Article

New Lumicyano Kit: Comparison Studies with the First Generation and Effectiveness on Nonporous Substrates

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Abstract: Lumicyano is a fluorescent cyanoacrylate that allows a one-step development of latent fingermarks without changing the fuming chamber settings. To improve the fluorescence intensity of the fingerprint revealed with Lumicyano as well as the stability of its fluorescence over time, the manufacturer of Lumicyano has developed a modified version (Lumicyano Kit), separating the cyanoacrylate (Lumicyano Solution) and the fluorophore (Lumicyano Powder). This study compares the first version of Lumicyano with Lumicyano Kit using a 1 % and 4 % Lumicyano Powder on nonporous substrates. This study demonstrates that on all of the substrates investigated (glass, aluminum foil, white and black plastic) on fresh or aged (one week, three weeks) fingermarks, the use of Lumicyano Kit improves the quality of the development.

Introduction

Lumicyano (Lumicyano, Crime Science Technology, Loos, France) as a one-step fluorescent cyanoacrylate has proven to be a credible alternative to two-step treatments (cyanoacrylate with a fluorescent post-treatment, such as BY40) [1, 2] to reveal latent fingermarks. Lumicyano provides high-quality development of latent marks with an excellent signal-to-noise ratio of fluorescence because of the excellent co-deposition of the fluorescent dye with the cyanoacrylate polymer. Lumicyano-assisted fingermark detection efficiency is comparable to two-step processes, with no modifications of the fumigation chamber required. However, without denying the importance of this one-step process, practitioners have expressed the reservation that the luminescence of fingermarks revealed with Lumicyano seems a little less brilliant compared to fluorescent prints obtained with a traditional two-step treatment such as BY40 [1]. Furthermore, the fluorescence intensity obtained with Lumicyano decreases, sometimes quickly, over time, depending on the substrate and the storage conditions. To overcome such difficulty, the manufacturer of Lumicyano has developed a modified version in kit form (named Lumicyano Kit) that separates the cyanoacrylate (named Lumicyano Solution) from the fluorophore (named Lumicyano Powder) so that the analyst can choose the amount of fluorophore that seems most appropriate to his or her experimental conditions. The purpose of this study was to determine the advantage of Lumicyano Kit over Lumicyano for use on nonporous substrates on the basis of three criteria of quality: contrast, ridge detail, and ridge continuity.

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Materials and Methods

Surfaces

Several nonporous substrates were used during this study:

- Microscope slides (StarFrost, Kinttel Glass, Braunschweig, Germany) used directly after being taken out of their packaging
- Pieces of black polyethylene trash bags (generic)
- Pieces of white polyethylene trash bags (generic)
- Aluminum foil (ALU, France, France)

Deposition Protocol

The donor was a 50-year-old man. The donor was asked to wash and dry his hands and then to wait for 20 minutes without touching anything. Before depositing natural marks on the substrates, he was asked to rub his fingers together to evenly distribute the secretions for the depletions. He also washed and dried his hands before loading his fingers with the reference pad control samples.

Three types of marks were deposited on each substrate:

- A depletion series of 10 marks placed successively (designated 1–10) with the same finger. By doing so, the quantity of secretion decreases from the first to the last mark.
- A mark with amino acid (Latent Print Reference Pad, Amino Acid Based, PART #1-2791, Lightning Powder Company, Jacksonville, FL) designated "AA".
- A mark with sebaceous oil (Latent Print Reference Pad, Sebaceous Oil Secretion, PART #1-2792, Lightning Powder Company) designated "SO".

Fingermarks were placed on glass, aluminum foil, black plastic bags, and white plastic bags. For the glass slides, the deposits were made across two glass slides. For the aluminum and plastic bag samples, the deposits were made and then they were halved in the vertical direction. Three sets of deposits were made on the first day of testing (D-0). The first set was processed immediately. The second and third sets were stored in the dark at room temperature for 7 days (D-7) and 21 days (D-21) before fuming.

