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Rapid detection of latent fingerprints utilizing fluorescent silica-rhodamine B powder

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Abstract: Novel S1 and S2 are developed and utilized by integrating rhodamine B with silica gel to detect latent fingerprints (LFPs). The obtained compounds were characterized using XRD, FTIR, and FSEM. The S1 and S2 containing different amounts of rhodamine B (5% for S1 and 10% for S2) with the best photostability are obtained by simple adsorption procedure. When exposed to (365 nm) light, the produced powder emits a bright red fluorescence in its solid state. S1 and S2 are highly effective at detecting fresh and aged latent fingerprints (LFPs) with minimal background interference. This is because the red fluorescence efficiently avoids interference from the substrates' self-fluorescence. These findings suggest that S1 and S2, with their excellent applicability and reliability, are promising candidates for visualizing LFPs.

Keywords: *Fluorescent, LFPs, Rhodamine B, Silica gel.*

1. Introduction

Although latent fingerprints (LFPs) are typically invisible, certain physical, chemical, and biological techniques can make them visible. LFPs are extremely useful evidence for identifying people in criminal investigations[1][2][3]. As of right now, forensic scientists are still quite interested in seeing the LFPs visualization improved[4]. The most popular approach for seeing and recognizing LFPs is still a conventional powder dusting technique[5]. The development of fingerprint powder has emerged as an important issue for the efficient use of the powder dusting method[6][7]. Although this technique works well to develop LFPs in many common situations, it still has several drawbacks, including toxicity, low contrast, low selectivity, significant background interference, and difficulties applying on various surfaces[8][5][9][10][11][12]. For the viewing of LFPs, fluorescent materials possessing high sensitivity, high efficiency, high contrast, and high resistance to background interference have garnered attention. [13]. Classical methods utilized to develop fingermarks are iodine fuming[14], powder dusting[15], ninhydrin spraying[16], silver nitrate soaking[17], and cyanoacrylate fuming[18][19]. Hybrid inorganic/organic including organic dyes and amorphous silica gel have been suggested[20][21][22]. The silica is a matrix material, it offers physicochemical stability, protecting the dye that is encapsulated from outside disturbances. Furthermore, silica has a readily functionalized surface on its own and is biocompatible[23][24]. Specifically, surface modification of the former can improve the interactions between silica and LFPs, improving detection. In this regard, it has been established that silica combined with dyes can be used for LFP detection[25]. On the other hand, data regarding the relationship between silica surface modification and LFP development efficiency is still insufficient. Therefore, surface modification with appropriate Rhodamine B is required to improve the interaction of silica with LFP. In this work, we report on silica gel coated with Rhodamine B as powder-

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dusting for efficient LFP detection, which was obtained by incorporating an organic dye (Rhodamine B) into silica gel using ethanol as a solvent.

2. Experimental

2.1. Materials and Instrumental

Rhodamine B was purchased from CDH. Also, silica gel was purchased from Lobachemie. All organic solvents were utilized without any further purification. The FTIR spectra were achieved using the SHIMADZU spectrophotometer, Japan. UV short and long wavelengths were used to visualize latent fingermarks using the Spectroline model CM-10A fluorescence analysis cabinet. X-ray diffraction (XRD) profiles of the powder samples were obtained using a X-Ray Diffraction \ Philips \ Netherlands an instrument equipped with a Cu (Kα) X-ray source. Scanning electron microscopy (SEM) images were captured with a Zeiss Supra 40VP FESEM, operating at an accelerating voltage of 20 kV. A sieve of type (Furat, size 45 mm) was used in this method.

2.2. Preparation of powder formulations (S1 and S2).

Two various formulations (S1 and S2) of rhodamine B and silica gel were prepared. To prepare formulations S1 and S2, 0.5 g or 1.0 g of rhodamine B was dissolved in ethanol (10 mL) followed by the addition of 10 g of silica and heated at 70 ^{0}C, stirred for 30-60 mins. The mixture was dried in an oven for 2-3 hrs. After that, the sample is crushed using a mortar and then sieved through a sieve of 45-micron size for obtained fluorescent powder, as shown in Figure 1.

