54
55 carrier bags to further evaluate the Lumicyano double fuming process. The methodology is
56
57 based on guidelines recommend by CAST (11) and the International Fingerprint Research
58
59 Group (IFRG) (12). Both CAST and the IFRG describe pseudo-operational trials as stage or
60
phase 3 out of 4

1
2
3 in fingerprint research. These trials are defined as a process to “establish whether the results
4
5 obtained in laboratory trials are replicated on articles/surfaces typical of those that may
6
7 be submitted to a fingerprint laboratory, or to distinguish between closely equivalent
8
9 formulations that cannot be separated in laboratory trials” (11). CAST classifies
10
11 fluorescent superglue fuming at low to medium maturity and as a category C process with
12
13 niche applications. As more peer-reviewed articles are published around the topic, the
14
15 technique may be upgraded to a category B process which is defined as a process that is
16
17 generally less effective but has not been fully evaluated by the Home Office CAST (11).
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

Methodology

Sample collection and preparation.

The collection of plastic carrier bags (mixture of HDPE, LDPE, recycled and bio) from work colleagues, family and friends became more difficult since a recent change in UK law (Wales 2011, Northern Ireland 2013, Scotland 2014 and England 2015) requiring large retailers to charge a small fee for all single-use plastic barrier bags. Plastic carrier bags were therefore collected from dedicated plastic bag recycling centres at big supermarkets. This increased the variation of donors, plastic bag types and fingermark age. Each trial consisted of 100 items in line with other studies (1-3,13) and the description (e.g. colour and material type) for each item was recorded. All items were treated with the required technique within three weeks of collection. For the three pseudo-operational trials, all items were split into three equal parts and labelled Process A, B and C from left to right as shown in figure 1. To eliminate any bias, samples were rotated whereby sample 1 was A-B-C; sample 2 was B-C-A; sample 3 was C-B-A and so on.

Pseudo-operational trials

Trial 1 used Lumicyano™, supplied by Crime Science Technology (CST) consisting of a clear cyanoacrylate solution (Lumicyano™ Solution) and a bright red-orange powdered dye (Lumicyano™ Powder), added at the 5% level (by weight). Process A consisted of a double fuming treatment with Lumicyano 5% followed by basic yellow 40 (BY40) staining. At least six hours had passed before the second fuming treatment and in general, it was done within 24 hours of the first treatment. Any detected fingermarks were counted between each process (Lumicyano 5%-Lumicyano 5%-BY40). Processes B and C were similar to process A; however, the second treatment was replaced with Lumicyano solution only and Lumicyano dye only respectively (figure 1). Trials 2 and 3 used co-fuming of the Lumicyano solution and dye.

1
2
3 Trial 2 treatment A involved 8% Lumicyano treatment (manufacturer's instructions at the time
4 of trial increased dosage to 8%) followed by BY40 staining whereas treatment C was the
5 conventional two-step cyanoacrylate fuming followed by BY40 staining. For treatment B, a
6 co-fuming process was carried out where the Lumicyano solution and the Lumicyano dye (8%)
7 were evaporated separately, but simultaneously, before BY40 staining. Trial 3 differed only
8 from trial 2 with treatment B (figure 1), where this process involved a co-fuming process of
9 Lumicyano 8% and Lumicyano dye only at 8%. For all three trials, BY40 staining was
10 performed the day after fuming. A small trial of 25 recycled bags (trial 4) was performed to
11 investigate the effect of the change in Lumicyano concentration from 5 to 8%.
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26

