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Visualization of Latent Fingerprints Using Neutral Alumina as an Inexpensive Fingerprint Developing Powder

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Abstract

The unicity, permanency, and generality of fingerprints make them as a reliable identification feature in crime and civil cases all over the globe. Various methods are available for the detection of latent fingerprint. Of them, powder dusting is a simplest and most commonly used procedure. Although several powders has been demonstrated earlier as visualization agents of latent fingerprints, in some context, they are expensive, toxic, and are not easily accessible as they usually composed of various materials. In this study, we have introduced neutral alumina, commonly used in thin layer chromatography as a stationary phase, as a new fingerprint visualizing agent. Neutral alumina is a cheap, easily available and accessible (one of the most common laboratory consumables), non-toxic, convenient material. In this study, the effectiveness of alumina as a fingerprint powder has been demonstrated on sixteen various substrates of different properties. The results revealed that the alumina powder can be used as an efficient alternative for other costly commercial powders. The alumina-developed friction ridges were also viewed with the aid of confocal laser scanning microscope and the results are discussed in this article. The alumina-developed fingerprint offers the possibility of extracting level 2 and level 3 features too. *Context*: The main objective of this work is to identify cheap, non-toxic, and easily accessible material for fingerprint detection as efficient alternative to costly and toxic commercial fingerprint powders. *Aims*: The aim of this work is to explore the efficiency of neutral alumina as a cheap and non-toxic fingerprint powder particularly in the scarcity of commercial powders. *Results*: Sixteen substrates with varying surface, color, and nature were chosen to deposit the fingerprints and their efficiency of development on the application of neutral alumina powder was explored. Most of the alumina-developed substrates were showed excellent contrast and visibility. *Conclusions*: The neutral alumina powder can be an effective and inexpensive substitute for other commonly used fingerprint powders particularly in the case of shortage.

Keywords: Powder dusting; Confocal laser scanning microscopy; Sweat pores; Ridge density; Minutiae; Ridge spacing.

Introduction

Application of fingerprints to personal identification in crime investigations has been in practice over a century.[1] In fact, the importance of fingerprints as identity marks has been known from ancient times when fingerprint impressions had been used as a seal.[2] For example, contracts were signed using fingerprints in Babylon in about 200 BC.[3] "Nadi Astrology" is one of the ancient arts of India which said to predict one's past, present and future using palmprint features.[4] In forensic investigations, the fingerprints are important physical evidences and

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are available in most of the crime scenes. Practically, it is a difficult job for a forensic examiner to identify, develop and lift the latent fingerprints found in a crime scene.[5] Most of the latent fingerprints are found in damaged or smeared conditions. Some of the crucial fingerprints are only partially available in many cases. Many different methods and strategies have been developed so far to obtain the latent fingerprints for crime investigations.[6-9] Majority of them are based on the natural secretions of the palm from the four different types of glands namely, eccrine, apocrine, apoeccrine, and sebaceous. Each gland secretes a slightly different blend of chemical components.[10-14] Although, several advancements have been developed to detect the invisible fingerprints, powder dusting method is the traditional one and one of the earlier references[15] dating back to 1891. The application of finely ground material and the subsequent removal of their excess by means of blowing, tapping or brushing has been the universal method for developing the latent fingerprints since the early days of the fingerprint technology.[16] The strategy purely depends on the physical adhesion of the powders on the aqueous and oily deposits on the friction ridges. Thousands of powder formulations have been devised so far by various researchers for the detection of latent fingerprints which are varying by color, chemical composition, size and shape of the particles, etc.[5-7,17] Some traditional powders, bears noxious constituents and pose potential health risks and some of them are costly. Hence, the search for the cheaper, easily available, non-toxic powder for latent fingerprint detection is keeps pursuing.

As a result, many non-conventional powders such as turmeric[18], food powders[19,20] and festival colors[20] have been demonstrated as fingerprint powders. Rakesh and co-workers[21] have applied Silica Gel G as a cheap, easily available fingerprint developing powder. They have reported that the results are comparable with the other conventional powders.