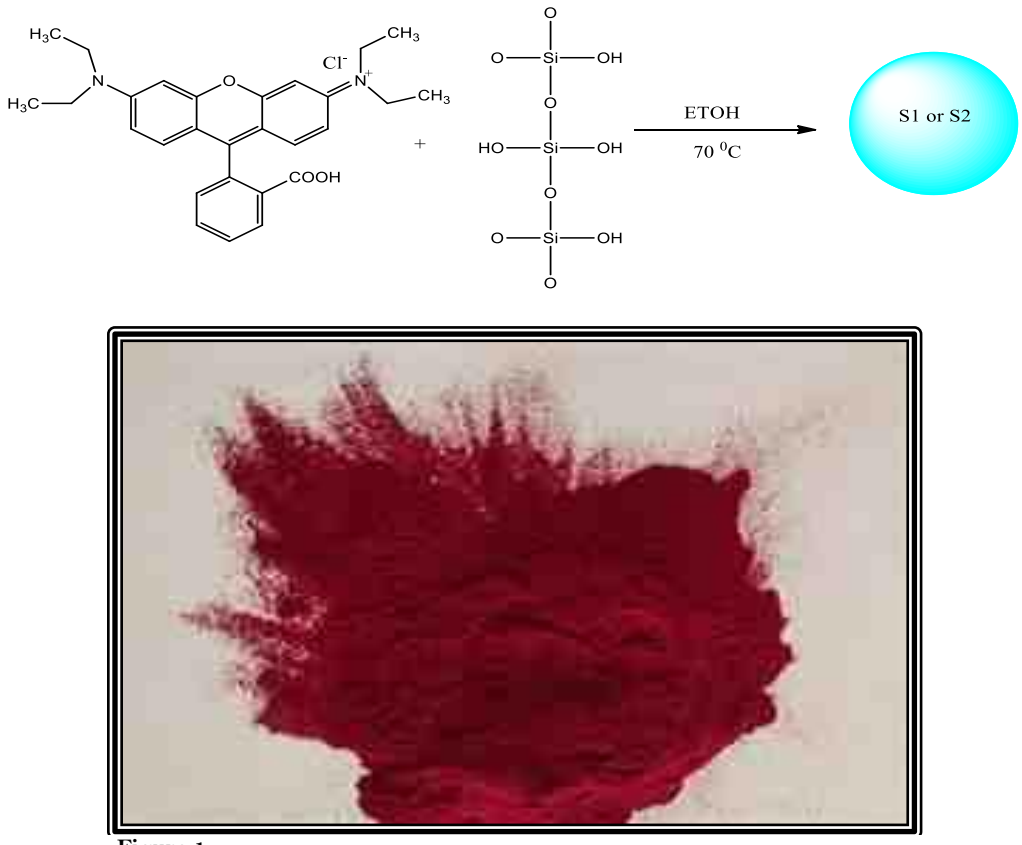

Figure 1.
Synthesis of powder formulations(S1&S2).

2.3. Development of Latent Fingerprints

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The tests were conducted at the Ministry of Interior of Iraq, Criminal Evidence Department. Glass was chosen as a representative substrate for the detection of latent fingerprints (LFP) under hydrophobic and hydrophilic conditions. All fingerprints were from a 30-year-old donor. To develop the LFP, S1 and S2 powders were carefully coated on the substrate. The excess powder was then removed using a blower for 80 seconds. The latent fingerprint's weak or nonspecific contact with each particle could be largely eliminated by the mild airflow. Consequently, this procedure ought to provide a more sensitive and focused visualization of latent fingerprints. The final samples were photographed under illumination from a UV lamp with a wavelength of 365 nm.

3. Results and Discussion

Fluorescents silica modified with rhodamine B dye (S1 and S2) were synthesized. Figure 2 shows the FTIR spectra of S1 powder. The spectrum distinctly displays characteristic absorption bands for the OH groups of silica gel at 3439 cm^{-1}. Additionally, the IR spectrum reveals a band at 1593 cm^{-1}, corresponding to the Si-O group in the silica. Also, the FTIR spectrum shows adsorption bands at 1745 and 2980 cm^{-1} due to the C=O of the carboxylic acid and C-H aliphatic of the CH_3 group of rhodamine B, respectively.

