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Mixture of dimethylaminobenzaldehyde and cyanoacrylate to develop fingerprints with fluorescence: a preliminary test

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Abstract: This study suggests a new one-step fluorescent cyanoacylate-fuming method for developing fingerprints by using a CAB mixed with dimethylaminobenzalde (DMAB) and cyanoacylate (CA) in a specific ratio. CAB is prepared by mixing 2.5 % (w/w) DMAB with CA and fumigated at 180 °C. Under these conditions, developing fingerprints showed the best results. The fuming method using CAB develops latent fingerprints into fluorescence and has a higher sensitivity than CA, and it showed comparable or better contrast to existing fluorescence enhancement methods. It was also applicable on a variety of non-porous surfaces that can be encountered at ordinary times. This method is more useful than conventional fluorescent dyeing methods in that it minimizes damage to fingerprints or samples, makes it easy to manufacture, saves time, and can use existing current equipment as it is.

Keywords: fingerprint, cyanoacrylate, dimethylaminobenzaldehyde, fluorescence, forensic science

1. Introduction

Cyanoacrylate (CA) fuming is a well-known method for developing latent fingerprints on non-porous surfaces, and the advantage that distinguishes this method from others is the minimized damage to fingerprints and specimens. In the CA fuming method, cyanoacrylate monomers form polymers on latent fingerprints via fuming of super glue; thereby, the fingerprints can be developed to allow visual examination.

The fingerprints developed by CA fuming appear in a white semi-transparent state, which poses challenges in examination. To alleviate this problem, selective fluorescence staining of CA polymers can be used, which allows examination of the fingerprints in a high contrast ratio. The two-step process after CA fuming, using fluorescent dyes like Basic yellow 40 (BY40),[1] Rhodamine 6G (R6G),[2] Ardrox,[2] and RAY,[3] is the most representative method. The fingerprints after CA fuming can be examined under fluorescence using BY40 and a combination of 460-nm forensic light source and 495-nm shielding filter, R6G and a combination of 495-540-nm forensic light source and 549-nm shielding filter, and Ardrox and a combination of 365-nm or 435-480-nm forensic light source and 476-nm shielding filter. The reagent RAY is a mixture of BY40, R6G, and Ardrox, and allows

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the fluorescence-mediated examination using all the aforementioned forensic light source and shielding filter combinations. Nevertheless, during the staining of CA polymers using a separate reagent, the solvent is in direct contact with the developed fingerprints and the specimens, thus causing damages.[4] To minimize such damages, the developed fingerprints should be dried adequately prior to applying the reagent, and the reagent should not be applied if the solvent can damage or stain the specimen surface.[5] In addition, at least 2-3 h of drying should precede the fingerprint examination after staining.[6]

To minimize the potential damages to fingerprints and specimens from solvents, the dry contact method is used. This method is based on the sublimation of dimethylaminobenzaldehyde (DMAB), which gives intensely blue fluorescence in UV light, along with high sublimation rate and selective adherence to cyanoacrylate polymers. Since this method involves the sublimation of DMAB for polymer adherence after the development of latent fingerprints using CA fuming, approximately 48 h is required.[7]

To reduce the time consumed by the two-step process of fluorescence enhancement after CA fuming, as well as the potential damages to fingerprints and specimens, a one-step fluorescence CA method was developed. The representative products are Lumicyano[8] of Crime Science Technology (France) and PECA[9] of BVDA (Netherlands). Groeneveld *et al.* (2014) produced poly-cyanoacrylate derivatives via the esterification of DMAB, dansyl chloride (DNSC), dimethylaminocinnamaldehyde (DMAC), and cyano-acrylate, for application in fingerprint development with fluorescence.[10] However, the commercially available products of one-step fluorescence CA are mostly expensive and the level of fingerprint development could be hampered if the reagent is purchased as a finished product and then stored for long periods or under unsuitable conditions. In addition, the powder products like PECA could leave a large amount of residues on the inside of the fuming chamber, pan, and filter, and incomplete removal of such products could affect subsequent developments.[8] PECA also requires a heating temperature above 200 ºC, which could generate hydrogen cyanide from cyanoacrylate, thus affecting the technician's health.[11] For the method suggested by Groeneveld *et al*. (2014), the required reagents may be produced on demand for use in the lab, but the need for separate devices and training and the long period of production prevent its practical applications.

