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Research Article

New Fluorescent Powders for the Development of Latent Fingermarks

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Abstract

New and inexpensive fluorescent powders have been prepared and used for the development of latent fingermarks on non-porous and semi porous surfaces. 10mM solutions of rhodamine 6G and basic yellow 40 dyes were used to prepare dye coated fluorescent silica gel powders. Results of these new fluorescent powders were compared with results of commercially available fluorescent powders. The new powders have shown results comparable with those of commercially available powders so can be easily prepared and used as an alternate, if commercial fluorescent powders are not available.

Keywords: Forensic Science; Latent Fingerprints; Fingerprints Development; Fluorescent Powders; Powder Dusting

Introduction

Fingerprints have been used as a source of personal identification for a long time. Latent fingermarks are most commonly found type of physical evidence at crime scenes, which help to identify unknown perpetrators. These are being widely used as the most important physical evidence in solving crimes, the importance is obvious from the available data that in the year 2005 forensic laboratories in United States of America received evidence from approximately 270000 criminal investigations involving requests for fingerprint examination along with requests for DNA analysis [1]. Latent fingermarks are produced as a result of secretions, from eccrine, apocrine and sebaceous glands, present on the friction ridge skin. These secretions consist of inorganic and organic components [2,3]. Several techniques have already been established and are being used for the development of latent fingermarks on porous and non-porous surfaces [2]. Powder dusting is the most widely used technique for the development of latent fingermarks on non-porous surfaces. The use of powders for the development of latent fingermarks dates back to the 19^{th} century. Sir Edward Richard Henry (1850-1931) suggested the use of mercury-based and graphite-based powders [4]. Powders for development of latent fingermarks mainly consists of resinous substances for adhesion and colorants for contrast [5]. The adhesion of powder particles to the fingerprint residue is achieved by pressure deficit mechanism. The lower side of the powder particles comes in contact and interact with the fingerprint residue, which results in pressure deficit inside the droplet due to the curvature of meniscus and as a result, the powder particles adhere with it [6]. A variety of powders are commercially available. The adherence of powders depends upon the size and shape of particles. Small and fine particles adhere more effectively as compared to large and coarse particles [5].

Over the years, a reasonable number of inorganic and organic compounds have been introduced to form powders [3]. A variety of new techniques, now being used for powder dusting of latent fingermarks, has been investigated. Garg et al. have investigated turmeric powder as a new technique for the development of latent fingermarks [7]. Most recently, Singh et al. have introduced silica gel G as a new powder for the development of latent fingermarks [8].

For the development of latent fingermarks on multi colored surfaces, sometimes no single powder (black, white etc.) results in good contrast so, fluorescent powders are required which absorbs a particular wavelength of light and then re-emit light of longer wavelength. Most of the time, the background surface does not interfere at the chosen emission wavelength, so it can be eliminated using barrier filter. Choi et al. have introduced the use of zinc oxide as fluorescent powder for the detection of latent fingermarks [9]. They studied the visualization of latent fingermarks by pure and lithium-doped zinc oxide powders. It was observed that zinc oxide produces clear fluorescent images of latent fingermarks when illuminated with long wave UV light. Theaker et al. have introduced the use of doped silica nano- and micro-particles for the development of latent fingermarks. The dyes used for doping of nano- and micro-particles of silica were thiazole orange, fluorescein, methylene blue, oxazine perchlorate, basic red 28, basic yellow 40, rhodamine 6G and rhodamine B. Clear images were obtained for both aged and fresh fingerprints in white light illumination as well as in UV light [10]. Choi et al. have reported a new perylene diimide dye and used it for preparing fluorescent TiO_2 powder for detection of latent fingermarks. The powder exhibited strong fluorescence at 650-700 nm when illuminated at 505nm. The results obtained on non-porous surfaces were good and found to be excellent on glass where even tertiary level details were clear [11]. Anedda et al. have studied rhodamine 6G dopped silica samples for the formation of fluorescent aggregates. They confirmed the formation of fluorescent aggregates in these samples by using steady state and time resolved photoluminescence measurements. It was investigated by using steady state and time resolved photoluminescence measurements. They observed that with the increasing concentration of dye on silica samples the emission peak red shifts and it was also observed that with the constant concentration the emission peak also red shifts with the decrease in excitation wavelength [12]. Keeping in view the results obtained from this study it is expected that such dye-coated powders may yield good results as fluorescent powders for the development of latent fingermarks.