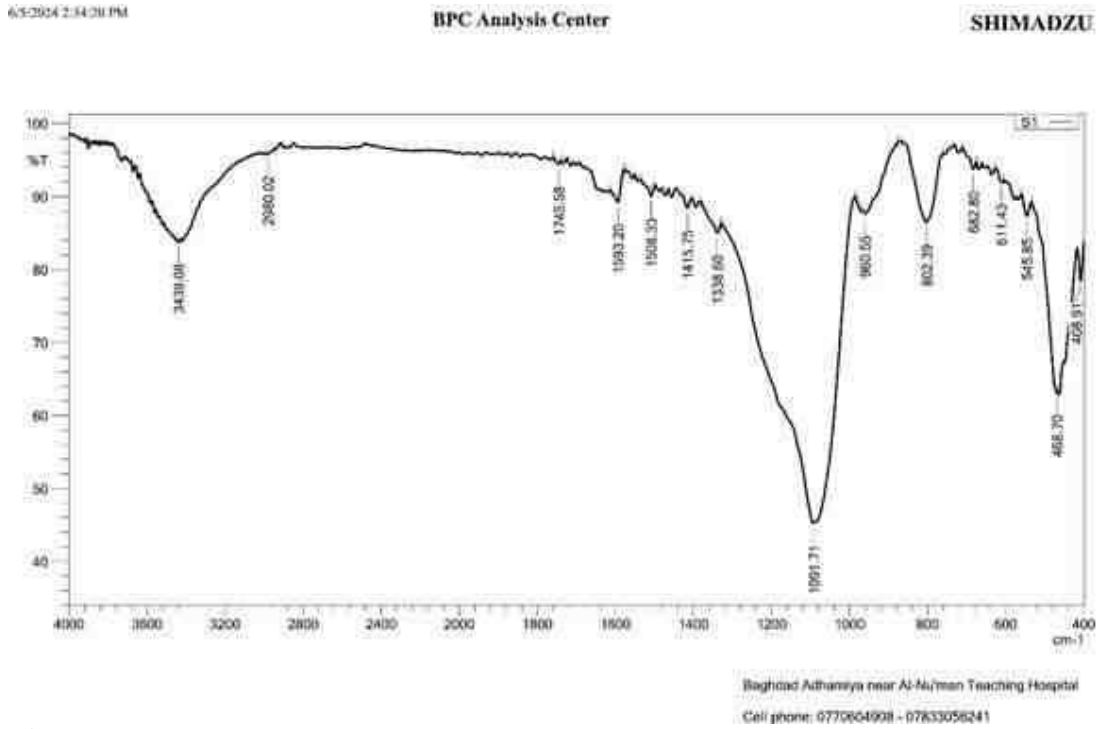

Figure 2.
FTIR spectrum of S1 powder.

The morphology of the S1 and S2 powders was examined using Field Emission Scanning Electron Microscopy (FSEM), as depicted in Figure 3. The images reveal that the powder particles vary depending on the amount of rhodamine B used. Figure 3(A) illustrates the powder containing rhodamine B, showing a non-smooth surface and irregular shape, with an average particle size of 35 nm. Figure 3(B) presents the silica gel powder, which has a smooth surface and irregular shape, with an average particle size of 13 nm, as observed by FSEM. Figure 3(C) depicts the characteristic powder S1, displaying a non-smooth surface and irregular shape. Figure 3(D) shows the characteristic powder S2,

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which also has a non-smooth surface and irregular shape, with an average particle size of approximately 25 nm, as determined by FSEM.

