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Experiments on Sweat Fingerprints Reflection Effects on Different Thickness Glass Surfaces by Shortwave Ultraviolet

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Abstract *Objective* To observe reflection effects of sweat fingerprints on surfaces of glasses of different thicknesses by shortwave Ultraviolet. *Method* Sweat fingerprints on slide and cover slide were appeared by use of UV reflectance imaging methods. The obtained results were compared. *Result* Differences in the thickness of the transparent glass objects significantly affect the UV reflectance imaging method for sweat fingerprints shooting. *Conclusion* For UV through the thin transparent glass, the transmission depth affects the fingerprints imaging. Certain methods have been proposed to improve the image quality.

Keywords: Forensic science, Shortwave Ultraviolet, Reflection photography, Sweat fingerprint, Transmission depth, Glass.

Introduction

As a nondestructive testing technique in forensic sciences, UV photography has been widely used for the showing and recording of latent fingerprint [1, 2]. Sweat fingerprints adhered to the object surface, for its characteristics of reflection natural fluorescence of body fluids[3], is capable of reflecting UV. With this feature, it can achieve optical appearance of sweat fingerprints on smooth objects by UV photography[4]. As transmission characteristics of shortwave UV in the transparent medium is very different from visible light [4-5], in taking sweat fingerprints by this method, the thickness of the transparent object has a great impact on shooting [6]. Through controlled experiments as glass the object, it has compared the reflecting effects in shooting by shortwave UV on transparent glass objects of different thicknesses, to explore the technique improvement of shortwave UV reflection of sweat fingerprints on thin transparent glass surface.

1 Materials and Methods

1.1 Samples

Without loss of generality, we adopt a glass slide and a cover glass that can be commonly seen and made of glass as bearing objects. The thickness of the glass slide is 1.1mm-1.3mm and the cover-glass thickness is 0.11-0.13mm. We press sweat fingerprints on the glass slide and the cover glass respectively.

1.2 Equipments for Experiments

254nm ultraviolet source(US Spectroline E/12-series); full-wave band CCD(US FLI PL4240-UV), an oiliness pen, a plotting scale.

1.3 Experimental Contents and Methods

Put Glass Slide A and Cover Glass B on the metal platform engraved with graticule lines. By using shortwave Ultraviolet reflectance imaging methods, adjust polishing angle at about the angle of 45 to get the best shooting effect. By using full-wave band CCD to shoot sweat fingerprint image to adjust the luminance, contrast and gamma of the images;

Fetch a new Glass Slide C free of fingerprints, and put Cover Glass B onto Glass Slide C. You will get the shooting results by using shortwave Ultraviolet reflectance imaging methods and picture processing methods;

Use a pen of oiliness to smear the

Fig.1 The sweat fingerprint on Glass Slide A got by using 254nm shortwave Ultraviolet reflectance imaging method. (Adjusted the luminance, contrast and gamma of the images to get the best showing effect)

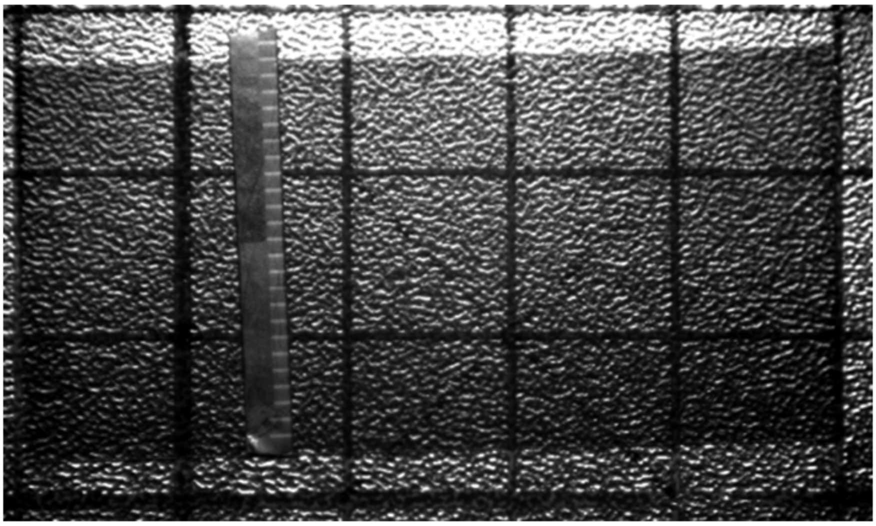

Fig.2 The shooting result got from Cover Glass B by using 254nm shortwave Ultraviolet reflectance imaging method. (Adjusted the luminance, contrast and gamma of the images to get the best showing effect)

