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Research Article
Development of Natural Luminescent Powder for the Detection of Latent Fingerprint

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Abstract

Background and Objective: Nowadays, Dyes is widely used to improve fingerprints identification test. Natural dyes are another interesting way that can be used instead of chemical dyes because of its non-toxicity and lower cost. In this research, the development of rust powder from *Plumeria* tree was applied for fingerprints identification due to its fluorescence property under UV. Rust and Small Particle Reagent (SPR), containing $ZnCO_3$ were applied to detect hidden fingerprints on non-porous surfaces in both dried and wet condition. **Materials and Methods:** Yellowish Rust from *Plumeria* tree was extracted with ethanol, grinded, dried and then mixed with $ZnCO_3$. Powder slurry was sprayed over fingerprint mark on different surfaces and monitored in both dried and wet condition. Visualization of fingerprint under UV was observed. Scanning microscope (SEM), UV-visible spectroscopy (UV-VIS), Fourier-Transform Infrared Spectroscopy (FTIR) and Energy-Dispersive X-ray (EDX) were also used to characterize physical and chemical properties of rust powder. **Results:** Fingerprints identification by dust technique using *Plumeria* rust powder as ingredient, provide best quality enhancement of fingerprints under UV light due to its fluorescent property, whereas a conventional technique of Small Particle Reagent technique (SPR) doesn't show fluorescent under UV. Data from SEM and FTIR show slight adhesion between zinc carbonate particles and rust powder. **Conclusion:** Fluorescence properties of rust powder is still interesting. Further improvement in powder recipe will be further investigated.

Key words: Non-porous surfaces, fluorescent powder, latent fingerprint, plumeria rust

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

At the crime scene both fingerprints and latent fingerprints can be found as the evidence which can be used to find the offender. The fingerprint is the latency of each person. But sometimes the case may occur in a dark area which is difficult to find evidence and fluorescent chemicals is necessary to assist in the examination of evidence

Many organisms are capable of emitting light, both in the sea and on land, from single-celled animals up to the sponges, jellyfish, corals, various sea worms, shellfish, squid, insects and fish. Microorganism such as fungi and various bacteria each have difference fluorescence varies, such as the color of the light, the pattern of the light, the light emitting at various positions of the body, rhythm and time of emitting. Some organism changes light color from time to time. The right fluorescent property of these organisms may be helpful to a forensic investigation.

The authors wanted to extract the fluorescent powder to use in fingerprint examination. To replace chemicals powder with the natural extracts, *Plumeria* rust, a round convex, bright yellow to yellow-orange, was a target of interest. It formed as clumps or isolated, spread across the underside of leaves of *Coleosporium plumeriae* Pat. This fungus produces a phosphor but is not toxic to humans. Rust, formerly known as Lan Thom, usually spreads severely during the rainy season until the beginning of winter. The orange-yellow color of some rust is caused by carotenoids pigment. There were four carotenoids in rust fungi such as Phytoene, Lycopene, γ-carotene and β-carotene[1]. The Small Particle Reagent (SPR) technique is a powerful technique and widely used for detecting fingerprints, especially on wet surfaces. The SPR are now available in white and black only[2-4]. This test method is suitable for testing on materials stored in dry conditions[5]. In 2016, Kapoor and Dhall[6], conducted a comparative study and assessed the effect of latent fingerprints present in the scene at the site of destruction using fluorescent small particle reagents made from Zinc carbonate, Zinc oxide and Titanium dioxide. The quality of the imprinted fingerprints and fingerprints that exist in the scene of the destruction was excellent and latent fingerprint could be recovered successfully even from the situation where the crime scene was destroyed. Good quality hidden fingerprints were obtained from newly stamped fingerprints, from objects landfilled in the ground or dropped into the water. Fingerprint from the event of explosions and landfills in the snow had poor results. The most effective substances were TiO_2>$ZnCO_3$>ZnO, respectively[6]. In 2016, Doibut and Benchawattananon[7] studied the use of small particle reagents containing zinc carbonate mixed with plant dyes (turmeric and pea flowers) and commercial liquid detergent. Fingerprints stamped on stainless steel, glass and plastic surfaces were soaked in a clean and dirty water for 30 days, then all surfaces were sprayed daily with the mentioned SPR formula. In this experiment, the most effective surface was stainless steel surface, followed by glass and plastic surfaces respectively[7]. In 2016, Janthong *et al.*[8]. studied the use of small particle reagent containing zinc carbonate and crystal dye violet to find hidden fingerprints that stuck on automotive parts such as car bodywork and car windows by various parts will be immersed in water supply and water drawn from public canals. It was found that the length of time that the fingerprint could be obtained in samples immersed in tap water was longer than in canal water. In addition, the hidden fingerprints obtained from darker car surface are significantly better than lighter colored car surface[8]. In 2016, Rohatgi and colleagues studied the feasibility of fingerprints by using small particle reagent formulated with zinc carbonate and basic fuchsin dye[9]. Submerged in water up to 45 days, fingerprints can appear sharp and clear on non-porous surfaces. It demonstrated an improvement of this SPR component compared to the results obtained from the SPR formulated with zinc carbonate and a crystal violet dye[9]. The main aim of this work was to develop a fingerprint testing technique using a rust fungus (*Coleosporium plumeriae* Pat.), taken from the leaves of the *Plumeria* tree and to study the physical property of powder comprised of rust fungi and SPR.