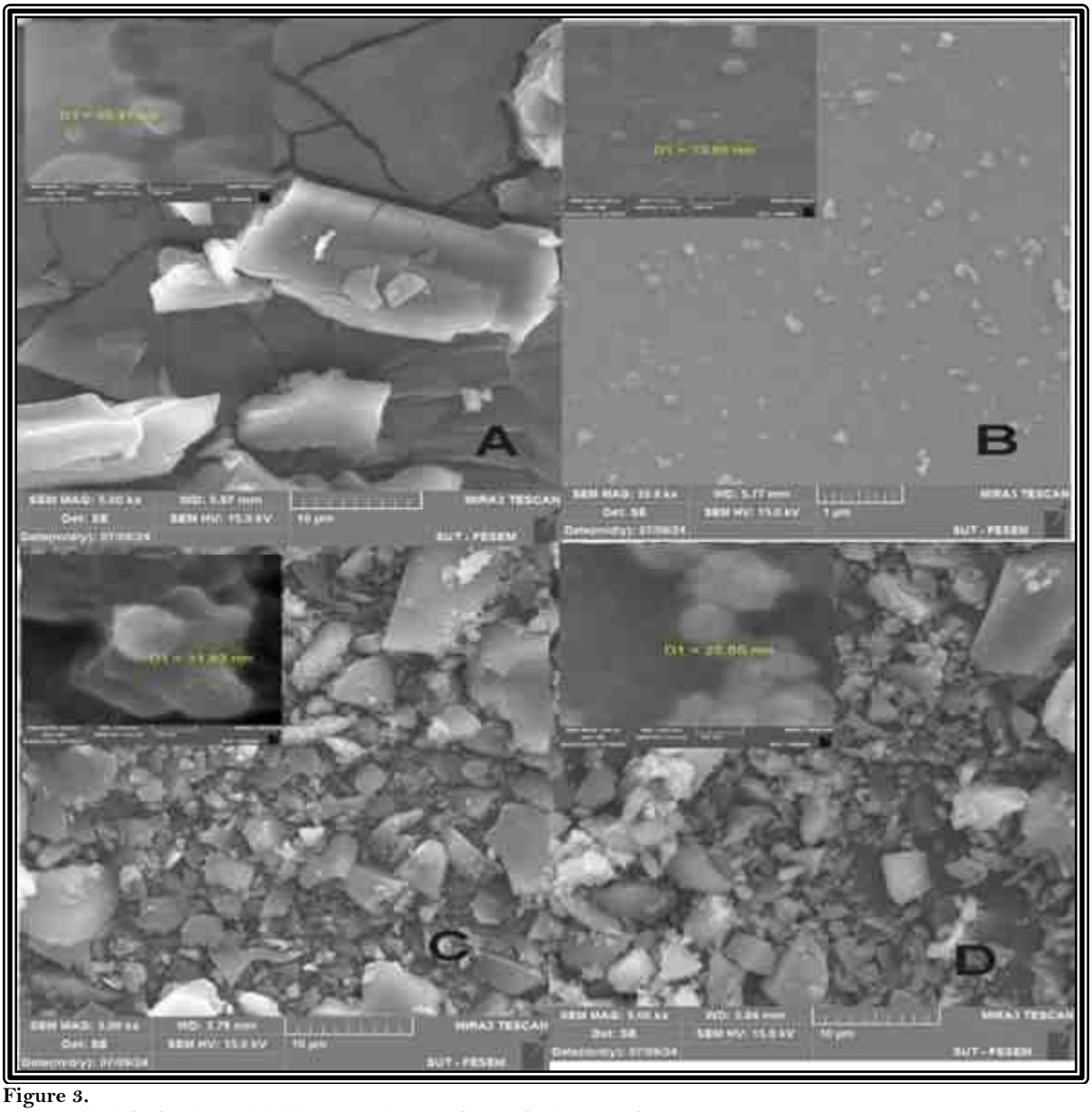

Figure 3.
FSEM of (A) rhodamine B, (B)Silica gel, (C)S1 powder., and(D) S2 powder.

The powder XRD spectra of the S1 and S2 samples exhibit featureless profiles with a broad peak at 22° (2θ), indicative of the characteristic diffraction peak of cubic SiO_2 structures[26], as shown in Figure 4. These XRD patterns suggest that S1 and S2 are predominantly amorphous.