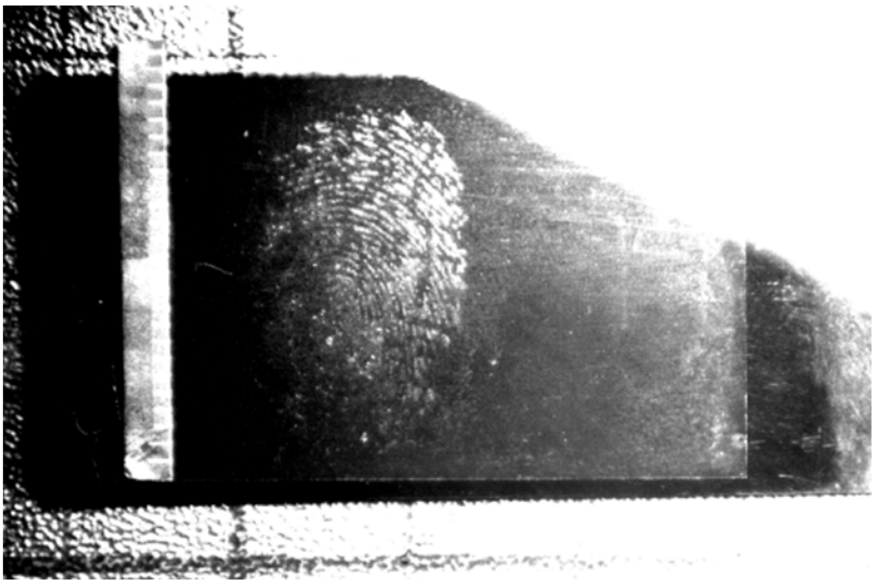

Fig.3 Put Cover Glass B on Glass Slide C and get the sweat fingerprint by using 254nm shortwave Ultraviolet reflectance imaging method. (Adjusted the luminance, contrast and gamma of the images to get the best showing effect)

reverse side of Cover Glass B, and make sure that it is well-distributed. You will get the shooting results by using shortwave Ultraviolet reflectance imaging methods and picture processing methods.

2 The Results of the Experiments

2.1 The shooting results got from Glass Slide A (Figure 1) and Cover Glass B (Figure 2).

2.2 The shooting result got by putting Cover Glass B on a new Glass Slide C. (Figure 3)

2.3 The shooting results got from the reverse side of Cover Glass B which has been well-distributedly smeared. (Figure 4)

3 Discussion

Figure 1, Figure 2 have demonstrated the shooting results got by using 254nm shortwave Ultraviolet reflectance imaging method. Because the glass slide is thick (1.1mm-1.3mm), the sweat fingerprint got in Figure 1 is the same as the bright rays against the almost absolute black background. On Glass Slide A where there is no sweat fingerprint, 254nm ultraviolet ray is almost completely absorbed, making it almost completely black background; the place where there is sweat fingerprint has light fringes because of the reflection of the fingerprint streakline to ultraviolet. In Figure 2 there is pressed sweat fingerprint, but we cannot get the image of sweat fingerprint on Cover Glass B by using 254nm shortwave Ultraviolet reflectance imaging method and we can see clearly the graticule lines of the metal platform below Cover Glass B. 254nm shortwave Ultraviolet penetrates Cover Glass B and the reflection takes place on the platform and penetrates Cover Glass B again and then reaches CCD and forms the image of the pattern of the platform. The cover glass is thin (0.11-0.13mm), 254nm shortwave Ultraviolet is not completely absorbed by the cover glass. We cannot get the image of sweat fingerprint by using 254nm shortwave Ultraviolet reflectance imaging method, but it penetrates the cover glass twice successively.