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Table 1: Powder and substrate types along with settings used for visualization and photography of developed latent fingermarks.

Powder Type	Substrate Surface	Excitation Wavelength	Camera Barrier Filter
Rh6G/Silica	Glass slides Metal plates Zip-lock bag Waxed paper	505nm	Orange # 21
REDescent™		505nm	Orange # 21
BY-40/Silica		455nm	Orange # 21
YELLOWescent™		455nm	Orange # 21
BY-40 + Rh6G/Silica		455nm 505nm	Orange # 21

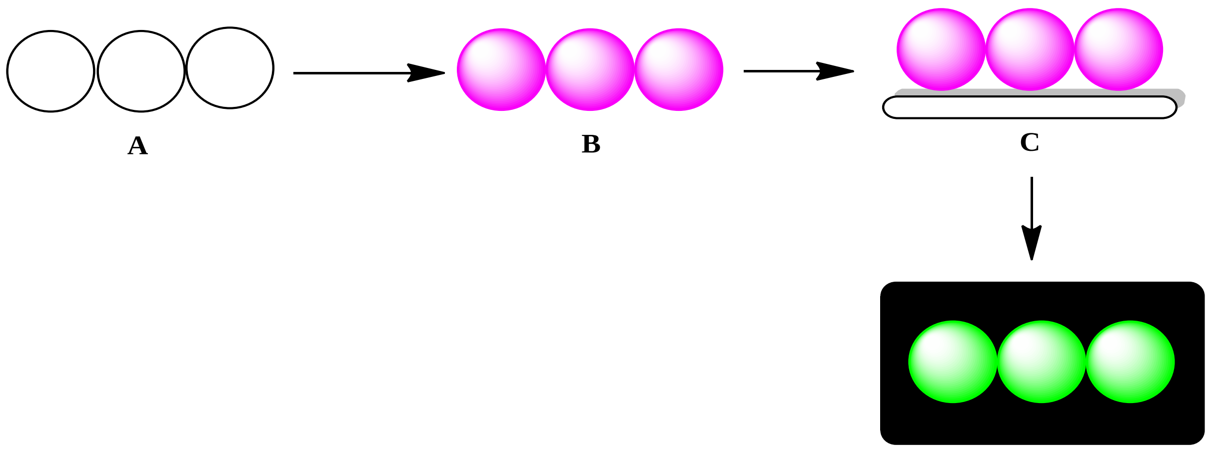

Figure 1: Schematic diagram about conversion of silica gel particles into new fluorescent powder and its application to the development of latent fingermarks.

TLC-silica gel 60 GF254 (with gypsum binder), which is used for the preparation of plates for Thin Layer Chromatography (TLC) is the silica gel powder chosen for this study. Chemically this powder has silicon atoms linked up covalently through oxygen atoms, these silicon atoms also have attached hydroxyl ($^{-}$OH) groups. These groups make it highly polar in nature and help it to bind with other surfaces and compounds through H-bonding or other non-covalent interactions. Hence, it has great ability to hold any polar dye molecules and then to bind with fingermark residue.

Here, we report the preparation of silica gel particles coated with rhodamine 6G and basic yellow 40; and their use as fluorescent powders for the development of latent fingermarks. Figure 1 represents the schematic diagram about conversion of silica gel particles into fluorescent powder and its application to the development of latent fingermarks; 'A' is representing silica gel particles, 'B' represents rhodamine 6G or basic yellow 40 adsorbed silica particles, 'C' shows dye adsorbed silica particles adhered to the fingermark residue and 'D' is indicating fluorescence of dye adsorbed silica particles under Alternate Light Source (ALS).

The results obtained from these newly formed powders were compared with results produced by commercially available powders REDescent™ and YELLOWescent™.

Materials and Methods

General

The TLC-silica gel 60 GF254 (mean particle size 15μm) was purchased from Merck and used as supplied. The dyes rhodamine 6G and basic yellow 40 were purchased from SIRCHIE and used as received. REDescent™ and YELLOWescent™ fluorescent powders used in this study were purchased from SIRCHIE. Fingermarks were illuminated using Polilight® PL500 and imaged using NIKON D810 AF-S Micro camera. All experiments were conducted at 25°C. Barrier filter Orange # 21 from TIFFEN® was used. Fiberglass brush from SIRCHIE was used for powder dusting of latent fingermarks.