Cyanoacrylate Fuming Chamber, Photography and Fluorescence

27
28 An Air Science fuming chamber (model number CA60T) was employed with an approximate
29 volume of about 1500 L (1.5 m³). The chamber is fitted with two independent hot plates capable
30 of reaching 400°C (both set at 120°C) and a humidifier (set to 80%). The two hot plates can
31 start simultaneously once a humidity of 80% is reached or the second hot plate can turn on at
32 a pre-determined time after the first hot plate (figure 2). For trials 2 and 3, the second hot plate
33 was set to come on 15 minutes after the first one. The hot plate and humidifier were calibrated
34 by means of a digital thermometer/thermocouple (RS 206-3738) and a Hygro-Thermometer
35 Psychrometer (Extech RH300). Fluorescence examination was carried out using Crime-Lites
36 and a Mason Vactron Quaser 2000/30 whereas UV examination was carried out using a 50W
37 Labino® SuperXenon Lumi Kit (peak excitation at 325nm) and viewed with a clear UV filter.
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
61
62
63
64
65
66
67
68
69
70
71
72
73
74
75
76
77
78
79
80
81
82
83
84
85
86
87
88
89
90
91
92
93
94
95
96
97
98
99
100
101
102
103
104
105
106
107
108
109
110
111
112
113
114
115
116
117
118
119
120
121
122
123
124
125
126
127
128
129
130
131
132
133
134
135
136
137
138
139
140
141
142
143
144
145
146
147
148
149
150
151
152
153
154
155
156
157
158
159
160
161
162
163
164
165
166
167
168
169
170
171
172
173
174
175
176
177
178
179
180
181
182
183
184
185
186
187
188
189
190
191
192
193
194
195
196
197
198
199
200
201
202
203
204
205
206
207
208
209
210
211
212
213
214
215
216
217
218
219
220
221
222
223
224
225
226
227
228
229
230
231
232
233
234
235
236
237
238
239
240
241
242
243
244
245
246
247
248
249
250
251
252
253
254
255
256
257
258
259
260
261
262
263
264
265
266
267
268
269
270
271
272
273
274
275
276
277
278
279
280
281
282
283
284
285
286
287
288
289
290
291
292
293
294
295
296
297
298
299
300
301
302
303
304
305
306
307
308
309
310
311
312
313
314
315
316
317
318
319
320
321
322
323
324
325
326
327
328
329
330
331
332
333
334
335
336
337
338
339
340
341
342
343
344
345
346
347
348
349
350
351
352
353
354
355
356
357
358
359
360
361
362
363
364
365
366
367
368
369
370
371
372
373
374
375
376
377
378
379
380
381
382
383
384
385
386
387
388
389
390
391
392
393
394
395
396
397
398
399
400
401
402
403
404
405
406
407
408
409
410
411
412
413
414
415
416
417
418
419
420
421
422
423
424
425
426
427
428
429
430
431
432
433
434
435
436
437
438
439
440
441
442
443
444
445
446
447
448
449
450
451
452
453
454
455
456
457
458
459
460
461
462
463
464
465
466
467
468
469
470
471
472
473
474
475
476
477
478
479
480
481
482
483
484
485
486
487
488
489
490
491
492
493
494
495
496
497
498
499
500
501
502
503
504
505
506
507
508
509
510
511
512
513
514
515
516
517
518
519
520
521
522
523
524
525
526
527
528
529
530
531
532
533
534
535
536
537
538
539
540
541
542
543
544
545
546
547
548
549
550
551
552
553
554
555
556
557
558
559
560
561
562
563
564
565
566
567
568
569
570
571
572
573
574
575
576
577
578
579
580
581
582
583
584
585
586
587
588
589
590
591
592
593
594
595
596
597
598
599
600
601
602
603
604
605
606
607
608
609
610
611
612
613
614
615
616
617
618
619
620
621
622
623
624
625
626
627
628
629
630
631
632
633
634
635
636
637
638
639
640
641
642
643
644
645
646
647
648
649
650
651
652
653
654
655
656
657
658
659
660
661
662
663
664
665
666
667
668
669
670
671
672
673
674
675
676
677
678
679
680
681
682
683
684
685
686
687
688
689
690
691
692
693
694
695
696
697
698
699
700
701
702
703
704
705
706
707
708
709
710
711
712
713
714
715
716
717
718
719
720
721
722
723
724
725
726
727
728
729
730
731
732
733
734
735
736
737
738
739
740
741
742
743
744
745
746
747
748
749
750
751
752
753
754
755
756
757
758
759
760
761
762
763
764
765
766
767
768
769
770
771
772
773
774
775
776
777
778
779
780
781
782
783
784
785
786
787
788
789
790
791
792
793
794
795
796
797
798
799
800
801
802
803
804
805
806
807
808
809
810
811
812
813
814
815
816
817
818
819
820
821
822
823
824
825
826
827
828
829
830
831
832
833
834
835
836
837
838
839
840
841
842
843
844
845
846
847
848
849
850
851
852
853
854
855
856
857
858
859
860
861
862
863
864
865
866
867
868
869
870
871
872
873
874
875
876
877
878
879
880
881
882
883
884
885
886
887
888
889
890
891
892
893
894
895
896
897
898
899
900
901
902
903
904
905
906
907
908
909
910
911
912
913
914
915
916
917
918
919
920
921
922
923
924
925
926
927
928
929
930
931
932
933
934
935
936
937
938
939
940
941
942
943
944
945
946
947
948
949
950
951
952
953
954
955
956
957
958
959
960
961
962
963
964
965
966
967
968
969
970
971
972
973
974
975
976
977
978
979
980
981
982
983
984
985
986
987
988
989
990
991
992
993
994
995
996
997
998
999
1000

