DEVELOPMENT OF MULTIPURPOSE FINGERPRINT POWDERS

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Abstract: This study was an attempt to develop multipurpose fingerprint powders using 4 materials. Nickel (Ni) powder and cobalt (Co) powder can be used for their magnetic properties because they can be applied using a magnetic applicator. Titanium dioxide (TiO_2) has been investigated extensively due to its interesting optical and photo-catalytic properties. Nickel(II) oxide (NiO) is a very fine black powder which can be used as a colourant. Various mixtures, such as Ni/TiO_2, Co/TiO_2, Ni/NiO, Co/NiO, Ni/NiO/TiO_2 and Co/NiO/TiO_2 were studied for their magnetic and fluorescent properties. Developed latent fingerprints on white and dark nonporous surfaces using these mixtures were found to exhibit good adherence and clarity. The mixtures consisting of TiO_2 were found to fluoresce slightly at 505 and 530 nm. The numbers of minutiae detected by an automated fingerprint identification system (AFIS) were comparable to those obtained using commercial powders.

Introduction: Fingerprint evidence is the most common type of physical evidence encountered in criminal investigations, and powdering is the simplest technique to obtain latent prints because it's easy and does not require complicated equipment[1]. Fingerprint powdering has been a detection technique for over 20 years and still is the most cost-effective method for treating fixed surface at a crime scene[2]. There are four classes of fingerprint powders: regular, luminescent, metallic, and thermoplastic. Each type of powder has special properties specific to a surface. Magnetic powder is sometimes more effective on rough, gained or porous surface which would otherwise become heavily coated with a regular powder which may destroy the fragile latent print when brushing[3]. Fluorescent powders are very strongly fluorescent and can be detect with a low power UV lamp or an alternate light source. Good fingerprint powders give good adherence properties and sometimes incorporate a luminescent material. This type of fingerprint powder is useful for the visualization of latent prints deposited on multicolor surfaces that would present a contrast problem if developed with a regular fingerprint powder[4]. Even, the simplest and most commonly used procedure for latent print development is powder dusting so the cost of the powders in Thailand is expensive because they have to be imported[5]. The aims of this study are to develop magnetic and fluorescent fingerprint powders and compare the performance of the prepared powders with that of the commercial fingerprint powders. The new magnetic and fluorescent powders developed in this study were expected to be effective in their application in crime scene investigation units.

Methodology: The materials used in this study were nickel (Ni) powder, cobalt (Co) powder, titanium dioxide (TiO_2) and nickel (II) oxide (NiO). Various mixtures, such as Ni/TiO_2, Co/TiO_2, Co/NiO, Ni/NiO, Ni/NiO/TiO_2 and Co/NiO/TiO_2 were studied. Each mixture is mechanically ground for intimate mixing. Fingerprints were deposited on nonporous surfaces after wiping the right index finger over the nose. All fingerprints were from the same donor.

Each experiment was repeated 5 times. The deposited prints were left at room temperature for a day and were developed using a magnetic applicator. The fluorescence property of the powders is also studied by using an alternative light source. Then the developed prints were photographed under natural light and under the alternate light source at wavelengths of 505nm and 530 nm. Then, each was lifted from the surface and transferred to the fingerprint collection card. The results of using prepared powders were compared with the results of using commercial black magnetic powder and commercial black ruby fluorescent powder. The comparison was performed by using an Automated Fingerprint Identification System (AFIS). The efficiency of minutiae detection of each mixture and surface was also calculated using the following equation (1):

$$\text{Efficiency (\%)} = \frac{\text{Average number of minutiae}}{\text{Number of minutiae of control}} \times 100 \qquad (1)$$

where the control sample is the right index finger inked print pressing on a police mate ink pad. The quality of the developed prints were graded as follows

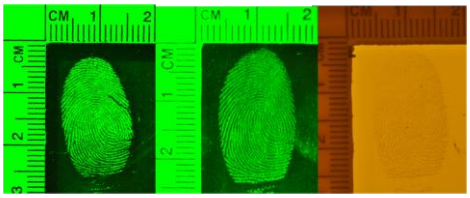
>80%	=	Excellent
66% - 80%	=	Good
50% - 65%	=	Fair
<50%	=	Poor

Results, Discussion and Conclusion: In the development of latent prints using these powders by using a magnetic applicator it was found that nickel powder and cobalt powder were strongly attracted (Figure 1) but NiO and TiO_2 were not.

