ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24JUL1675

Review: Synthesis of Chemical Materials for Fingerprint Detection

Aseel M. Aljeboree [1] ; Israa M. Radhi[2] ; Ahmed I. AbdulLatif[3] ; Firas H. Abdulrazzak [4] ;
Ahmed. M. Abbas[2] ; Ayad F. Alkaim [1].; Takialdin A. Himdan[5] ; Falah H. Hussein [6]
[1] College of science for women, University of Babylon, Iraq
[2] Chemistry Department, College of education for pure science\Ibn al-Haytham, University of Baghdad, Iraq
[3] Chemistry Department, College of education for pure science, Diyala University, Diyala, Iraq
[4] Forensic Departments, College of Science, University of Karkh, Iraq
[5]Medicine lab ,Al-Esraa University College, Baghdad, Iraq
[6] College of Pharmacy, University of Babylon, Iraq
Corresponding Authors: Firas H. Abdulrazzak

Abstract:- Fingerprint is a famous tool for identifying the identity of people by using the ten fingers, which should be left traced for remaining materials, and that could be achieved by specific chemical compounds made as developer reagents. In this review, we mention some chemical compounds that are used for developing fingerprints and that include inorganic and organic materials in classic and Nano size. The reported materials in this work include pristine samples such as SiO_2 and carbon dote or hybrid materials with specific materials to produce new compounds with new physio-chemical properties able to interact with trace fingerprints.

***Keywords**:- Fingerprint, Forensic, Organic, Inorganic, Nano-Material.*

I. INTRODUCTION

Forensic science with chemistry technology was used to investigate various confirmed criminals in many different fields by using many processes, such as flame and color analysis, chemical reactions with specific reagents, extraction and separation methods, and microscopy techniques. One of the most common fields for study represent by fingerprint appearance which required for specific chemical compound to identification trace evidence from drugs and fingerprints.

Fingerprints could be found in two types: visible (including patent prints and plastic prints) and invisible latent prints [1]. Patent prints as a visible type are accrued when the fingers left or merge with a colored surface such as blood, ink, dirt, or some kind of oil. Plastic prints or impressed prints are the second visible print accrued after rides of finger touch dust or dirty surfaces contain putty, wax, and soap. An impressed print can create a three-dimensional fingerprint, which can be seen easily and can take the photograph for the print without doing any other development, thus detecting the spoof fingerprint.

The latent fingerprint, which cannot be seen with the naked eye while dusting or fuming with some chemical reagents, can be made detectable. Mostly, latent fingerprints are left accidentally at the scene of a crime, which are created by the sweat obtained from our bodies, water, salt, and amino acids. Figure 1 shows that the common [2-4] fingerprint patterns classified include three categories: arches, loops, and whorls.

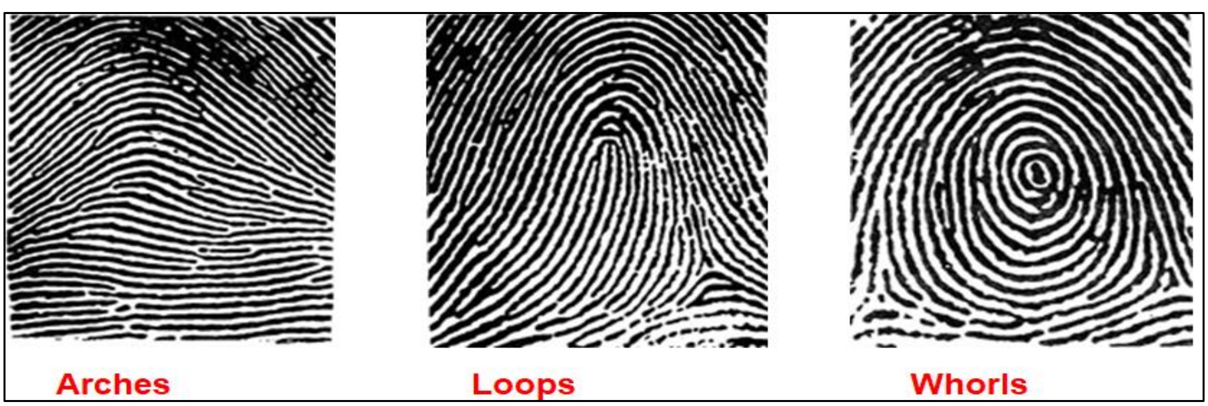

Fig 1: Three Main Fingerprint Types Arch, Loop, and Whorl.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24JUL1675

Huge applications of fingerprints, such as criminal identification, legal documents, the conduct of background checks, defense security clearance, concealed weapon permits, accessing secured systems at all domestic and international flights in airports with different requirement such as immigration or banks process for authentication, and passwords to unlock phones [4]. Latent fingerprint powders LFP are important condition in the identification of LFPs in forensic applications. It is often severing by poor resolution and reduce contrast for image, which is a very critical requirement [5].