Cyanoacrylate

4 g of cyanoacrylate (CSI equipment Ltd, UK) was required for the volume of the cabinet. A cycle time of 60 minutes ensured that 99.99% of the cyanoacrylate had evaporated as checked by the weight difference before and after the cycle.

5% and 8% Lumicyano™

The manufacturer recommends a concentration of 5% and 8% of powder by weight of cyanoacrylate solution. For example, 5% solution was prepared by adding 0.2g of Lumicyano dye to 4 g Lumicyano cyanoacrylate solution. After fuming, fluorescence was observed using the Quaser 2000/30 by exciting with a blue/green light (band pass filter 468–526 nm at 1% cut-on and cut-off points respectively) and viewed with an orange long pass 529 nm filter (1% cut-on point). UV examination was carried out using a 50W Labino® SuperXenon Lumi Kit (peak excitation at 325nm) and viewed with a UV face shield for UV protection.

BY40 staining (14)

The BY40 solution was prepared by dissolving 2 g of BY40 (Sirchie) in 1 L of ethanol (Fisher). The items to be processed were submerged in the BY40 solution for 15-20 seconds before rinsing off the excess dye with running tap water and allowed to dry at room temperature overnight prior to fluorescence examination. BY40 dyeing on fumed items was performed the following day after fuming. BY40 fluorescence was observed using a Quaser 2000/30 by exciting with a violet/blue excitation source (band pass filter 400-469 nm at 1% cut-on and cut-off points respectively) and viewed with a yellow long pass 476 nm filter (1% cut-on point). A blue Crime-Lite® 82S [10% band width 420–470 nm with a 445 nm peak and viewed with a yellow long pass 476 nm filter (1% cut-on point)] was also used.

1
2
3 *Evaluation of the number and quality of latent marks recovered by each process*

4 Any prints developed with continuous ridge detail and an area greater than 64mm² were
5
6 counted. Each of these marks was graded 'a' for good contrast or 'b' for poor contrast. The
7
8 quality of the marks was assessed after each treatment in the sequence. Marks that
9
10 showed signs of over-developed were also noted.
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

Results and Discussion

In general, a high number of recycled and life-long plastic bags were observed which differed significantly from previous studies (1-3). An evaluation of the number and quality of latent marks recovered by each treatment in each process and trial was performed. For all trials, there was some marks with poor contrast (grading b); however, subsequent fluorescence examination improved the contrast and almost all marks were graded as 'a'. Although a considerable number of marks were observed visually, the use of fluorescence provided a quicker visualisation method with less stress on the eye. In general, for Lumicyano, the blue-green excitation source (orange filter) provided better contrast than UV fluorescence. Over-fuming of marks was rarely observed with all fuming techniques.

Trial 1

Figure 3 summarises the number of marks detected for each treatment with each process as observed visually (V) and under fluorescence (F). The double fuming process (process A) resulted in an increased detection rate after the initial fuming cycle from 153 marks to 209 marks. This is in line with a previous study (3) which reported that the increased detection rate during the Lumicyano double fuming process was not due to the amount of cyanoacrylate or the fuming time but rather the break in the two fuming cycles. A similar pattern was reported for other one-step fluorescent cyanoacrylates, such as Polycyano and PECA Multiband, but not for the traditional two-step cyanoacrylate process (9). The increased detection rate may be due to Lumicyano targeting cyanoacrylate deposits and the marks undetected from the first fuming cycle could be acting as activation points for the polymer growth in the second fuming cycle (3). Processes B and C from trial 1 appear to suggest that the increased detection rate for the double fuming process A is due to both the Lumicyano solution and dye since both the