This protocol was repeated for the four substrates studied: each time, 3 sets (to be fumed at D-0, D-7 and D-21) of 12 deposits (2 reference and10 depletion) were made. This represented a total of 144 fingermarks.

Fuming Protocol

Lumicyano and Lumicyano Kit are both produced by Crime Science Technology. Lumicyano consists of a cyanoacrylate solution containing 1% of fluorophore (a fluorophore is a fluorescent chemical compound that re-emits light upon excitation). The quantity of fluorophore is set by the producer. Lumicyano Kit consists of a cyanoacrylate solution (Lumicyano Solution) and a fluorophore (Lumicyano Powder). The quantity of fluorophore can be adjusted by the analyst. In this study, two fluorophore concentrations were chosen: 1% (same amount of fluorophore that is in Lumicyano) and 4% (amount of fluorophore significantly increased while keeping a reasonable cost for fingermark development).

A 200 L capacity cyanoacrylate fuming cabinet (MVC 1000, Foster+Freeman, Vale Park, United Kingdom) and 0.75 g of cyanoacrylate (manufacturer's recommendation) were used to fume the samples.

In this study, the fuming time was set to 15 minutes. Parameters were those commonly advocated and in accordance with our accredited protocol under ISO 17025: a maximum of 80% humidity rate and 120 °C fuming temperature [3, 4].

Table 1 shows the quantity of Lumicyano Powder that must be added to the Lumicyano Solution for the two different sets of fuming using Lumicyano Kit.

	Proportion of Lumicyano Powder	Lumicyano Solution (g)	Lumicyano Powder (mg)
Trial 1	1%	0.75	7.5
Trial 2	4%	0.75	30

Table 1

Quantities of Lumicyano Solution and Lumicyano Powder used for the different trials.

Mixtures of Lumicyano Solution and Lumicyano Powder were prepared in aluminum dishes and were used directly after preparation. Lumicyano Powder was completely dissolved in Lumicyano Solution in a few seconds under manual stirring of the aluminum dish. The fuming cycle was subsequently started.

Ridge details revealed with Lumicyano Kit were compared to those obtained with the cyanoacrylate previously used in our laboratory (Adhesive Cyanoacrylate 2006, Cyberbond, Hauconcourt, France). For fuming with Cyberbond cyanoacrylate, a 200 L capacity cyanoacrylate fuming cabinet (MVC1000, Foster & Freeman) and 0.210 g cyanoacrylate (Cyberbond 2006) were used. The fuming time was set to 10 minutes. Parameters were those commonly advocated and in accordance with our accredited protocol under ISO 17025: a maximum of 80 % humidity rate and 120 °C fuming temperature. Cyanoacrylate was poured in aluminum dishes.

Imaging

Photographs were taken with a Nikon D700 camera and an AF-S VR Micro-Nikkor 105 mm f/2.8G IF-ED lens, always at the same distance from the slides. Photographs were registered on an electronic workstation (DCS-4, Foster+Freeman). Camera white balance was automatically defined by the DCS-4 workstation. Other camera settings were chosen to get the best contrast. Contrast was not further improved by image processing.

Each substrate was photographed under three different lighting conditions: white light, using a halogen source (EKE,

Polytec, Harpenden, U.K.), no filters; UV light at 325 nm, using a lamp (Super Xenon Uva-325 nm, Labino, Solna, Sweden) with a yellow filter (GG 495, Schott AG, Mainz, Germany); visible light at 500 nm, using a Crime-Lite 8x4 (Foster + Freeman, Vale Park Evesham, Worcestershire, U.K.) with an orange filter (GG 529, Schott AG).

For a given substrate and a given wavelength excitation, all of the luminescent fingermarks were photographed with the same exposure time. The exposure time chosen was the one used to photograph the deposition of amino acid (marked "AA") revealed with the Lumicyano.

Scoring

Two fingermark halves from the same deposit, revealed with either Lumicyano or Lumicyano Kit, were compared separately by two analysts on the basis of three criteria:

1. The contrast of the fingermark with the substrate
2. The level of detail of the fingermark (definition of ridges and furrows)
3. The ridge continuity

For each criterion, a value was assigned according to the scale detailed in Table 2.