In this study, we developed a process to overcome the drawbacks of the two-step process where fingerprints are developed with fluorescence after CA fuming. A mixture of DMAB and CA is also suggested because it can be produced with ease and can replace the commercially available one-step fluorescence CA. The optimum mixing ratio for the mixture, the fuming temperature, and the ability to develop ridge have also been determined.

2. Materials and Methods

2.1. Reagents and apparatus

The followings surfaces were tested in this study: white/black tile (Sheetline, Korea), stainless steel (Ian Industry, Korea), aluminum (Changjo Tech, Korea), and transparent acryl plate (Akobigs, Korea). The super glue used in the CA fuming method was Amos 402 (Amos, Korea), and DMAB (Merk, USA) was used as an additional reactant. Commercially available BY 40 (BVDA, Netherlands) and PECA multiband (BVDA, Netherlands) were used. The chamber used for CA fuming was HEVA1410 (Altlight, Korea).

For the non-destructive enhancement of the fingerprints developed by CA fuming, CPII100 (Altlight, Korea) equipped with the D5500 (Nikon, Japan) was used for episcopic co-axial illumination.[12] Following the application of the CA and DMAB mixture, PECA multiband, and CA fuming method (CA+BY40), BY40 post-processing was performed, and the developed fingerprints were photographed using D5500 equipped with the LAOWA 60-mm macro lens (Venus Optics, China). For fluorescence imaging of the developed fingerprints after applying the CA and DMAB mixture and PECA multiband, UV irradiation was applied in a dark room using the

Polilight flare plus 2 UV (Rofin forensic, Australia). For the developed fingerprints obtained after treatment with CA+BY40, Polilight flare plus 2 450-nm (Rofin forensic, Australia) was used in a dark room with subsequent imaging using OG515 (Rofin forensic, Australia).

2.2. Fingerprint depletion and storage

To obtain latent fingerprints, the natural fingerprints from three adult donors, two males and one female, were used. The natural fingerprints were left on the surfaces after each donor washed their hands and performed daily activities for one hour. Five fingerprints were serially left at a time to quantitatively vary the latent fingerprints (Depletion series).

When methodological comparisons were required, the latent fingerprints were formed on separate, adjacent surfaces in an area where the two surfaces were in contact with each other. All the latent fingerprints were stored at the ambient temperature of the lab (light-shaded, temperature = 18-21 ºC, relative humidity = 30-50 %) for at least one day and up to 28 days for subsequent experiments.

2.3. Fingerprint development and imaging

The relative humidity of the CA fuming chamber was maintained at 80±2 % because it is reportedly the most suitable for fingerprint development.[12] When experimental conditions were changed, the interior of the chamber was cleaned using acetone and alcohol, followed by adequate ventilation.

For CA fuming, 2 g of super glue was heated in the chamber at 120 ºC for 25 min before use. BY40 was sprayed on the fingerprints developed by CA fuming. The residual BY40 after use was washed by running water.[12] For the PECA multiband, 1 g of the reagent was heated in the chamber at 230 ºC for 25 min before use. For CA fuming based on the mixture of DMAB and CA, 2 g of super glue was dissolved in 0.05 g of DMAB and heated in the chamber at 180 ºC for 25 min before use. For post-processing by the dry contact method using DMAB on the fingerprints developed through CA fuming, the procedure reported by Takatsu *et al*. (2012) was followed. Briefly, in a 0.3-L sealed glass container, the fingerprints developed by CA fuming and 5 g DMAB were placed, and left under the lab conditions for 48 h.[7] For post-processing by DMAB fuming after CA fuming, 0.5 g DMAB was heated in the chamber at 120-220 ºC before use. All the experiments were repeated five times or more.

3. Results and Discussion

3.1. Fingerprint development according to the DMAB and CA mixing ratio

Most of the fluorescent dyes used in the experiments formed polymers in the mixture as a result of facilitated CA polymerization upon dilution with CA and lacked an adequate level of sublimation, which prevented their use in the one-step fluorescence CA method. DMAB is a substance that can overcome both drawbacks. Although DMAB at a level above a set quantity could also lead to rapid solidification of the mixture via facilitated neutralization, the dilution of a suitable amount allowed fluorescence enhancement and simultaneous development of latent fingerprints.