Dye coated powders

Following three different types of dye, coated powders were prepared for development of latent fingermarks.

Rhodamine 6G coated Silica Gel Powder (Rh6G/Silica): 10mM solution of rhodamine 6G was prepared by dissolving 0.133g of it in 30mL of dichloromethane. 15mL of this solution were added to 5g of TLC grade silica gel to prepare slurry. The solvent was allowed to evaporate from the slurry at room temperature to leave behind fine dye coated particles of silica gel.

Basic Yellow 40 coated Silica Gel Powder (BY-40/Silica): 0.111g of basic yellow 40 dye were dissolved in 30mL of dichloromethane to prepare a 10mM solution. 15mL of this solution were added to 5g of silica gel to prepare slurry. The solvent was allowed to evaporate from the slurry at room temperature to leave behind fine dye coated particles of silica gel.

Silica Gel Powder coated with the mixture of Rhodamine 6G and Basic Yellow 40 (BY-40+Rh6G /Silica): 15mL mixture of dye solutions was prepared by mixing 7.5mL each of 10mM rhodamine 6G and 10mM basic yellow 40. This mixture was added to 5g of TLC

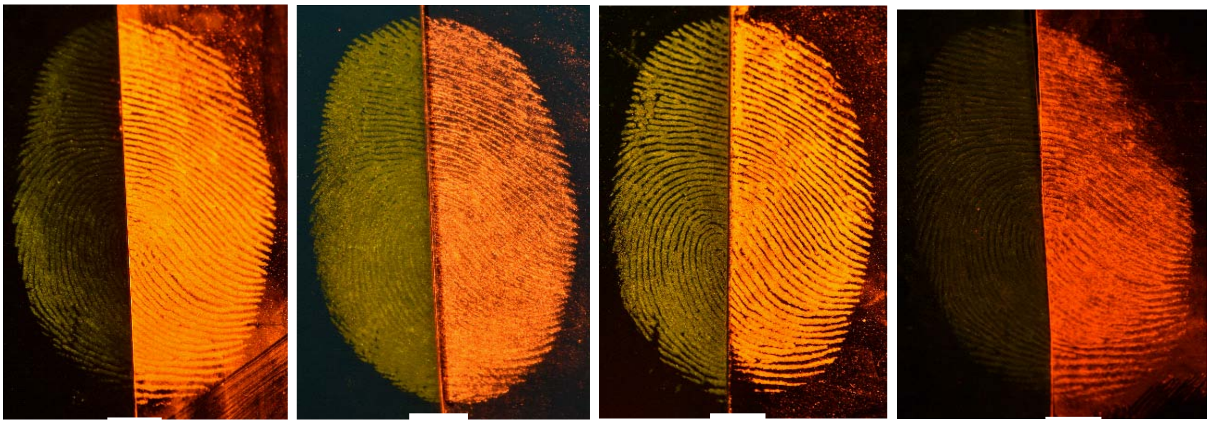

Figure 2: Comparative visualization of latent fingermarks developed with Rh6G/silica (left) and REDescent™ (right) powders on: a) Glass slide; b) Waxed paper; c) Metal; d) Zip lock bag.

grade silica gel and slurry was formed. The solvent was evaporated to leave behind fine dye coated powder.

Deposition and development of fingermarks

Prior to fingermark deposition, donors washed their hands with soap and water and dried them. They rubbed their fingers around their nose and forehead and then rubbed their hands together to get uniform sebaceous fingermark deposits. Non-porous and semi porous surfaces including glass slides, metal plates, zip lock bags and waxed paper were used in this study.

For better comparison of newly formed powders with commercially available powders, the fingermarks were deposited and splitted into two halves. The portion of fingermark on left half of each substrate was developed with newly formed powder and remaining portion on right half was developed with commercially available powder. Both portions were then photographed together under same settings as mentioned in the Table 1.

For comparison of results obtained from the powder, produced with mixture of solutions of dyes Rhodamine 6G and Basic Yellow 40 i.e. BY-40 + Rh6G/Silica with both commercial powders, the latent prints were splitted up into three portions. Top half portion was developed with new powder BY-40 + Rh6G/silica. The bottom left portion was developed with REDescent™ powder and bottom right portion of the latent print was developed with YELLOWescent™ powder.