Value	Scale
-	Fingermarks developed with Lumicyano Kit have a lower quality than the ones revealed with Lumicyano
0	The quality of the fingermark developed with Lumicyano Kit is equivalent to that of the trace revealed with Lumicyano
+	Fingermarks developed with Lumicyano Kit have a better quality than the ones revealed with Lumicyano
++	Quality of the fingermarks developed with Lumicyano Kit is greatly superior to that of the traces revealed with Lumicyano

Table 2

Grading criteria used in the comparison of Lumicyano versus Lumicyano Kit at 4% fluorophore.

In the two cases where both analysts attributed a different score for a criterion, they worked together to reach a consensus. The quality of a fingermark was dependent on the three criteria. An overall score was assigned to each fingermark as explained in Table 3.

Overall Score	Contrast	Level of Detail	Ridge Continuity
-	At least one criterion scored -		
0	0	0	0
+	At least one criterion scored + and no -		
++	At least one criterion scored ++ and no -		

Table 3

Overall score assigned to each fingermark.

Fluorescence Fading

To determine the effect of the Lumicyano Powder amount on the fluorescence fading of the developed marks, for each substrate, fingermarks revealed with 1% and 4% of Lumicyano Powder were placed in a dry atmosphere and in the dark after their initial examination. For each of the four substrates, developed fingermarks of the 5th depletion from the set of samples developed at D-0 were observed at 325 nm and 500 nm every day over a period of 6 days and photographed.

Physical Examination

To investigate the quality of the polymerization process, a physical examination was performed with two devices: a JSM-5900LV scanning electron microscope (JSM-5900LV, JEOL, Croissy sur Seine, France) and a stereoscopic microscope (WILD M8, Type 346910, Wild-Leitz, Heerbrugg, Switzerland).

For each amount of Lumicyano Powder, ridges revealed on the black plastic substrate were photographed at low magnification (6X and 25X) with the stereoscopic microscope and at high magnification (between 90X and 1600X) with the scanning electron microscope and an accelerating voltage of 20 kV. The samples were carbon metallized to avoid any surface charge phenomena.

Ridge details revealed with the cyanoacrylate usually used in our laboratory (Cyberbond 2006) were compared to those obtained with Lumicyano Kit for each amount of Lumicyano Powder, at high magnification (between 90X and 1600X) with the scanning electron microscope to compare the quality of the polymerization process of the Lumicyano Kit to the one obtained with the cyanoacrylate previously used in the Institut National de Police Scientifique in operational cases.

Results and Discussion

Comparison Between Lumicyano Kit Using 1% and 4% of Lumicyano Powder

Examination Before Fuming

A visible examination of each deposit was performed with a vertical and an oblique white light illumination. All of the deposits on the aluminum foil and on the glass were visible in the viewing conditions. Natural deposits (1st to 10th depletion) on white and black plastics were not detected. Only traces loaded with amino acids or sebaceous oil were visible under these conditions.

Examination after Fuming

Deposited marks, whether natural or from the reference pads, were observable in the different viewing conditions of the trial. However, beyond the 5th deposition in depletion, regardless of the concentration of Lumicyano Powder (1% or 4%), marks displayed a thinner polymer deposit in white light, and luminescence at 325 nm or 500 nm was weaker. The fluorescence arises from the polymer crust of the fingermark. The thinner the polymer crust is, the weaker the fluorescence intensity will be. At 1% of Lumicyano Powder, the low intensity of luminescence induced a low contrast. In addition, the marks appeared dotted because of the lack of homogeneity of the revelation. Finally, photography with conventional equipment (camera and photographic bench) was difficult to perform.

With 4% of Lumicyano Powder, the intensity and homogeneity of the luminescence had better qualities, and fingermarks were easier to photograph. Marks revealed at this concentration were also better for observing with a white light, and photography was further facilitated. Figure 1 illustrates such increase of homogeneity and intensity of the luminescence when 4% of Lumicyano Powder was used.