The relative humidity of the CA fuming chamber

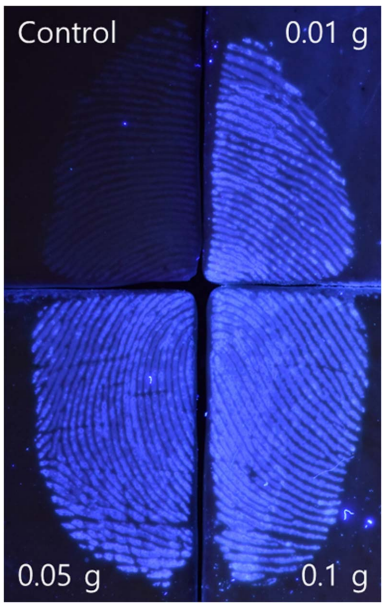

Fig. 1. Fingerprints developed by diluting different amounts of DMAB in CA 2 g, Control did not diluted DMAB.

was maintained at 80 % and the specimens with the latent fingerprints were placed in the chamber. The DMAB:CA mixture at a specific ratio was fumed at 180 °C for 25 min for fingerprint development (*Fig.* 1).

The results showed that an adequate level of fluorescence could be achieved by the addition of only 0.01 g of DMAB to 2 g CA (i.e. a DMAB concentration of 0.5 % (w/w)). The addition of a higher content of DMAB did not increase the fluorescence intensity, and when the DMAB concentration exceeded 5 % (w/w), the resulting rapid polymerization in the mixture before sufficient development prevented an adequate level of fingerprint development. Thus, the subsequent experiments were performed using the mixture of 0.05 g DMAB and 2 g CA (i.e. 2.5 % (w/w), hereafter referred to as CAB).

3.2. Fingerprint development according to the heating temperature

The level of ridge development obtained by the CA fuming methods depend on the fuming temperature. It was thus conjectured that CAB would have a specific requirement for the fuming temperature, and an experiment was conducted to determine the temperature most suitable for CAB fuming. As shown in *Fig.* 2, all developed fingerprints showed fluorescence at fuming temperatures of 120-220°C. As shown in *Fig.* 3, the level of development was as

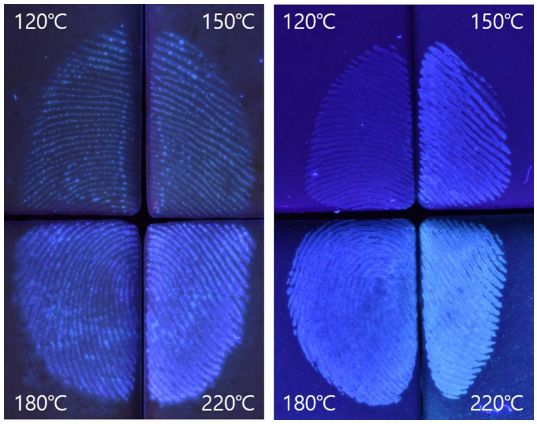

Fig. 2. Comparison of fluorescent of fingerprints developed with different CAB heating temperatures (left) and fingerprints enhanced with different DMAB heating temperature after CA fuming (right).

Fig. 3. Level 3 detail of fingerprints developed with CAB fuming method.

high as defining the sweat pores at all temperatures. The level of ridge development was equivalent to the highest score of 4 in the quality evaluation criteria suggested by the Scientific Working Group on Friction Ridge Analysis, Study and Technology (SWGFAST), and the intensity of fluorescence showed a trend of increase with increasing temperature.

To provide further evidence, the fingerprints developed by CA fuming were placed in the chamber once again, while 0.05 g of DMAB was separately fumed in the chamber. The method likewise allowed the enhancement, and the intensity of fluorescence increased with increasing DMAB fuming temperature. The result showed a trend similar to that of the CAB fuming method (*Fig.* 3).