In the present study, we have recognized the Neutral Aluminium Oxide G (TLC Grade) as a new material for the visualization of latent fingerprints. Aluminium oxide or Alumina is a cheap, non-toxic material and is easily available. Of the three variants of the alumina namely, acidic, basic, and neutral, the neutral alumina is used in this work. Gypsum is added as the binder in the commercially available neutral alumina G for TLC applications. The structure of the neutral alumina is complicated. However, it is thought to have the structure portrayed in the Fig. 1. The aluminium atoms are connected with oxygen atoms which can form hydrogen bonds with water and other hydroxyl compounds.[22-24] The polar nature of the alumina surface attracts other polar compounds by electrostatic or hydrogen bonding interactions or through Van der Walls forces of attractions. Moreover, alumina as a Lewis acid, can form coordinate bonds with lone pair containing hetero atoms such as nitrogen and oxygen[25] (amino acids and hydroxyl compounds for example) present in the natural secretions of fingers. It is well known that the natural secretions of palm contain 98 % water and many amino acids. Both these emanations can interact well with the alumina. The interactive groups on the surface of neutral alumina in contact with aqueous solvent are mostly hydroxyl groups as analogous to the interaction between hydroxyl groups and silica gel. On the other hand, the polar surface of the alumina can form electrostatic interactions with the polar amino acids. The Scheme 1 illustrates some of the possible interactions between the neutral alumina and fingerprint secretions such as amino acids and hydroxyl compounds. To our knowledge, no reports have been published so far on the application of alumina as a fingerprint powder. On this context, we have employed the neutral alumina G to visualize latent fingerprints and presented the results here. We hope these findings will be useful to the forensic fingerprint experts in handling the latent fingerprints.

Materials and Methods

The neutral aluminium oxide G for TLC (with binder) was purchased from Sisco Research Laboratories Pvt. Ltd. Common household articles were selected as the adsorbents for latent fingerprints. The experiments were carried out in the month of December which is the winter season in India. The local temperature and humidity were 30°C to 32ºC and 72 % to 77 % respectively. The volunteers washed and dried their hands before an hour prior to deposit their fingerprints. While depositing the fingerprints the volunteers were slightly sweating. The alumina powder was applied on the surface under investigation and pressed gently. The excess powders were removed by tapping and blowing. The developed fingerprints were photographed using a smart phone (brand: oppo, model: realme 1) with the camera capacity of 13 MP. The ridge spacing and the pore morphology of alumina developed fingerprints were viewed under a confocal microscope (LEICA DMIRE2) with the laser wavelength of 633 nm. 10x objective was used to view the fingerprint.

Sixteen various porous and non-porous surfaces were used in this work on which the fingerprints were deposited. The non-porous or smooth surfaces used in this work are a glass microscopic plate, top surface of a watch, a brown color plastic bottle, a black color belt buckle, wind shield of a helmet, non-writable surface of a compact disc (CD), touch screen of a smart phone, a stainless steel (SS) vessel, a glass jar, a brown color glass bottle, a multicolor identity card, and a SS pen drive. The developed latent fingerprints are shown in the Fig. 2 (a)-(l).

The porous / textured / engraved surfaces employed in this study are a nickel brass (German silver) currency coin, a black color plastic mouse, a SS lock, engraved area of a CD, a SS currency coin, a multicolored match box, a currency paper, and a jewellery cloth box. The corresponding developed latent fingerprints are presented in the Fig. 3 (a)-(h).

Results and Discussions

The friction ridges of alumina-developed latent fingerprints on non-porous surfaces are very clearly or fairly visible in all the cases. Even those developed on porous surfaces also exhibit a good distinction between the friction ridges and the background. Alumina-developed fingerprints are visible in various colored surfaces. Even, it showed good visibility in white backgrounds Fig. 2 (f) and (k). The multicolor cardboard surface of the match box also generates a readable fingerprint on application of the alumina powder (Fig. 3(f)). On the other hand, negative results are obtained for currency paper (Fig. 3(g)) and jewellery cloth box (Fig. 3(h)) due to poor contrast.