Mostly fingerprints were disappearing [6-7] on the scene, without the characteristic properties, which required methods to obtain this evidence in the most efficient way and that needed for regent to do that. In this work, we reported some chemical compounds that were synthesized, identified, and applied to identification fingerprints. We make a brief explanation for the reaction and structure of synthesized materials, beside focusing on the physical properties to use as an advantage to increase the development of the LFP.

The work includes extraction materials, derivatives for organic compounds, pristine carbon materials, and inorganic nanomaterials in binary systems with different physical properties.

A. Berberines Extraction

Natural berberines [4] were synthesized in complex form when used Coptis chinensis in extraction phase with β-CD and applied as developer regent for LFP. According to figure 2, ethanol was used as extraction reagent for first materials, berberines, before synthesized the complex. The complex of β-CD was characterized by UV–visible spectrum and fluorescence spectrum to analyzed the function groups, while FTIR, SEM, and TGA, to analyzed nature of bonding and to found size of particles, and thermal graphmatric analysis respectively.

The researcher tested four types of synthesized materials, powder, in developing LFP, which are: pristine berberine, derivative berberin with β-CD and physical mixtures, and pristine β-CD. The results show that berberine/β-CD was more active compared with the other three powders, which characterized uniformly adsorbed and visibly with the LFP on the glass surface and behave sensitive materials under 365 nm of UV-light, which increased the contrast between LFP and the surface.

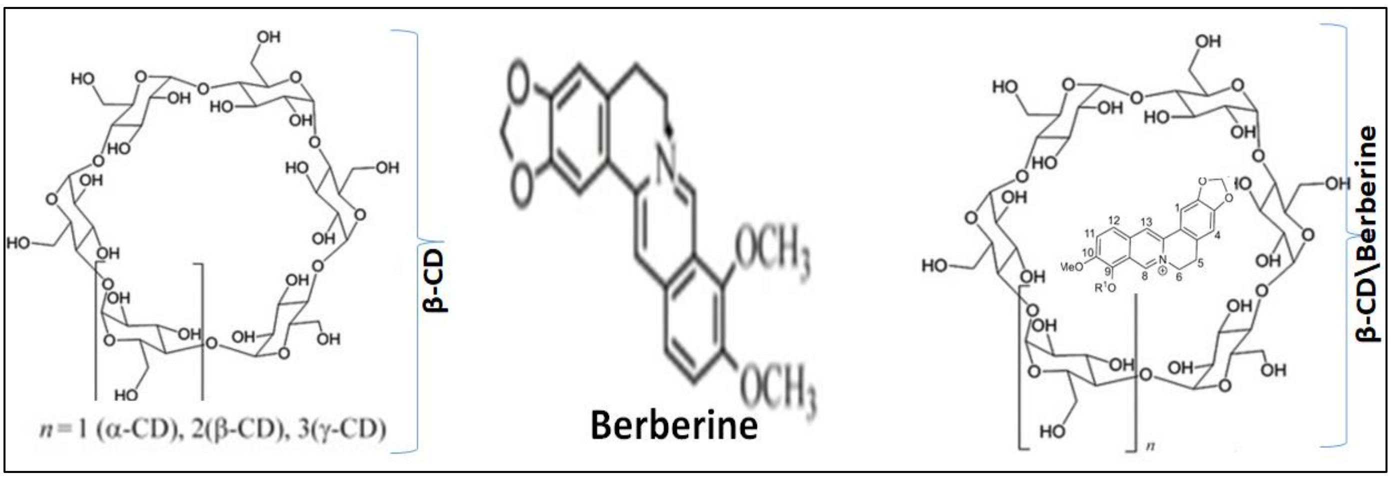

Fig 2 : The structures of three materials (β-CD) , (Berberine), and (β-CD/Berberine).

B. Aunps/Indanedione

Gold as a physical developer [9] was used with a ten-carbon alkylthiol chain and the basic principle of a bi-functional reagent containing (1,2-indanedione), forming new abilities with fast activity that were clearly visible. The synthesized nanomaterial was tested as developer for LFP as well as elucidating the underlying mechanism between the functionalized AuNPs and FPs residues on various types of paper substrates. In figure 3, the results show that 1,2-indanedione as a bi-functional reagent succeeded in designing a series of novel bi-functional reagents that were modified by 5- steps and displayed efficiency as compare to many ether chemical reagents.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24JUL1675