Based on these findings, the most suitable temperature for the CAB fuming method was determined to be 180-220 °C, at which DMAB and CA were each presumed to have undergone fuming. However, since heating at temperatures above 200 °C can generate hydrogen cyanide from CA, the suggested heating temperature is 180 °C.[11]

3.3. Comparison of sensitivity between the CA and CAB fuming methods

3.3.1. Depletion series

To determine the sensitivity of the CAB fuming method, the developed fingerprints were experimentally compared with those developed by the CA fuming method. To prevent the potential damages to the developed fingerprint ridges during the post-processing

Fig. 4. Comparison of sensitivity between CA fuming method and CAB fuming method in developed fingerprint (depletion #5), enhanced with co-axial illumination.

in the CA fuming method,[4] the enhancement was performed by non-destructive co-axial illumination, instead of using a separate reagent or powder. The co-axial illumination was used in the CAB fuming method to maintain identical conditions for comparison as well.

Since the residual amounts of latent fingerprints cannot be controlled, a method of depletion series was used. This method allowed the comparison of sensitivity based on quantity by gradually decreasing the amount of latent fingerprint residues. When the last of the depleted latent fingerprints was developed by CA fuming and CAB fuming to be examined by co-axial illumination, the polymer formation did not exhibit significant differences. However, fluorescence examination of the fingerprints enhanced by the CAB fuming method allowed more accurate examination of fingerprints compared to co-axial illumination (*Fig.* 4).

3.3.2. Aging

The effects of fingerprint development may be reduced after a long period of time passes from the time of fingerprint left. The level of polymer formation from fingerprints with varying aging time was compared between the CAB fuming and CA fuming methods. As shown in *Fig.* 5, compared to the CA fuming method, in which the fingerprints could not be developed after seven days, the CAB fuming method allowed the development of identifiable fingerprints even after 28 days.

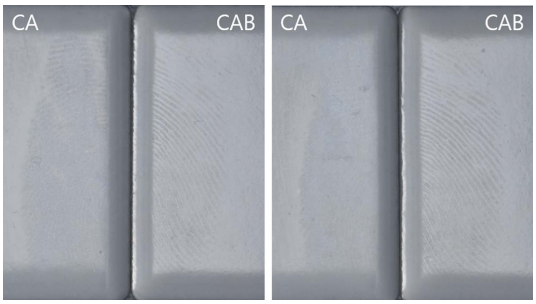

Fig. 5. Comparison of development between CA fuming method and CAB fuming method in aging fingerprints (depletion #1) on 7 days (left) and 28 days (right). Fingerprints developed by CA, CAB fuming was enhanced with co-axial illumination.

3.4. Comparison with other development methods

3.4.1. Comparison with the DMAB dry contact method

A common feature shared by the CAB fuming method and the dry contact method reported by

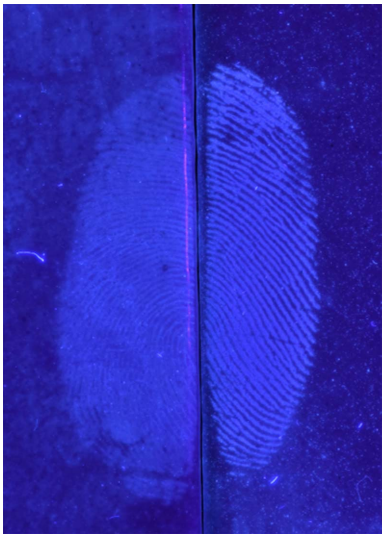

Fig. 6. Comparison of development between DMAB dry contact method (left) and CAB fuming method (right).

Takatsu *et al.* (2012) is the use of DMAB. In this study, the comparison between the CAB fuming method and the conventional dry contact method revealed that the two methods led to the same UV fluorescence on the fingerprint ridges. However, relatively stronger fluorescence was obtained on the background of the surface in the dry contact method, which had a negative impact on the differentiation between ridges and furrows. In contrast, the background fluorescence was not significant in the CAB fuming method, which allows the ridges to be observed more clearly (*Fig.* 6).