The minutiae details can be clearly observed in most of the fingerprints developed by alumina. For example, the Fig. 2 (a) is enlarged to observe the minutiae details. On enlarging, many minutiae features such as dot, island, enclosures, bifurcations, trifurcation, delta, spur, disconnection, ridge endings, lake, ridge crossover, and core are clearly observed and are presented in Fig. 4. Hence, it is clear that "Level 2" information can be extracted from the fingerprints developed by alumina powder. The fingerprint characteristics can be divided in to three levels.[27] Level 1 refers to the general pattern formed by the flow of ridges on the papillary surface, singular points and types. These are macro details of a fingerprint. The level 2 features are due to major deviations on the ridge patterns such as bifurcation, ridge ending, dot, etc. These distinct points are referred as "minutiae" or "Galton characteristics". On the other hand, the level 3 features include all dimensional attributes of the ridge path deviation, such as alignment and shape of each ridge units, shapes and relative positions of pores, etc. The pore morphological features are micro level details of a fingerprint. It is worth to note that a large number of sweat pores are obviously visible all over the Fig. 4 especially around the core area. In most of the images shown in the Fig.2 and 3, the sweat pores are clearly visible especially in the fingerprints developed on microscopic glass slide, top surface of the watch, non-writable surface of the CD, and the nickel brass currency coin. Hence, these fingerprints could also provide level 3 information.

In this context, the fingerprint in Fig. 4 is digitally enlarged at a selected area around its core region and the contrast is digitally increased to 50 %. The resulting image is showed as Fig. 5. The enlarged Fig. 5 clearly reveals the presence of many pores on the friction ridges. Some of the pores are circled to highlight. From the image, the relative positions of the pores and the pore morphology such as its shape and relative size can be extracted.

The Fig. 4 also reveals a very good contrast between the friction ridges and the furrow. To explore the micro level details more clearly, we have viewed the alumina-developed fingerprint using a confocal laser scanning microscope (CLSM). Literatures are rarely available on the visualization of fingerprints using CLSM. CLSM is a very good tool to view micro dimensions with a great resolution. The ridges were focused using CLSM and photographed directly using a smart phone and presented as Fig. 6 in which some of the pores are encircled. Images of the developed ridges recorded using CLSM are shown in Fig. 7 in different colors for the better visualization. The pores can be visualized well in Fig. 7. The selective adherence of neutral alumina on the ridges rather than the furrow is also revealed well from Fig. 6 and 7. The spacings between the ridges were measured and are shown in the Fig. 8. The average ridge spacing in the area under investigation is about 173.5 μm.

CLSM images can also provide quantitative details about a fingerprint such as ridge density. Ridge density can be defined as the number of ridges per unit distance. The ridge density feature finds its valuable application on partial fingerprints which are the only fingerprints available in most of the crime scenes. The pattern class is obviously indecisive in partial fingerprints and is indefinite for noisy fingerprints. In addition, some reports even claim sex determination from fingerprint ridge density.[28-30]

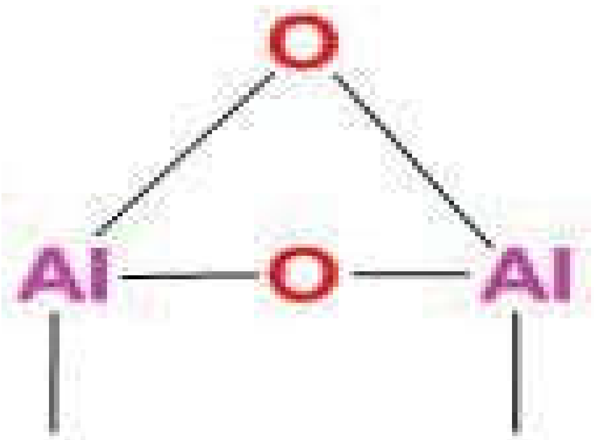


Fig. 1: Structure of neutral alumina.

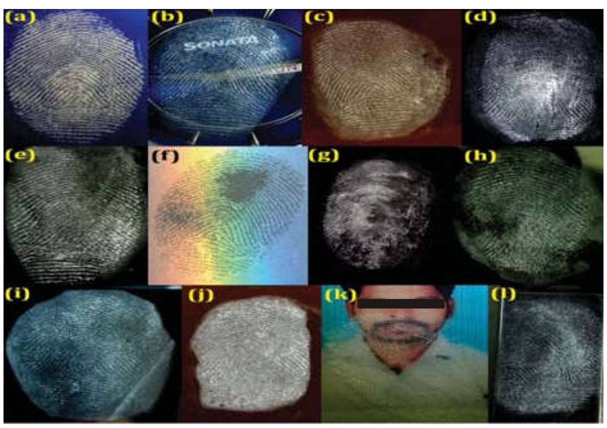


Fig. 2: Alumina-developed fingerprints on smooth surfaces (a) a glass microscopic plate, (b) top surface of a watch, (c) a brown color plastic bottle, (d) a black color belt buckle, (e) wind shield of a helmet, (f) non-writable surface of a compact disc (CD), (g) touch screen of a smart phone, (h) a stainless steel (SS) vessel, (i) a glass jar, (j) a brown color glass bottle, (k) a multicolor identity card, and (l) a SS pen drive.