MATERIALS AND METHODS

Development and testing of powder for fingerprint were carried out at the Chemistry Department, Faculty of Science, Khon Kaen University and the Synchrotron Light Research Institute, Nakhon Ratchasima between August and December, 2020.

Chemicals: Ethanol of 95% purity, a commercial grade, Zinc carbonate of Sigma Aldrich, polyvinyl alcohol of Sigma Aldrich and Liquid Detergent of commercial grade Attack 3D were used as received.

Making of a modified SPR: Leaves of *Plumeria* tree with rust fungus on the underside of the leaf were collected during the month of August to October, 2020 at the recreation park at Khon Kaen University. Rust was soaked in 95% ethanol, filtered, dried and kept at room temperature. The dried yellow rust was mechanically grinded and was used as an ingredient in powder recipe. Each slurry recipe will consist of rust, $ZnCO_3$, polyvinyl alcohol (PVA), liquid detergent and distilled water. The ratio used was shown in Table 1.

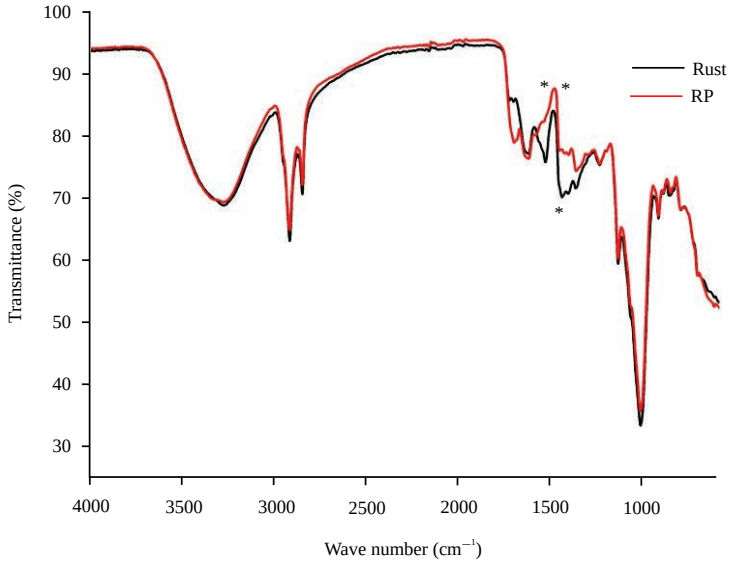


Fig. 1: FTIR result of rust as collected from tree (rust, *) and modified SPR (RP, **)

Table 1: Recipe of a modified small particle reagent (SPR)

Sample	Ratio of $ZnCO_3$ and rust fungi	Volume of distilled water (mL)	Volume of PVA (mL)	Volume of liquid detergent (mL)
ZR0.5	2.5:1	5	0	0.02
ZR1	5.0:1	10	0	0.04
ZR2	10.0:1	20	0	0.08
PZR0.5	2.5:1	0	5	0.02
PZR1	5.0:1	0	10	0.04
PZR2	10.0:1	0	20	0.08

Development of latent fingerprints: Glass substrate was selected for deposition of a fingerprint. All of the fingerprint samples were prepared based on the same method and collected from the same male donor. To develop the latent fingerprints, controlled amount of the modified SPR slurry was carefully sprayed onto the imprinted samples and excess of power was gently removed by airflow for 30 sec after drying. The samples were then place in UV cabinet with 365 nm excitation. The fluorescent photographs were then captured.

Characterization: Functional groups of chemicals in rust and modified SPR were characterized using FTIR beamline 4.1 at the Synchrotron Light Research Institute (Public Organization) Nakhon Ratchasima, Thailand. Morphology of dried samples was performed by SEM, LEO 1450VP model. Energy-Dispersive X-ray (EDX) mode was used to find chemical element of rust and modified SPR powder.