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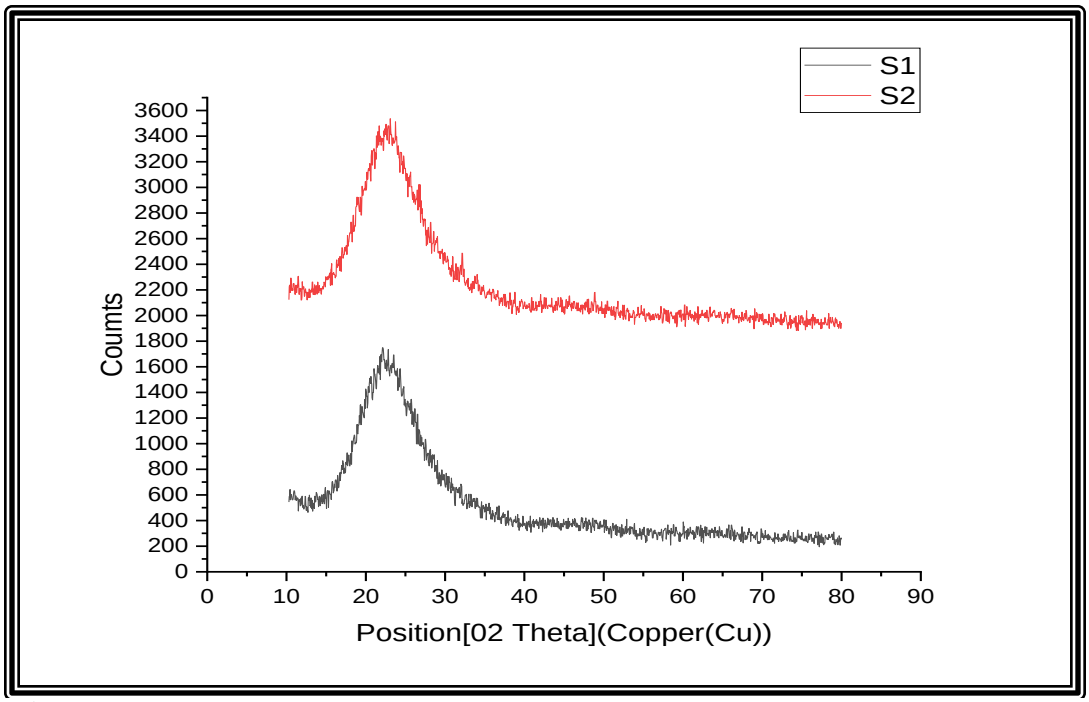
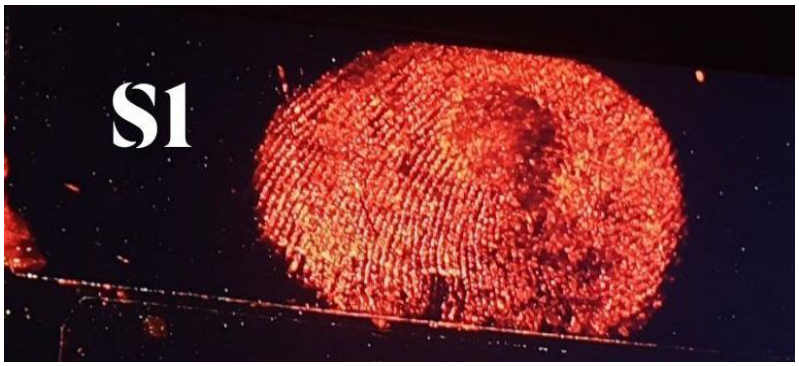


Figure 4.
XRD profiles of S1 and S2 powder.

Classical powder technology is used to image LFPs on glass plate surfaces. Through adsorption interactions such as physical adsorption and static attraction, residual LFP components can interact with the powders[27]. Based on the particles' fluorescence characteristics, LPF images can be seen. Using the S1 and S2 powders as the fingerprint agent under 365 nm light irradiation, the LFPs images on the glass plate are observed (Figure 5). Figure 3a shows the red emission of an LFPs image based on the S1, and Figure 3b shows the red emission of an LFPs image based on the S2. The use of S1 and S2 powders containing relatively high levels of rhodamine B produced clearer LFP images with distinct ridge details and high contrast. Although there were some differences in the fluorescence intensity and color of the LFP images produced by S1 and S2, S1 was selected as the fingerprint agent for subsequent tests.



a

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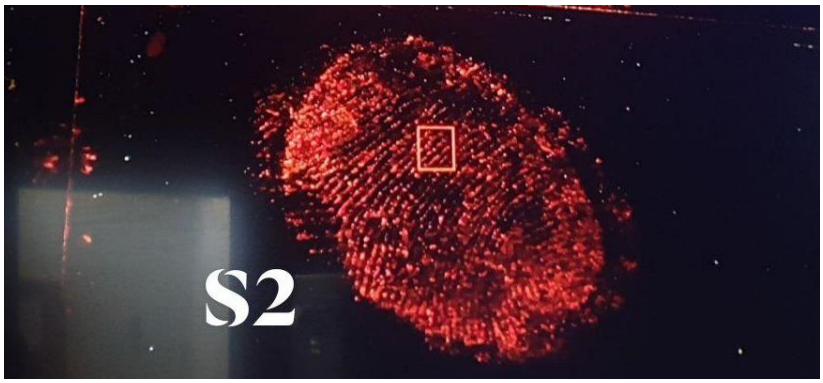

b

Figure 5.
The detection of the LFPs on the glass plate using S1 and S2.

4. Conclusions

S1 and S2 have strong and stable red fluorescence and can be used as solid-state fluorescence to visualize clear feature details of LFP on glass substrates. They have high contrast, good brightness, excellent sensitivity, high resolution, and minimal background interference. In addition, they can also view images of aged LFP. These properties indicate that S1 has great potential in high-quality imaging and detection of LFP.

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