Moreover, observation of ridges with a stereoscopic microscope (Figure 2) emphasized the homogeneity of the polycyanoacrylate deposition on the ridges together with a better contrast when 4% of Lumicyano Powder was used. The deposit was especially more prominent around the pores, allowing identification of third-level details.

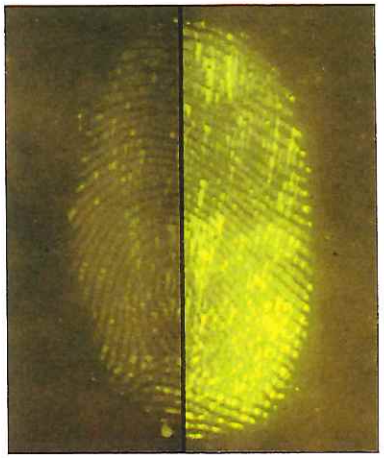


Figure 1

Comparison of the development of a 3rd depletion fingermark deposited on black plastic with the use of 1% (left) and 4% (right) Lumicyano Powder; observed with a light at 500 nm.

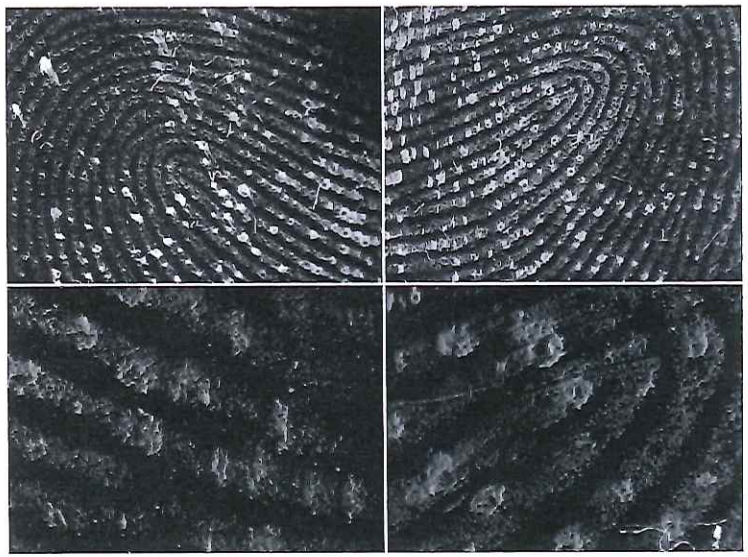


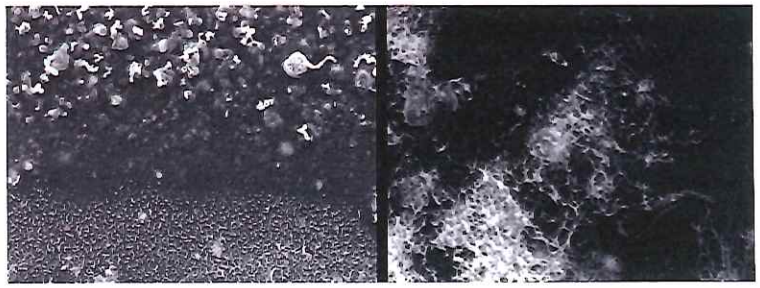
Figure 2

Comparison of the development of a 5th depletion fingermark deposited on black plastic with the use of 1% (left) and 4% (right) Lumicyano Powder; observed with a stereoscopic microscope with a magnitude of 6X (top row) and 25X (bottom row).

Observed with a scanning electron microscope, the ridge aspects were different depending on whether the fingermarks were revealed with the cyanoacrylate used routinely (Cyberbond 2006) or with the Lumicyano Solution, regardless of the amount of Lumicyano Powder. In the former case, the surface was grainy when it was observed under a 1200X magnification (Figure 3a). In the latter case, the deposit showed a fibrous appearance, fluffy when it was observed under a 1600X magnification (Figure 3b). Several studies [3, 5, 6] have shown that this noodlelike polymerization is associated with a good macroscopic development of the latent fingermark.