1
2
3 secondary treatments of process B (solution) and process C (dye) resulted in an increased
4
5 detection rate after treatment with 5% Lumicyano. A higher number of marks was reported for
6
7 the double fuming process of 5% Lumicyano - 5% Lumicyano (209 marks) compared to 192
8
9 marks (process B) and 184 marks (process C). The final BY40 staining step resulted in
10
11 additional marks for all treatments as reported in other studies for BY40 (1-3) and Rhodamine
12
13 6G (4-5).
14
15
16
17
18
19

20 *Trial 2*

21
22
23 Figure 4 demonstrates that the number of marks, visually and fluorescent, detected for each
24
25 treatment with each process. Process A resulted in a significantly increased detection rate after
26
27 BY40 staining marks previously treated with Lumicyano 8%. It is important to note that trials
28
29 2 and 3 were performed about six months after trial 1 and, in that time, the recommended
30
31 concentration of Lumicyano changed from 5% to 8%. This increased detection rate after BY40
32
33 is higher than the 15-25% in trial 1 and previous studies (1-3). The high increase in the number
34
35 of recycled bags in trials 2 and 3 (>90%) when compared to trial 1 and previous studies may
36
37 explain this. The increased concentration of Lumicyano from 5% to 8% did not appear to
38
39 influence the results (small scale study of 25 plastic bags in trial 4); however, the increased
40
41 detection after BY40 was evidenced again. A recent study (15) reported that substrate
42
43 characteristics play a significant role in determining the number and quality of marks
44
45 developed. Furthermore, another study (11) on the detection of fingermarks on plastics by the
46
47 UK Home Office CAST highlighted a change in the relative performance of enhancement
48
49 techniques from trials done in 1986 and 2009 due to changes in the manufacturing process of
50
51 plastics. Process B, involving the co-fuming of the Lumicyano solution and dye (8%), revealed
52
53 a lower detection rate by about a third than when Lumicyano was mixed at a concentration of
54
55 8% (Process A). This suggests that Lumicyano is more effective when the solution and dye are
56
57
58
59
60

1
2
3 mixed together rather than co-fumed separately. Process C, two-step cyanoacrylate followed
4
5 by BY40, resulted in a lower detection rate when compared to process A and B, but only after
6
7 the use of BY40 on these two processes.
8
9

10 11 12 *Trial 3*

13
14
15 Figure 5 demonstrates that, as per trial 2, Process A resulted in a significantly increased
16
17 detection rate after BY40 staining marks previously treated with Lumicyano 8%. The co-
18
19 fuming of Lumicyano 8% and Lumicyano dye (8%) resulted in an increased detection rate (85
20
21 marks) when compared to only using Lumicyano 8% (63 marks). This may be because more
22
23 dye material is present resulting in a prolonged strong fluorescence. As per the previous trial,
24
25 Process C (two-step process) resulted in less marks than processes A and B; however, the two-
26
27 step process detected a similar number of marks (64 marks) when taking into consideration
28
29 only the one-step process (without the additional step of BY40) for processes A (63 marks).
30
31 This trial suggests that the use of co-fuming Lumicyano 8% in addition to more dye (Process
32
33 B) may result in the detection of more marks. For both trials 2 and 3, the increased dye
34
35 concentration of 8% did not result in an increase in background development during
36
37 fluorescence examination.
38
39
40
41
42
43
44
45

46 47 *Trial 4*

48 This small pseudo-operational trial of 25 recycled bags (not a double fuming process)
49
50 confirmed that the change in Lumicyano concentration did not have a detrimental effect on the
51
52 number of marks detected (figure 6). This also reflected the increased detection rate of BY40
53
54 after Lumicyano with recycled bags. As in previous studies (1-3), the two-step process of 5%
55
56 and 8% Lumicyano (71 and 83 marks respectively) is comparable to the two-step process with
57
58
59
60

1
2
3 BY40 (72 marks); however, the use of BY40 after Lumicyano treatment can result in a
4
5 considerable increase in detected marks.
6
7
8