3.4.2. Comparison with the BY40 and PECA multiband methods

BY40 in the CA fuming method is used for the enhancement of the developed fingerprints with green fluorescence. However, as shown in *Fig.* 7, the staining of the background rather than the fingerprint could lower the contrast ratio compared to that in the CAB fuming method, with a certain degree of damage to the ridges.

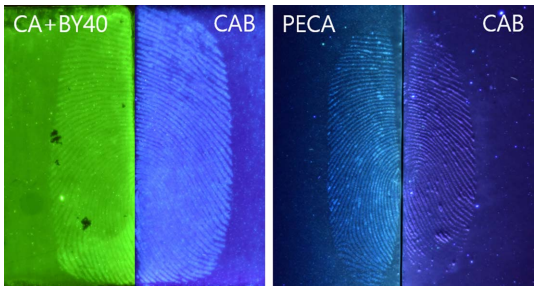

Fig. 7. Compare CAB fuming with CA+BY40 (left) and PECA multiband fuming (right).

Compared with the fingerprints developed with the PECA multiband, no significant difference in fingerprint quality was found, with only slight color variations (*Fig.* 7). The CAB fuming method, unlike the PECA, ensures the technician's safety from hydrogen cyanide that might be produced upon heating, as the required temperature does not exceed 200 °C and a powder form is not used to prevent floating or adhering of residues inside the fuming chamber.

3.5. Application in various surfaces

The CA fuming method is a technique for developing latent fingerprints on non-porous surfaces. The CAB fuming method was used on various surfaces to verify the ability of the development of latent fingerprints, because fingerprint development is influenced by surface texture and color. All the surfaces used in the experiments with dark colors and with applications in daily life showed a high level of fingerprint development (*Fig.* 8). This suggested that, regardless of the surface texture and color, the fingerprints on various types of non-porous surfaces can be developed by CAB fuming methods.

4. Conclusions

The fingerprints developed by the DMAB and CA mixture fuming (CAB fuming) method described herein show blue fluorescence upon UV irradiation. The DMAB concentration for fluorescence was 0.5 % (w/w) with respect to CA, and the addition of more DMAB did not increase the fluorescence intensity.

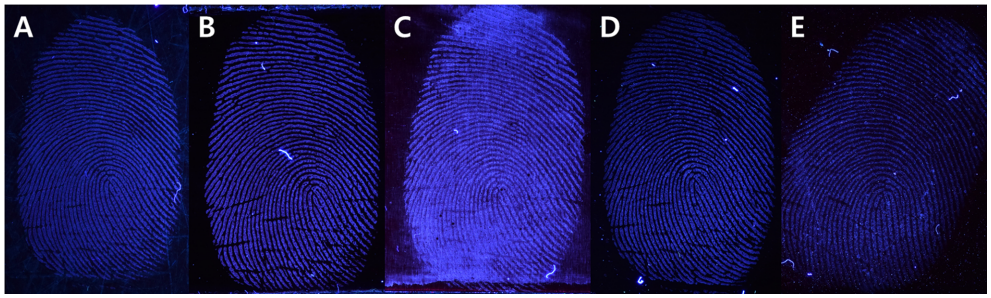

Fig. 8. Fingerprints (depletion #1) left on various surfaces developed with CAB fuming method. A: transparent acrylic, B: stainless steel, C: aluminum, D: black acrylic, E: black tile.

With increasing temperature, the fluorescence of the fingerprints developed by CAB fuming increased in intensity. DMAB and CA are presumed to undergo fuming independently. The sensitivity obtained by CAB fuming was higher than that obtained by CA fuming, with more reliable results for more aged fingerprints. Compared to the conventional methods of enhancement using fluorescence, drawbacks like background staining, fingerprint degradation, harmful gas release, and time-consuming procedures could be resolved, while allowing the use of the conventional CA fuming chamber. Nevertheless, the CAB fuming method should be applied carefully because the contrast ratio between the developed fingerprints and the surface decreases upon UV fluorescence on the fingerprint depleted surface.

This was a preliminary study to verify the potential development of fingerprints as fluorescence based on an adequate ratio of DMAB to CA. Whether a higher level of polymerization occurs on fingerprints of aged specimens via CAB fuming in comparison to CA fuming should be verified in future studies.

Acknowledgements

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