When light travels through substance, it will be absorbed by the substance[6] . The atom is made up of nucleus and electron. Actually, nucleus is quite active, it can absorb photon to increase its energy. As long as the light is absorbed, the substance is not transparent any more. But it does not mean that any kind of light will be absorbed. The specific selection is decided by quantum mechanics law. Light is electromagnetic wave, and when it comes into any medium or travels in any medium, the microscopic particle in the medium actually absorbs its energy and electric polarization and forced vibration takes place. The dipole oscillator appears and the vibratory dipole oscillator gives out subwave.

The light travels through the glass. The light we see is not the original light any more. It is the subwave given out by microscopic particle inside the glass. Amorphous substance is often transparent, such as the glass. As non-conductor, the incidence of the electromagnetic wave will not produce free charge and conduction current in it. Therefore, the electron of glass cannot absorb visible light because of the restriction of quantum mechanics[7], and the light directly penetrate the glass and it looks transparent. However, the glass is not always transparent, for example, to some infrared ray and ultraviolet ray, it is not transparent, for the two can be absorbed by glass[8].

We can suppose that a hank of parallel light travels in homogeneous medium. After it travels through the lamina (thickness *dl*), because of the absorption of the medium, the decrement of the light intensity will be dl. The light intensity decreases from I to (I-dI). According to Lambert's law, dI/I should be in direct proportion to the thickness of the absorbed layer dl:

$$dI/I = -K\cdot dl$$

K is absorption coefficient, minus means the reduction of the light intensity and the result of the differential equation is:

$$I = I_o\, e^{-K\cdot l}$$

I_o is the light intensity when $l = 0$.

The bigger the absorption coefficient, the more intense the absorption of the light wave becomes. When $l = 1/K$, the light intensity will reduce to $1/e$ of the original intensity. The absorption coefficient K is the function of the wavelength. Within the scope of the visible light, general colorless transparent optical glass absorbs less and K hardly changes with the wavelength. The absorption coefficient K is about $10^{-2}cm^{-1}$. That is to say, we can regard the general optical material to be transparent in visible region[6].

However, in ultraviolet region, the absorption of the optical glass to the ultraviolet region has remarkable changes. Especially in SW ultraviolet region, though the optical glass has strong absorption, the SW ultraviolet will not be completely absorbed until it travels certain distance in optical glass. This distance is called depth of penetration. During the course of complete absorption of the glass to 254nm UV-light travels in glass, when the thickness of glass is greater than the depth of penetration, ultraviolet ray will be completely absorbed by glass; but when the thickness of glass is not greater than the depth of penetration, ultraviolet ray can still penetrate the glass, which has negative effects on sweat fingerprint image on the glass object.

Fingerprints taken from the glass slides by UV reflection demonstrates that, it is mainly used the complete absorption effect of 254nm UV for glass slides A, making great contrast of the sweat fingerprint part and the blank background and thus showing a sweat fingerprint image (Figure 1). And because the cover glass is thin, that 254nm UV light is not completely absorbed to penetrate