9 10 **Conclusion**

11
12 This study has demonstrated that the increased detection rate during the double fuming cycle
13
14 of Lumicyano is due to both the solution and the dye part of the product. Further trials revealed
15
16 that the detection rate of latent fingermarks is reduced if the two Lumicyano components are
17
18 used separately (but simultaneously) when compared to mixing the two components together.
19
20 On the other hand, the simultaneous co-fuming of Lumicyano 8% with extra dye at a
21
22 concentration of 8% was more effective due to an increased in fluorescent material. In
23
24 summary, the use of a double fuming cycle can result in a higher detection rate; however, co-
25
26 fuming of Lumicyano 8% with additional Lumicyano dye can produce similar or a higher
27
28 detection rate during one cycle rather than two. Furthermore, the use of BY40 dye staining
29
30 resulted in a pronounced increased detection rate (more than previous studies), which may
31
32 be explained by the fact that most plastic bags currently in circulation are recyclable. Future
33
34 work will need to address the effect of substrate composition on latent fingermark detection
35
36 due to the increased circulation of recyclable, compostable and biodegradable plastic bags.
37
38 There is no doubt about the advantages of a one-step fluorescent cyanoacrylate process;
39
40 however, extensive further research by the forensic community is required to improve the
41
42 maturity level of these processes.
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

References

1. Farrugia KJ, Deacon P, Fraser J. Evaluation of Lumicyano™ cyanoacrylate fuming process for the development of latent fingermarks on plastic carrier bags by means of a pseudo operational comparative trial. *Sci Justice* 2014;54(2):126–32.
2. Farrugia KJ, Fraser J, Calder N, Deacon P. Pseudo-Operational Trials of Lumicyano Solution and Lumicyano Powder for the Detection of Latent Fingermarks on Various Substrates. *J Forensic Identif* 2014;64(6):556–82.
3. Farrugia KJ, Fraser J, Friel L, Adams D, Attard-Montalto N, Deacon P. A comparison between atmospheric/humidity and vacuum cyanoacrylate fuming of latent fingermarks. *Forensic Sci Int* 2015;257:54-70.
4. Chadwick S, Xiao L, Maynard P, Lennard C, Spindler X, Roux C. PolyCyano UV: an investigation into a one-step luminescent cyanoacrylate fuming process. *Aust J Forensic Sci* 2014;46(4):471–84.
5. Khuu A, Chadwick S, Spindler X, Lam R, Moret S, Roux C. Evaluation of One-Step Luminescent Cyanoacrylate Fuming. *Forensic Sci Int* 2016;263:126–31.
6. Khuu A, Chadwick S, Moret S, Spindler X, Gunn P, Roux C. Impact of one-step luminescent cyanoacrylate treatment on subsequent DNA analysis. *Forensic Sci Int* 2018;286:1–7.
7. Bentolila A, Totre J, Zozulia I, Levin-Elad M, Domb AJ. Fluorescent cyanoacrylate monomers and polymers for fingerprint development. *Macromolecules* 2013;46(12):4822–8.
8. Groeneveld G, Kuijer S, de Puit M. Preparation of cyanoacrylate derivatives and comparison of dual action cyanoacrylate formulations. *Sci Justice* 2014;54(1):42–8.
9. Stewart V, Deacon P, Farrugia K. A review of one-step fluorescent cyanoacrylate techniques. *Fingerprint Whorld* 2016;41(162):6–29.

- 1
2
3 10. Fung TC, Grimwood K, Shimmon R, Spindler X, Maynard P, Lennard C, et al.
4
5 Investigation of hydrogen cyanide generation from the cyanoacrylate fuming process
6
7 used for latent fingerprint detection. *Forensic Sci Int* 2011;212(1–3):143–9.
8
- 9
10 11. Sears VG, Bleay SM, Bandey HL, Bowman VJ. A methodology for finger mark
11
12 research. *Sci Justice* 2012;52(3):145–60.
13
- 14
15 12. IFRG. Guidelines for the Assessment of Fingerprint Detection Techniques. *J Forensic*
16
17 *Identif* 2014;64(2):174–200.
18
- 19
20 13. Downham R, Mehmet S, Sears VG. A Pseudo-Operational Investigation into the
21
22 Development of Latent Fingerprints on Flexible Plastic Packaging Films. *J Forensic*
23
24 *Identif* 2012;62(6):661–82.
25
- 26
27 14. Centre for Applied Science and Technology (CAST). *Fingerprint Visualisation*
28
29 *Manual*. Home Office U.K, 2014.
30
- 31
32 15. Chadwick S, Moret S, Jayashanka N, Lennard C, Spindler X, Roux C. Investigation of
33
34 some of the factors influencing fingerprint detection. *Forensic Sci Int* 2018;289:381–
35
36 9.
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