Development of fingermarks

Powder was taken on the paper and was applied with the help of brush for the development of latent fingermarks. The developed fingermarks were visualized with orange goggles under different excitation wavelengths of light as mentioned in the Table 1 and were photographed by using orange # 21 camera filters. The fingermarks developed with powder BY-40 + Rh6G/silica were visualized and photographed under both above mentioned conditions separately. The results obtained for these powders on different substrates are shown in Figure 2-5.

Results and Discussion

Figure 2 indicates that the results obtained by using Rh6G/Silica

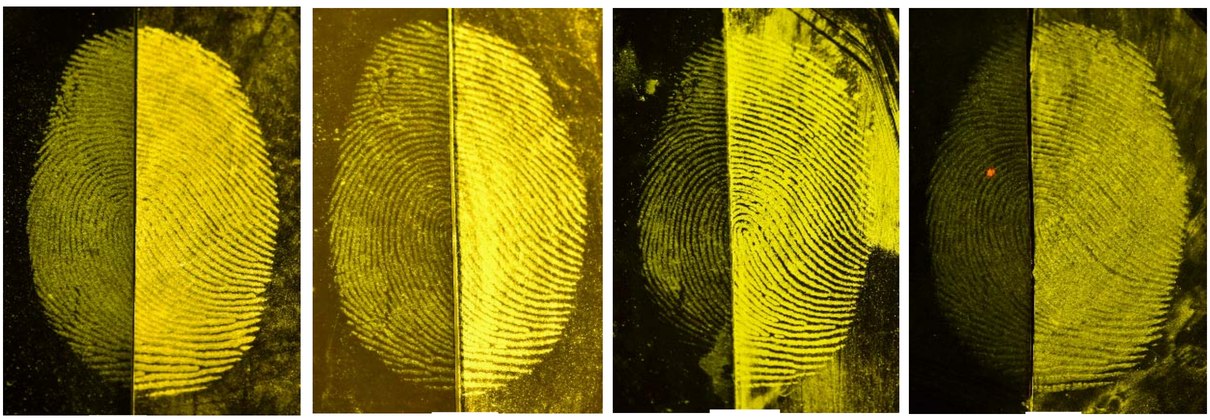

Figure 3: Comparative visualization of latent fingermarks developed with BY-40/silica (left) and YELLOWescent™ (right) powders on: a) Glass slide; b) Waxed paper; c) Metal; d) Zip lock bag.

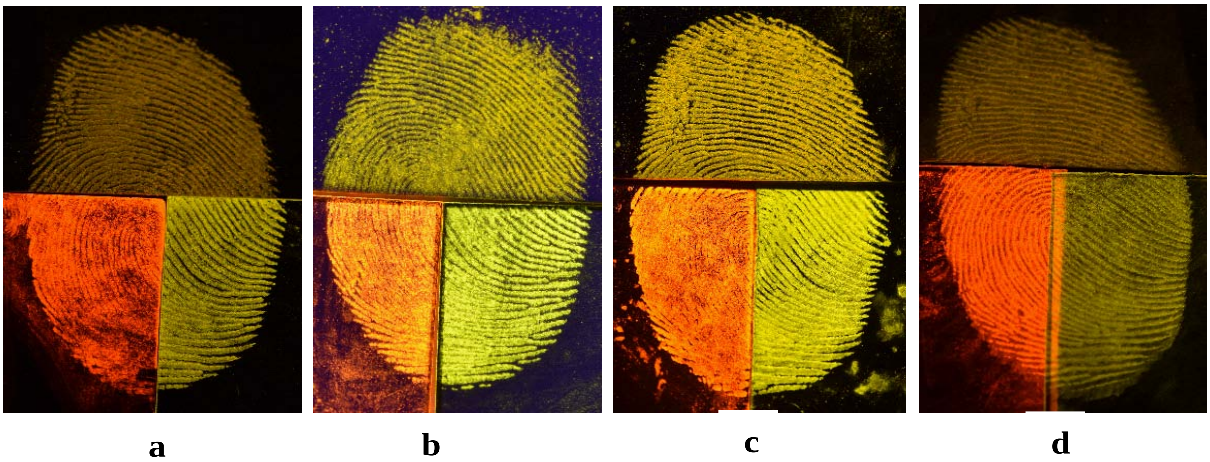

Figure 4: Comparative visualization of latent fingermarks developed with BY-40 + Rh6G/silica (top half) and YELLOWescent™ (bottom right), REDescent™ (bottom left) powders at 455nm excitation wavelength on: a) Glass slide; b) Waxed paper; c) Metal; d) Zip lock bag.