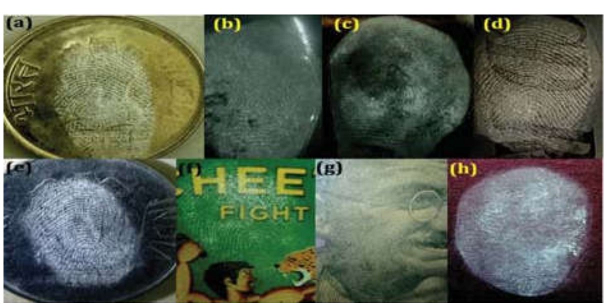


Fig. 3: Alumina-developed fingerprints on porous/textured/ engraved surfaces (a) a nickel brass (German silver) currency coin, (b) a black color plastic mouse, (c) a SS lock, (d) engraved area of a CD, (e) a SS currency coin, (f) a multicolored match box, (g) a currency paper, and (h) a jewellery cloth box.

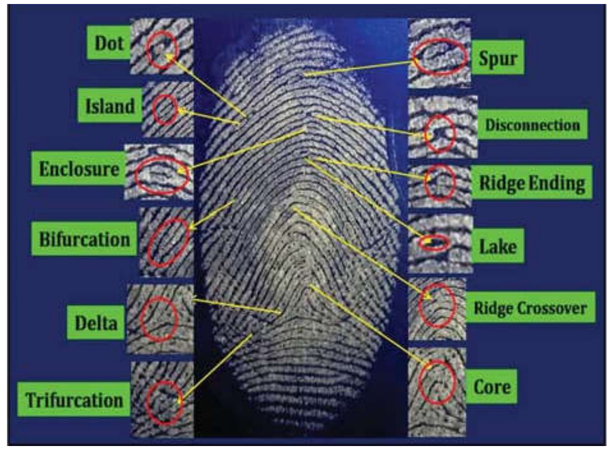


Fig. 4: Various minutiae points observed in an alumina-developed fingerprint.

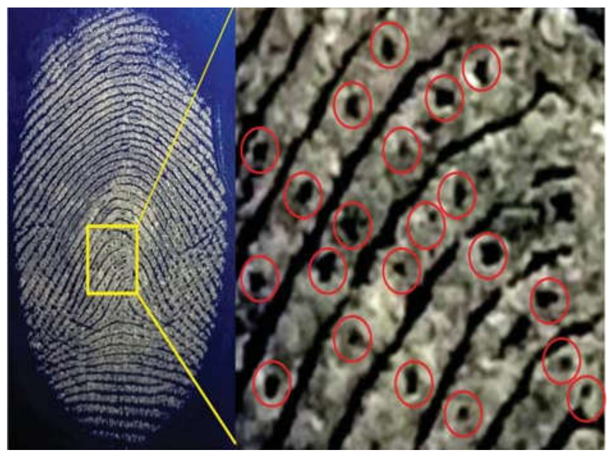


Fig. 5: Visualization of sweat pores on the digitally enlarged alumina-developed fingerprint.

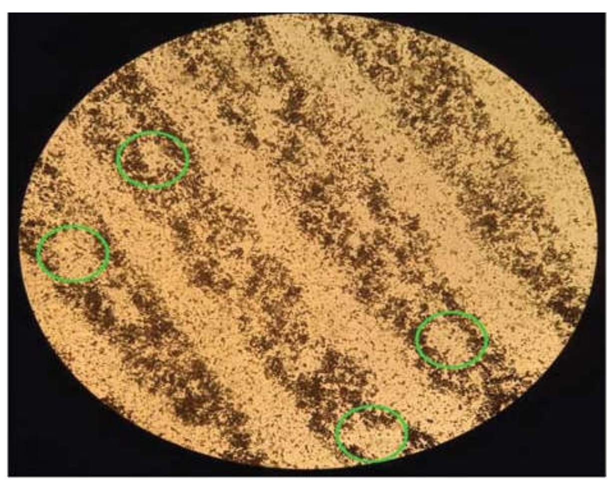


Fig. 6: Direct photograph of alumina developed friction ridges focused using CLSM. Light green circles indicate pores.