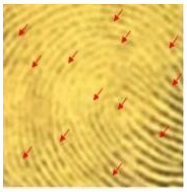
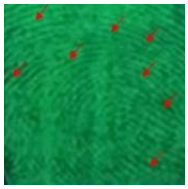
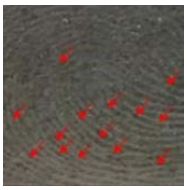
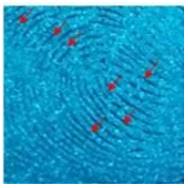
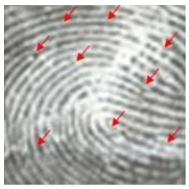
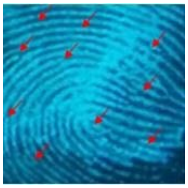
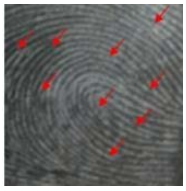
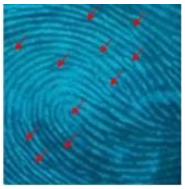
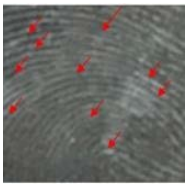
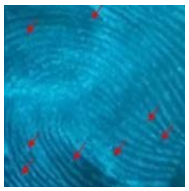
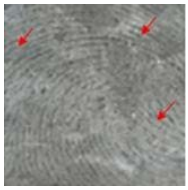
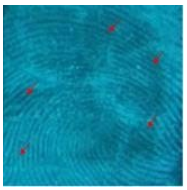
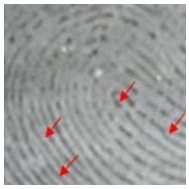
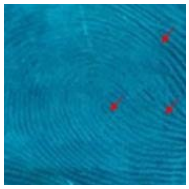
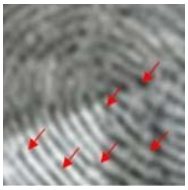
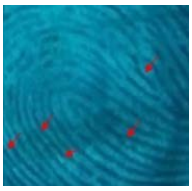
RESULTS

Visualization of key characteristics or minutiae of hidden fingerprint, following a guideline of the Standardization Committee of the International Association for Identification, were carried out and shown in Table 2. With an addition of rust in modified SPR the images of hidden fingerprints were more noticeable under UV. The increasing amount of $ZnCO_3$ of up to 5 times of rust yield a better number of observed minutiae under UV compared to white light. However, an obscuring of minutiae was observed when higher amount of $ZnCO_3$ and PVA was added. This was due to formation of polymer film layer and blockage of big SPR particle on narrow groove of fingerprint.

FTIR result obtained from fresh collected rust, shown in Fig. 1, indicated with an asterisk, showed peak of OH stretching at 3275 cm^{-1} and aromatic C=C stretching at 1629 and 1538 cm^{-1}, a prove that rust can absorb UV via aromatics. Modified SPR, sample ZN0.5, indicated with a double asterisk, showed a similar peak of OH stretching, however a slight shift of aromatic C=C stretching to 1629 and 1706 cm^{-1} was observed. This was due to an interaction between rust and SPR, resulting in better image under UV.

The morphology of rust and a modified SPR was performed using SEM technique and showed in Fig. 2. As can be seen, rust particle is cluster together, showing a small pore on the surface. Particle size of rust was reduced from around 42-44 micron to 0.3-0.5 micron after making it into slurry.

Table 2: Key characteristics, indicated by arrow, found on the hidden fingerprints performed by various techniques.

Examination techniques		Under the white light	Under UV light
Powder technique	Rust powder		
	Carbon black		
SPR technique	ZR0.5		
	ZR1		
	ZR2		
SPR technique With PVA	PZR0.5		
	PZR1		
	PZR2		