The use of Lumicyano Kit allowed fingermak development until the 10th depletion. Using 4% of Lumicyano Powder increased the quantity of fluorophore and thus facilitated the observation of fingermarks for high depletions by improving the contrast between the fingermark and the substrate (Figure 4). Moreover, as shown in Figure 5, the remanence of the luminescence increased with the percentage of Lumicyano Powder. With 4% of Lumicyano Powder, the analyst has up to a week to photograph fingermarks with a good signal quality.

To conclude, the quality of the marks revealed using Lumicyano Kit was very good. Ridges were thin and well defined. After development, in addition to the white light observation, it was necessary to observe the traces at 325 nm and 500 nm, because the results obtained with these wavelengths varied depending on the substrate and background noises. In addition, the development obtained using Lumicyano Kit was highly homogeneous. The high quality of the revealed fingermarks allowed poroscopic analysis [7, 8].



(a) (b)

Figure 3

Comparison of the polymerization between a standard cyanoacrylate (Cyberbond 2006) and Lumicyano Kit with 4% fluorophore. (a) Cyberbond 2006 is observed with a 1200X magnification; (b) Lumicyano Kit with 4% fluorophore is observed with a 1600X magnification.

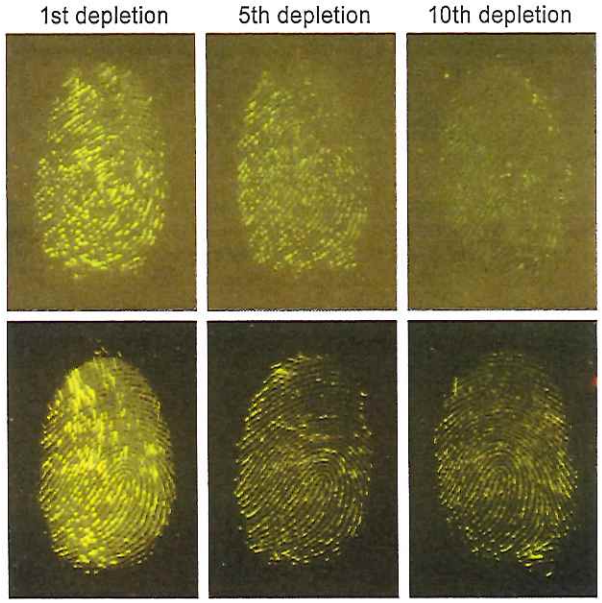


Figure 4

Comparison between the use of 1% (top row) and 4% (bottom row) of Lumicyano Powder to develop fingermarks of 1st, 5th, and 10th depletion on white plastic; observed with a light at 500 nm.

result was slightly poorer for black plastic and white plastic (36 observations), where the quality was improved in 66.7% and 58.3% of cases, respectively (Table 5).

With the light at 500 nm, the gain of 4% Lumicyano Kit was spectacular (Figure 6c). For all substrates and all ages of fingermarks combined (144 observations), the quality was clearly increased for 92.4% of the fingermarks (scored + or ++) and improved dramatically for 34.7% of the fingermarks (scored ++). The quality was lower only in 0.7% of the fingermarks (scored -). Contrast was improved in 90.3% of cases; the detail was improved in 47.9% of cases; continuity of ridges was improved in 35.4% of cases (Figure 6c). The improvement quality of fingermarks on aluminum and white plastic was 100%, 97.2% on glass, and 72.2% on black plastic (Table 5). The quality for fingermarks on black plastics was less impressive than on other substrates mainly because of the already high quality with Lumicyano, which rendered difficult the observation of further improvement.