1
2
3 **List of Figures**
4

5 Figure 1 - Sample division for a plastic carrier bag in the three trials.
6

7 Figure 2 – The two hot plates in the CA fuming chamber used during co-fuming.
8

9 Figure 3 - Number of detected latent fingerprints in pseudo-operational trial 1.
10

11 Figure 4 - Number of detected latent fingerprints in pseudo-operational trial 2.
12

13 Figure 5 - Number of detected latent fingerprints in pseudo-operational trial 3.
14

15 Figure 6 - Number of detected latent fingerprints in pseudo-operational trial 4.
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

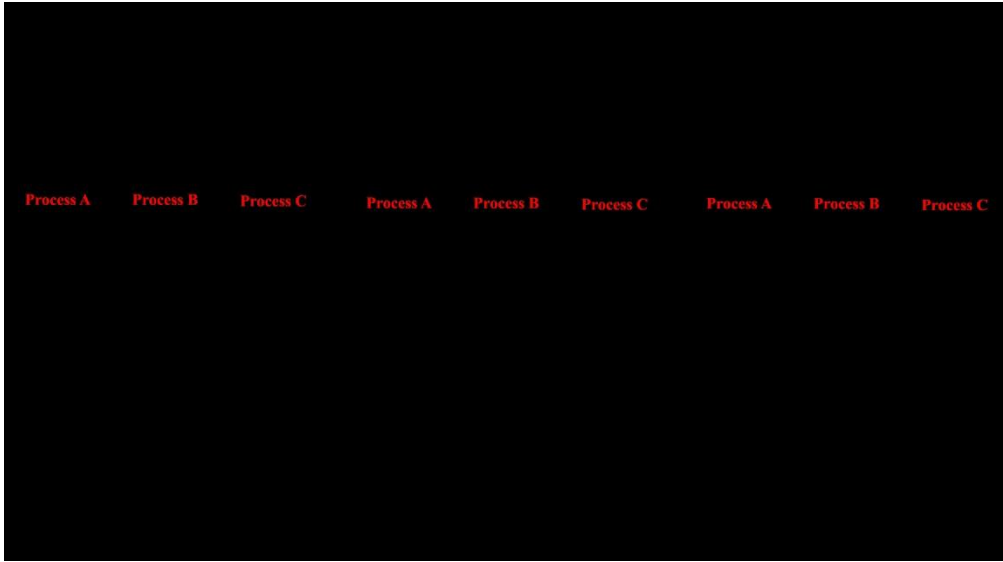


FIG. 1 - Sample division for a plastic carrier bag in the three trials.

441x246mm (300 x 300 DPI)



FIG. 2 – The two hot plates in the CA fuming chamber used during co-fuming.

350x241mm (300 x 300 DPI)