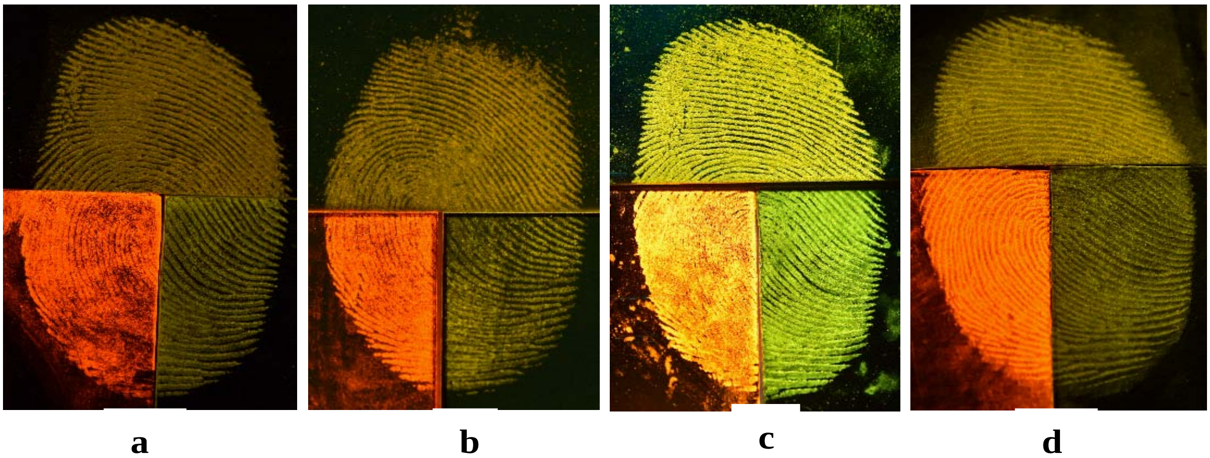

Figure 5: Comparative visualization of latent fingermarks developed with BY-40 + Rh6G/silica (top half) and YELLOWescent™ (bottom right), REDescent™ (bottom left) powders at 505nm excitation wavelength on: a) Glass slide; b) Waxed paper; c) Metal; d) Zip lock bag.

powder are comparable with the results obtained by REDescent™ fluorescent powder on most of the surfaces except on zip lock bag where fluorescence of Rh6G/silica powder is not good although the latent print is enhanced and useful for identification purpose.

Excellent results are obtained for BY-40/Silica powder, which are almost of same quality as those obtained by YELLOWescent™ fluorescent powder as shown in Figure 3.

As the powder BY-40 + Rh6G/Silica contains both rhodamine 6G and basic yellow 40 dyes, so the fingermarks developed with this powder were examined at excitation wavelengths 455nm and 505nm corresponding to basic yellow 40 and rhodamine 6G respectively. The results obtained were compared with results of both commercially available powders. Figure 4 and 5 shows that results obtained by newly formulated powder BY-40+Rh6G/silica at 455nm and 505nm are of comparable quality with results obtained from YELLOWescent™ and REDescent™ powders respectively.

The comparison of developed fingermarks in Figure 2 and 5 indicates that results produced by powder formulated by mixture of dyes rhodamine 6G and basic yellow 40 are better than the powder produced alone from rhodamine 6G. However, comparison of Figure 3 with all three Figure 2, 4 and 5 indicates that the results obtained from powder produced by using basic yellow 40 are excellent and are almost of same quality as those obtained with commercial YELLOWescent™ powder. Here, examples of only two dyes are discussed but it is expected that by using same procedure, different other new fluorescent powders can also be prepared by using other fluorescent dyes.

Conclusion

It can be concluded from this study that commercially available silica gel powder can be easily converted into fluorescent powder for the development of latent fingermarks on a variety of surfaces. The method is inexpensive, simple and quick. In developing countries, fluorescent powders have to be imported and the import process is time taking so, if no commercial fluorescent powder is available then these laboratory developed powders can be effectively used for development of latent fingermarks.

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