(A) (B)

Figure 1. A. Attraction between nickel powder and magnetic applicator And B. attraction between cobalt powder and magnetic applicator

In the study of fluorescence property using an alternate light source it was found that TiO_2 was slightly fluorescent. On a glass plate and black plastic clipboard TiO_2 gave clearer details of the ridges and a lower background than on a laminated plate (Figure 2).



(A) (B) (C)

Figure 2. Fluorescent property of TiO_2 at wavelength 530 nm on a glass plate (A) and black plastic clipboard (B), (C) fluorescent property of TiO_2 at wavelength 505 nm on a laminated plate

NiO was used for contrast especially on a light background. To increase the magnetic property, the powder was mixed with nickel powder or cobalt powder by grinding together. The mixtures: Ni/TiO_2, Co/TiO_2, Ni/NiO, Co/NiO, $Ni/NiO/TiO_2$ and $Co/NiO/TiO_2$ were found to be strongly attached to the magnetic applicator (Figure 3).

Figure 3. Attraction between the prepared powders and magnetic applicator; (A) Ni/TiO_2, (B) Ni/NiO, (C) Ni/NiO/TiO_2, (D) Co/NiO/TiO_2,(E) Co/TiO_2, (F) Co/NiO, (G) commercial black magnetic powder and (H) commercial black ruby fluorescent powder

The fluorescence properties of the prepared powders were also studied using an alternate light source at a wavelength of 505nm on a laminated plate (Figure 4) and 530nm on a glass plate (Figure 5) and a black plastic clipboard (Figure 6). Most of them gave very clear details with low background. The mixing ratio chosen in this work for TiO_2 and NiO were a part per hundred by mass of nickel and cobalt (1:100) because of the attraction between the powders and magnetic applicator.

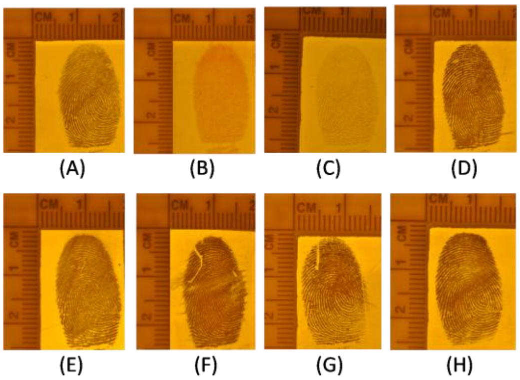


Figure 4. Fingerprints on a laminated plate developed by using (A) commercial black magnetic powder, (B) commercial black ruby fluorescent powder, (C) Ni/TiO_2, (D) Co/TiO_2, (E) Ni/NiO, (F) Co/NiO, (G) Ni/NiO/TiO_2, (H) Co/NiO/TiO_2 at 505nm

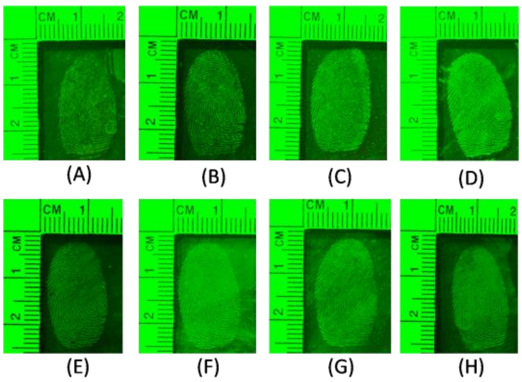


Figure 5. Fingerprints on a glass plate developed by using (A) commercial black magnetic powder, (B) commercial black ruby fluorescent powder, (C) Ni/TiO_2, (D) Co/TiO_2, (E) Ni/NiO, (F) Co/NiO, (G) Ni/NiO/TiO_2, (H) Co/NiO/TiO_2 at 530nm