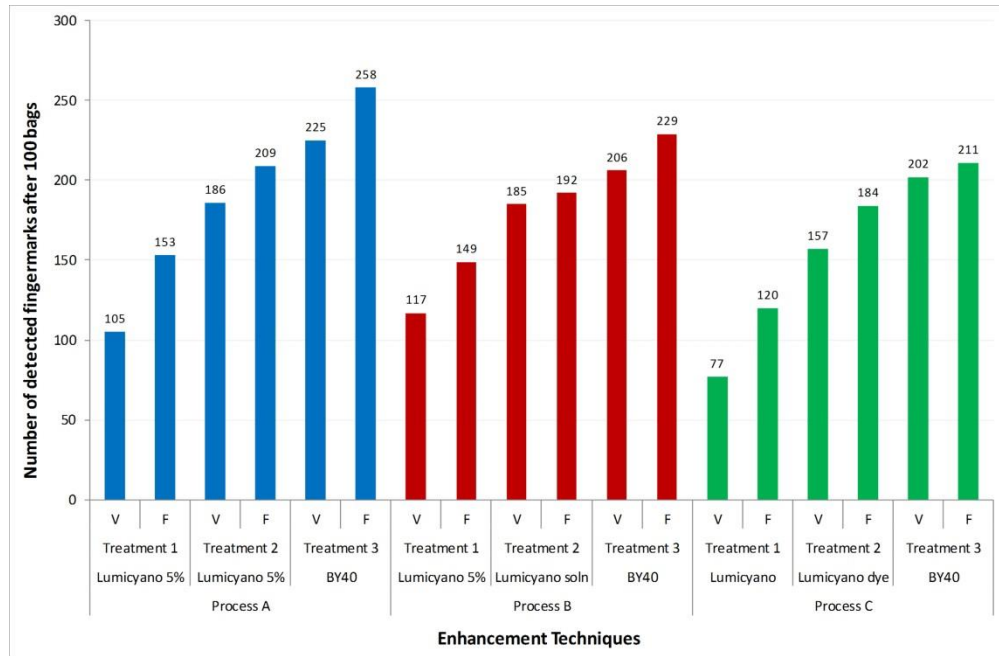


FIG. 3 - Number of detected latent fingerprints in pseudo-operational trial 1.
393x256mm (300 x 300 DPI)

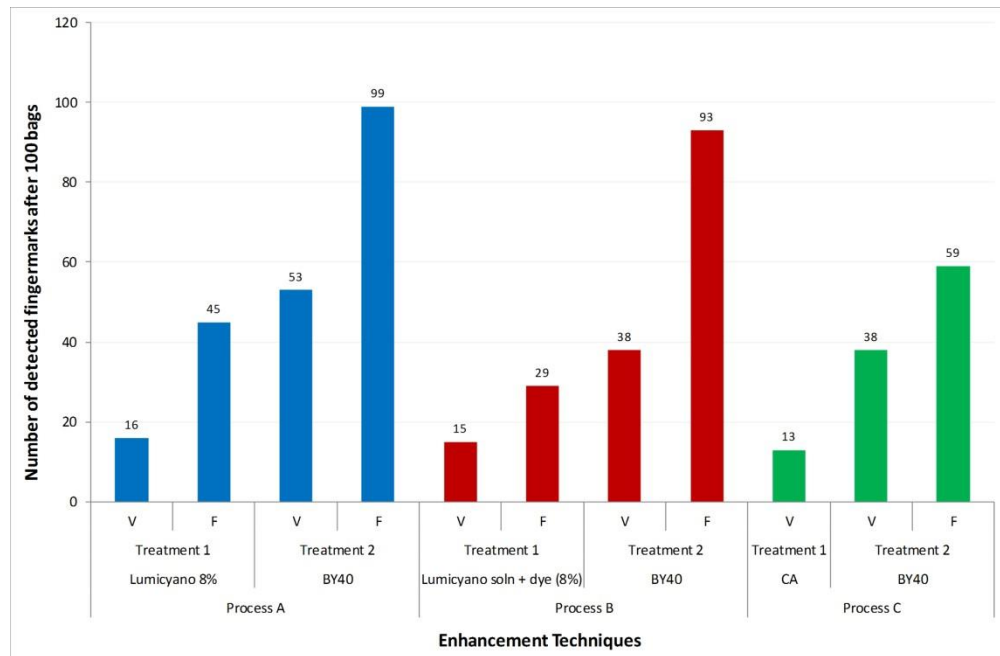


FIG. 4 - Number of detected latent fingerprints in pseudo-operational trial 2.
370x242mm (300 x 300 DPI)