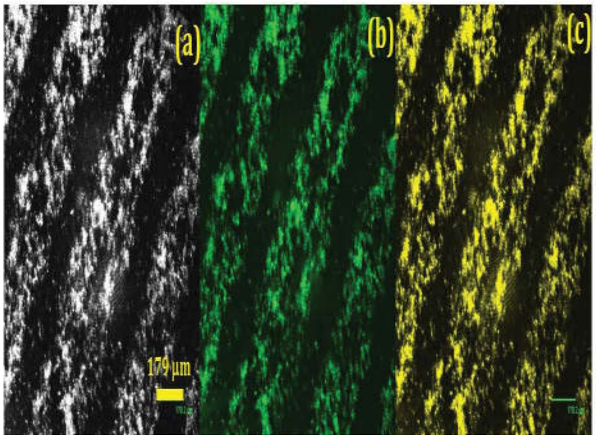


Fig. 7: CLSM images of alumina-developed finger ridges using different color filters for better visualization. The scale bar represents 179 µm.

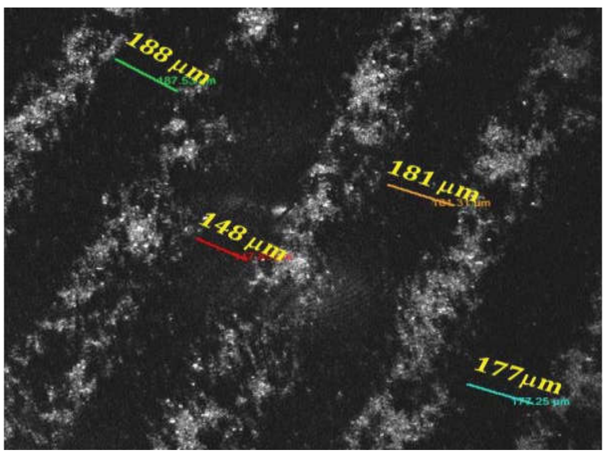
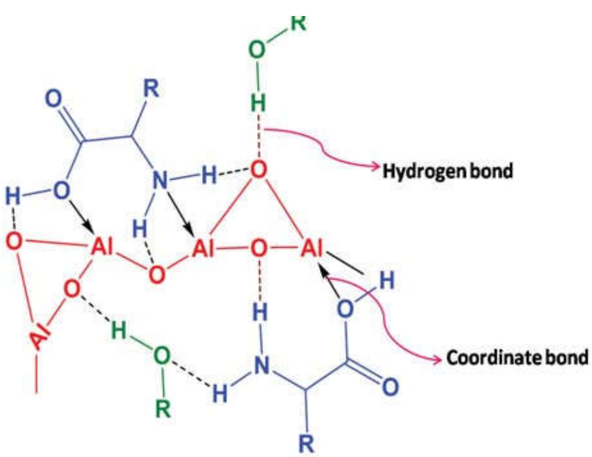


Fig. 8: CLSM image revealing the distance between two parallel friction ridges



Scheme 1: Illustration of some of the possible interactions between neutral alumina and fingerprint secretions such as amino acids and hydroxyl compounds.

Conclusion

A cheap, easily available, non-toxic, easy to handle material, neutral alumina was identified as a new fingerprint powder and its application as a fingerprint powder was demonstrated in this study. Sixteen substrates with varying surface, color, and nature were chosen to deposit the fingerprints and their efficiency of development on the application of neutral alumina powder was explored. Most of the alumina-developed substrates were showed excellent contrast and visibility. Confocal laser scanning microscope was used to view the micro level features of an alumina-developed fingerprint. The possibility of extracting all the three level information from the alumina-developed fingerprints was discussed. The neutral alumina powder can be an effective and inexpensive substitute for other commonly used fingerprint powders particularly in the case of shortage.

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