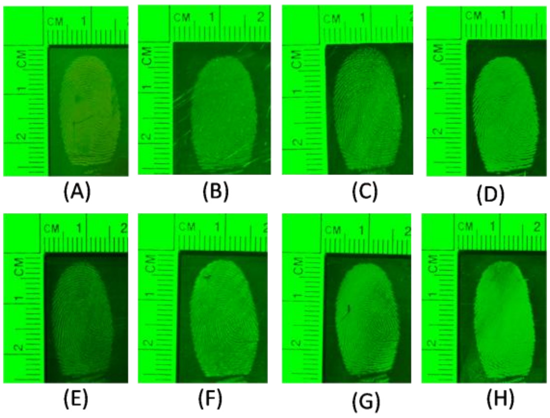
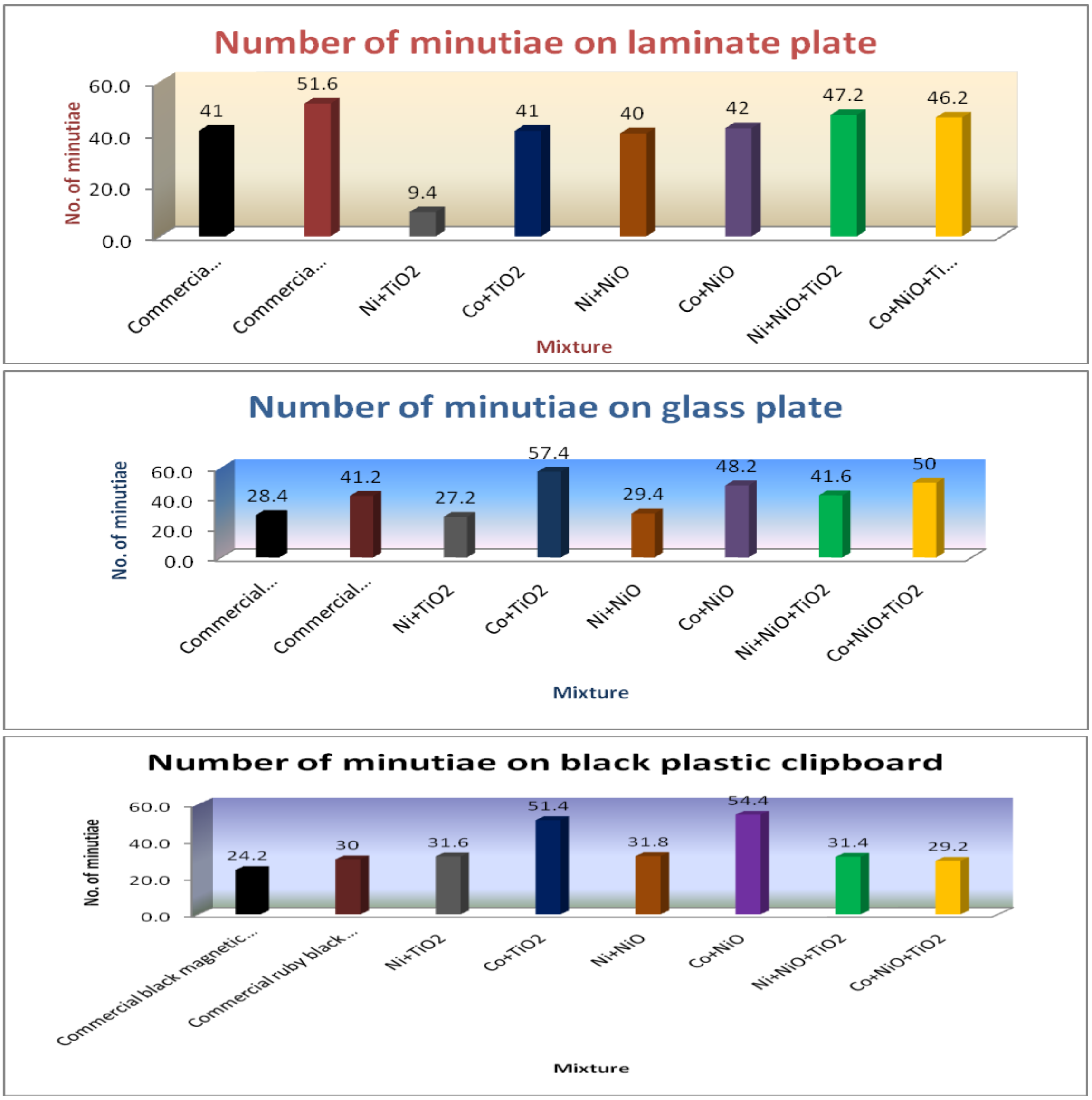


Figure 6. Fingerprints on a black plastic clipboard developed by using (A) commercial black magnetic powder, (B) commercial black ruby fluorescent powder, (C) Ni/TiO_2, (D) Co/TiO_2, (E) Ni/NiO, (F) Co/NiO, (G) Ni/NiO/TiO_2, (H) Co/NiO/TiO_2 at 530nm

Fingerprints on the impressed surfaces were developed by using the prepared powders and compared with the results from those obtained using the commercial black magnetic powders. Most developed prints showed clear details on every surfaces except for the mixture of nickel and titanium dioxide which appeared rather faint on the laminated plate (light background). The Automated fingerprint identification system (AFIS) was used to compare the numbers of minutiae of developed fingerprints with the number of minutiae of the control sample (n=67) (Figure 7).