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

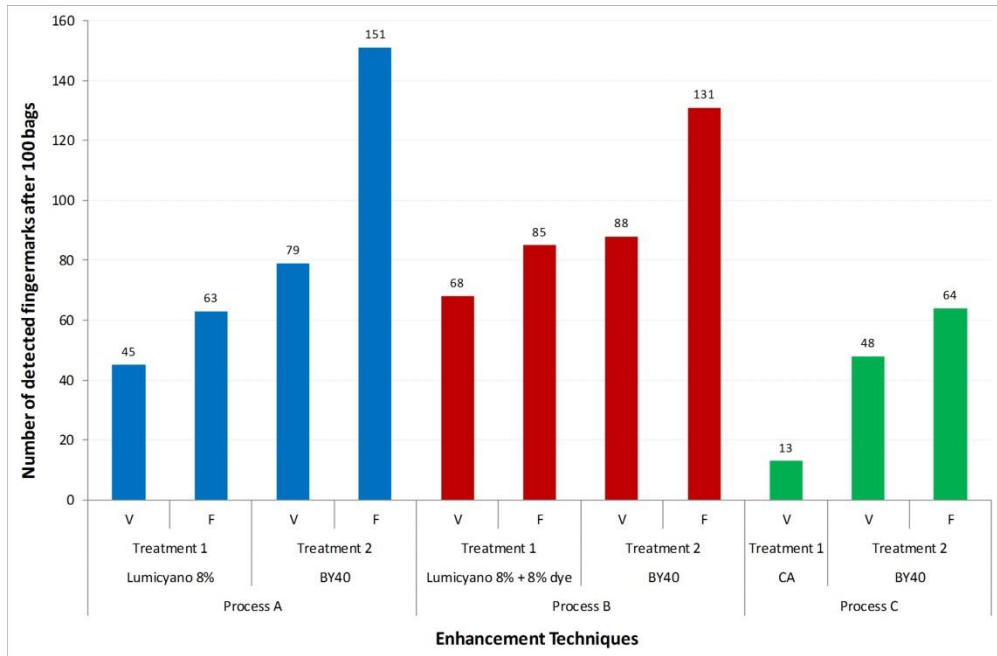


FIG. 5 - Number of detected latent fingerprints in pseudo-operational trial 3.
376x246mm (300 x 300 DPI)

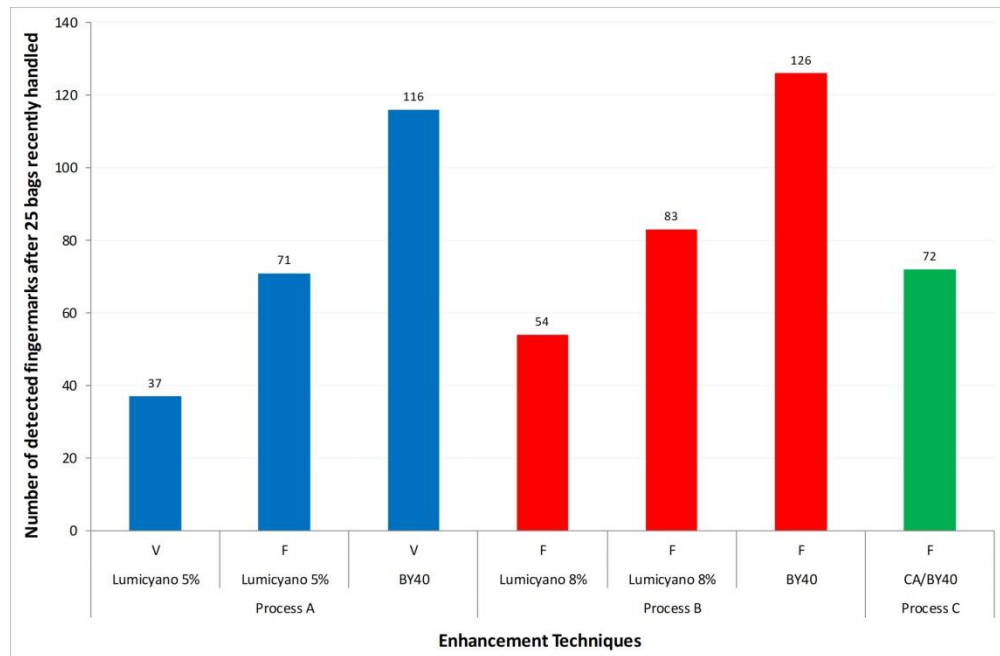


FIG. 6 - Number of detected latent fingerprints in pseudo-operational trial 4.
362x236mm (300 x 300 DPI)