All Substrates	N	White Light		325 nm		500 nm	
		% + or ++	% -	% + or ++	% -	% + or ++	% -
All ages	144	36.8	14.6	78.5	1.4	92.4	0.7
D-0	48	16.7	27.1	87.5	2.1	97.9	0
D-7	48	60.4	6.3	77.1	0	89.6	0
D-21	48	33.3	10.4	70.8	2.1	89.6	2.1

Table 4

Summary of the overall scores obtained as a function of fingermarks ages and as a function of illumination sources.

All Ages	N	White Light		325 nm		500 nm	
		% + or ++	% -	% + or ++	% -	% + or ++	% -
All substrates	144	36.8	14.6	78.5	1.4	92.4	0.7
Glass	36	19.4	5.6	91.7	5.5	97.2	0
Aluminum foil	36	8.3	11.1	97.2	0	100	0
Black plastic	36	16.6	16.7	66.7	0	72.7	2.8
White plastic	36	50	2.8	58.3	0	100	0

Table 5

Summary of the overall scores obtained as a function of substrates and as a function of illumination sources.

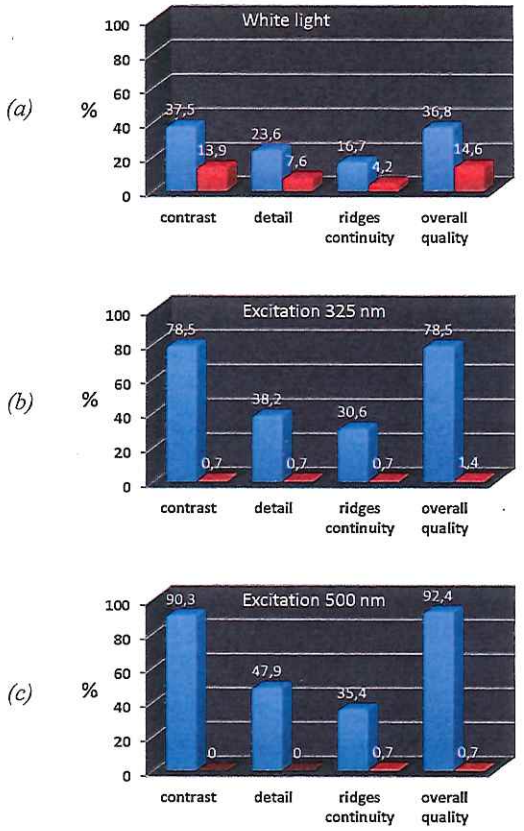


Figure 6

Evaluation of the gain in all substrates and all ages of fingermarks combined for each lightning condition obtained by the use of Lumicyano Kit with 4% of Lumicyano Powder vs Lumicyano under (a) white light, (b) an excitation at 325 nm, and (c) an excitation at 500 nm.

Conclusion

Lumicyano, even if its packaging is unopened and ideally stored, does not remain fluid; it becomes thick and viscous with time. However, the Lumicyano Solution remained fluid and stable over time under suitable storage conditions. After using Lumicyano Kit, the walls of the fuming chamber were easier to clean than after use of Lumicyano, which is a savings of time and energy for the operator. Fingermarks revealed by Lumicyano Kit had a more intense and more homogenous luminescence than the fingermarks revealed with Lumicyano. Its use saves time for the analyst who detects and conducts photography. The observation of the mark is easier and therefore faster, and the exposure time is considerably reduced.

A comparative examination of the fingermarks revealed with Lumicyano and with Lumicyano Kit showed that those revealed with Lumicyano Kit were better than those revealed with Lumicyano, regardless of the age or subtract. With 4% of fluorophore, the gain in luminescence was always observed and was often striking. Given the many benefits it offers, Lumicyano Kit is to be favored over Lumicyano to reveal fingermarks on smooth surfaces. Recently, a study [9] has shown that Lumicyano Kit is able to reveal as many latent fingermarks as the traditionally used two-step process (cyanoacrylate fuming + BY40 dying) on smooth surfaces, especially plastic bags. Additionally, the one-step Lumicyano Kit process reduces operating time compared to the two-step process. Lumicyano Kit is becoming the reference method for the French National Forensic Science Institute to reveal fingermarks on smooth surfaces.

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