Figure 7. Number of minutiae detected by AFIS from the control fingerprint sample (ink pad)

Figure 8 shows graphs of the number of minutiae on different nonporous surfaces using the commercial powders and the prepared powders. Commercial black ruby magnetic powder shows the maximum number of minutiae (n=51.6) on the laminated plate while Ni/TiO_2 shows the minimum number of minutiae (n=9.4) and other mixtures show similar moderate numbers of minutiae. On the glass plate, Co/TiO_2 shows the maximum number of minutiae (n=57.4) while Ni/TiO_2 shows the minimum number of minutiae (n=27.2). For the other mixtures there are two sets of data. The commercial black magnetic powder and Ni/NiO give lower numbers of minutiae while the commercial ruby black fluorescent powder, Ni/NiO/TiO_2, Co/NiO and Co/NiO/TiO_2 give higher numbers. The last nonporous surface is the black plastic clipboard. Co/NiO shows the maximum number of minutiae (n=54.4) and Co/TiO_2 shows a little lower number of minutiae (n=51.4). The commercial black magnetic powder shows the minimum number of minutiae (n=24.2) and other mixtures show similar numbers of minutiae. Apparently, both the powders and the surfaces affected the clarity of the prints. In the case of Ni/TiO_2, some of the ridge details might have been destroyed during lifting of the prints before AFIS examination, rendering only a small number of minutiae being detected. This may also be true for the case of the glass plate.



(A)
(B)
(C)

Figure 8. Graphs of number of minutiae detected by AFIS on (A) a laminated plate (B) a glass plate and (C) a black plastic clipboard

The percentage efficiency of each mixture and surface is shown in Table1. On the laminated plate most of mixtures gave good efficiency, the highest percentage of efficiency is 77.01% using commercial ruby black fluorescent powder and the prepared powder Ni/NiO/TiO_2 gave 70.45%, very close to that at the commercial powder. But Ni/TiO_2 gave a very low percentage at 14.02%. On the glass plate Co/TiO_2 gave excellent result with the highest percentage of efficiency at 85.67%. The mixtures Co/NiO and Co/NiO/TiO_2 gave good results with 71.94% and 74.63%. The commercial black ruby fluorescent powder gave fair results as well as Ni/NiO/TiO_2 with 61.49% and 62.09%. The commercial black magnetic powder, the mixtures Ni/TiO_2 and Ni/NiO/TiO_2 gave low percentages of efficiency (<50%) with poor results. On the black plastic clipboard, the mixture of Co/NiO gave an excellent result with the highest percentage at 81.19% and Co/TiO_2 gave percentage of efficiency at 76.72% with good result. Other mixtures gave poor results, with efficiency lower than 50%, including the commercial powders.

Table1. Percentage Efficiency

Powders	Percentage (%)		
	Laminate	*Glass*	*Plastic*
Black magnetic	61.19	42.39	36.12
Black ruby fluorescent	77.01	61.49	44.78
Ni/TiO_2	14.02	40.60	47.16
Co/TiO_2	61.19	85.67	76.72
Ni/NiO	59.70	43.88	47.46
Co/NiO	62.69	71.94	81.19
$Ni/NiO/TiO_2$	70.45	62.09	46.87
$Co/NiO/TiO_2$	68.96	74.63	43.58

In examining the percentage efficiency of mixtures it was found that the mixture of Co/TiO_2 gave good efficiency on both the laminated plate and plastic clipboard and the highest percentage of efficiency on the glass plate with excellent result as well. Furthermore Co/TiO_2 gave clear details of the ridge under the alternate light source with a strong fluorescence. Most mixtures retain fairly high efficiency and some of them gave better result than the commercial powders such as on the glass plate and the plastic clipboard. These can be useful for identification purposes on many different non porous surfaces. However, the use of a mask and gloves is recommended while dusting because some of the powders may be carcinogenic.

In conclusion, in order to obtain a fingerprint of good quality for AFIS examination, one has to be extremely careful in choosing the proper powder for the particular surface. The use of a magnetic powder avoids destruction of the ridge details while the use of a fluorescent powder is convenient for light backgrounds. From this investigation, the mixtures Co/TiO2 and Co/NiO/TiO2 are both suitable as fluorescing magnetic fingerprint powders.

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Keywords: fingerprints, fingerprint powder, magnetic powder, fluorescent powder, forensic science