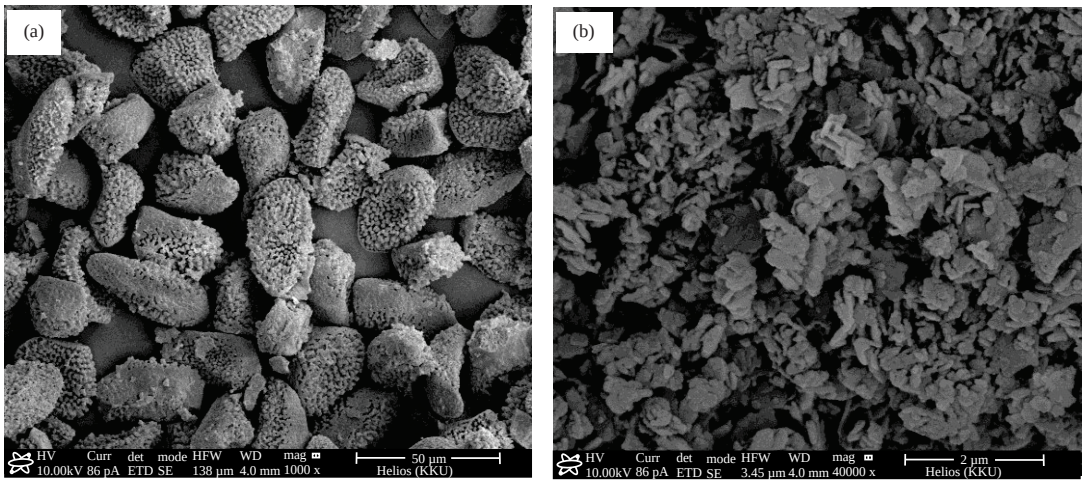


Fig. 2(a-b): SEM image of (a) Rust as collected and (b) A modified SPR, sample ZR0.5

Fragmentation of particle is needed to aid a penetration into groove of fingerprint and a better adhesion. Formation of $ZnCO_3$ particles being larger than 2 microns on average, which reduces the adhesion efficiency of fingerprints[9].

DISCUSSION

The presence of natural products such as polyphenols, alkaloids, triterpenoids and flavonoids in *Plumeria* part was reported and used as a traditional medicine[11]. Rust was then chosen for an alternative raw material for fingerprint powder due to its non-toxicity and fluorescence property. The ratio of $ZnCO_3$ and rust of up to 5 yield an enhancement of the observed minutiae in fingerprint under UV compared to white light. This was due to interaction between compound in rust and $ZnCO_3$.

The quality assessment of fingerprint, according to a scale assessment of Castello' s work[12], grade 2-3 of carbon black, 3 of conventional SPR and current work with no PVA and 1-2 of our work with PVA were observed under UV light. Even though the grade scale was non-significantly different under white and UV light, a sharp blue fingerprint was clearly observed and easier to grading. This provides a promising recipe using natural *Plumeria* rust as main ingredient. Mark grading of our works under white light cannot be compete with works of Janthong *et al.*[7] using Crystal violet dye, Rohatgi. and Kapoor[8] using rose bengal dye, Kapoor *et al.*[13] using mixed Robin blue and silver dual powder, Benchawattananon[14] using fluorescein dye and However, our recipe does have a highlight on using a non-modified natural powder that will not destroy an original fingerprint via chemical reaction. Elements such as H, B, N, O, P and transition metal Ti, Cr, Ni, Co and Zr are known to form optically active defects and can produce luminescence[15]. Emission of blue light are resulted from an excitation of elements with an appropriated energy and wavelength.

A shift of aromatic C=C stretching in FTIR spectra from 1629 to 1706 cm^{-1} also confirm an interaction between rust and SPR, resulting in better image under UV. Fragmentation of rust particle by mean of grinding is required in order to provide a better penetration into groove of fingerprint and a better adhesion. In this study, 0.3-0.5 micron in diameter was observed, in line with Frank's work of less than 2 micron[10]. A study on the effect of adhesion aid, polyvinyl alcohol (PVA), was perform with little success. A glassy and viscous property of PVA film may coat and cover groove of fingerprint, resulting in a blockage of main ingredient powder. To improve its compatibility, other matrix[16-17] or composition ratio[18] will be adjusted. Our powders showed an effective luminescent property on a variety of substrates under a 365-nm UV lamp, such as glass, aluminum and a plastic poly (ethylene terephthalate).

This study is restricted to nature of fingerprint and way of applying it on to surface. More samples are needed to investigate since each evident scene is different and variable. Water type, DNA, immersion time and substrate can also affect the fingerprint[19]. A forensic scene of submerging evidences, difficult or impossible to recover latent fingerprint is interesting and can be explore using our *Plumeria* rust recipe.

CONCLUSION

Rust fungi is a promising ingredient of making SPR powder for detection of latent fingerprint. It shows a better image of fingerprint when right amount of rust is added. Our

finding the suitable ratio between $ZnCO_3$ and rust are not higher than 5 times. Particle size of 0.3-0.5 microns are observed to provide a good adhesion. A shift in aromatic C=C peak also prove that there is interaction between rust and SPR. Ongoing investigation of better adhesion and clearer image under UV will be performed using surfactant. Different substrates will also be focused.

SIGNIFICANCE STATEMENT

No previous study on mixing of *Plumeria* rust with small particle reagent for detection of fingerprints was done on the development of natural luminescent powder. This non-toxic and naturally available Rust provides an alternative and easy way to detect latent fingerprint.

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