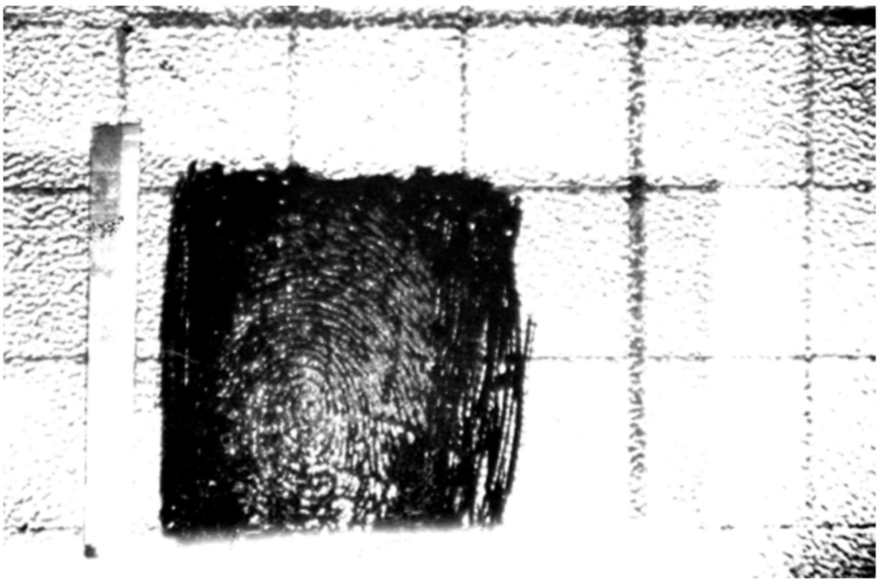

Fig.4 Well-distributedly smeared reverse side of Cover Glass B by using 254nm shortwave Ultraviolet reflectance imaging method. (Adjusted the luminance, contrast and gamma of the images to get the best showing effect)

the coverslip, which can not satisfy the conditions required for the UV reflection shooting method (Figure 2).

To realize the UV reflection shooting of sweat fingerprints on coverslips, it can be through a certain way to let the 254nm UV light be completely absorbed by the cover glass to achieve the desired condition. One method of the experiment was taken Superposition, that is, to coverslip the cover glass on the slide, increasing the penetrating thickness, so that the ultraviolet from the coverslip can be completely absorbed by . This method has been proven (Figure 3) to help achieving sweat fingerprints on the cover glass, but will not destroy the original of the cover glass. Superposition is from Beer-Lambert Law [6], also known as the Bouguer-Lambert-Beer Law in optics. As the basic law of light absorption, when a bunch of monochromatic light hitting the absorption surface of the medium, after passing through a certain thickness of the media, because of the partly absorbing of the light for the media, the intensity of the transmitted light would be weakened. The greater concentration of the absorbing medium, the greater thickness of the medium, and the light intensity decreases more remarkable. Its physical meaning is that, when a parallel beam of monochromatic light going vertically through a light non-uniform scattering absorbing substance, the absorbance A is proportional to the concentration c of the light-absorbing substance, and to the thickness l of the absorption layer. For homogeneous glasses, then the absorbance A and the concentration c of light-absorbing substance are fixed, the absorption layer thickness l directly determines the transmission of light. Therefore, increasing the thickness of the thin glass, it can obtain equal appearance effect to the thick glass, achieving the purpose of fingerprints appearance under short waves.

But there are some problems on Superposition. Under normal circumstances, due to the smooth surface of cover glass and slide, the gap between the cover and the slide will not have a significant effect on the UV reflection shooting. However, if these surfaces are not flat, or have other debris leaving a clear angle, it is easy to generate interference fringes and stamped line between them, as interference on sweat fingerprint lines [6].

Thus, this paper also proposes the Back-coating method. Due to the strong absorption of shortwave ultraviolet for the colored ink oil[8], it can spread evenly on the back of the cover glass (side B without sweat fingerprints) by the daily used oil-based pen, to let the shortwave ultraviolet be completely absorbed by the colored ink on the cover glass, which can assist appearance of sweat fingerprints on cover glasses (Figure 4). However, this method also has limitations. Because of directly painting on the cover glass by the oil-based pen, which to some extent undermined the original samples, it is limited on situations of low requirements samples for the Back-coating method.

4 Conclusion

Although optical glass and other materials has a strong effect to absorb short-wave UV, but when the short-wave UV transports in these internal materials before being completely absorbed, there is a depth of penetration. For the thin object, the penetration depth impacts the short-wave UV reflection that it may not appear sweat fingerprints. In this situation, it can use the method with an optical interference effect, e.g., to increase the thickness (Superposition) to completely absorb; or to enhance the background's contrast (Back-coating method) to achieve the conditions to get fingerprints visualization. In actual cases, it should base on non-destructive requirements to choose the right visualization program.

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