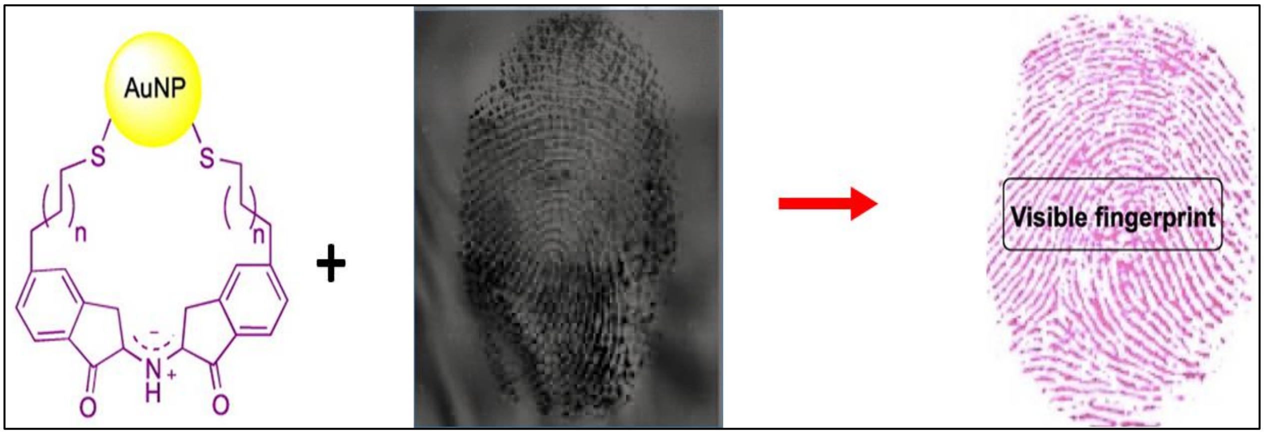

Fig 3: Skim for hybridization of AuNP/organic compound with fingerprint as developer

C. Phenyl Derivatives

Figure 4 refers to heterocyclic organic compound derivative from phenyl, pyridine and carbonitrile, which was prepped by Upendranath et al. [10] and confirmed using spectroscopic approaches and characterized with different techniques. In the theoretical analysis, compounds showed higher photo stability, reactivity with many reactive sites. The synthesized compounds were shown to be efficient materials for forensic science applications when used to develop the LFP by the powder dusting method. Level II and III features of LFPs are observed on porous or non-porous surfaces "without optical hindrance, and images were taken in normal and 365 nm of UV light".

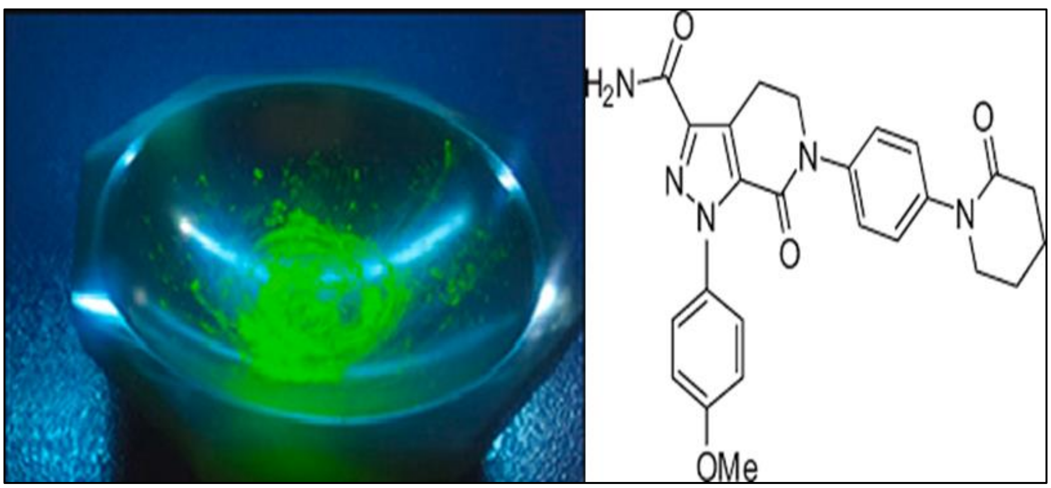

Fig 4: The photograph image and structure of 4-(4-substitutedphenyl)-6-(4-substitutedphenyl)-2-oxo-1,2-dihydropyridine-3-carbonitrile

D. Organosilicon

The attractive fluorescence, [11] environmental friendly, and stable structure make Carbon dots (CDs) desirable prospects for replacing classical fluorescent materials in the field of FPs powder. According to figure 5, CDs embedded in organosilicon OSi which refers by (CDs-OSi) composites were synthesized by utilizing 3-ureidopropyl $(OSi)_3$ and L-(−)-malic acid. The synthesized process depends on controlling the ratio of H2O: CH3OH in a solvo-thermal process to obtain CDs-OSi with tunable fluorescence from blue to green. The synthesized CDs-OSi composites exhibit uniform size from 0.12 µm to 5 µm. The CDs-OSi composites, which were applied to detect LFPs using different emission. Experimentally shown that the simple powder dusting method by CDs-OSi composites can be easily adsorbed onto FPs with high performance of detection for levels 2 and 3.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24JUL1675

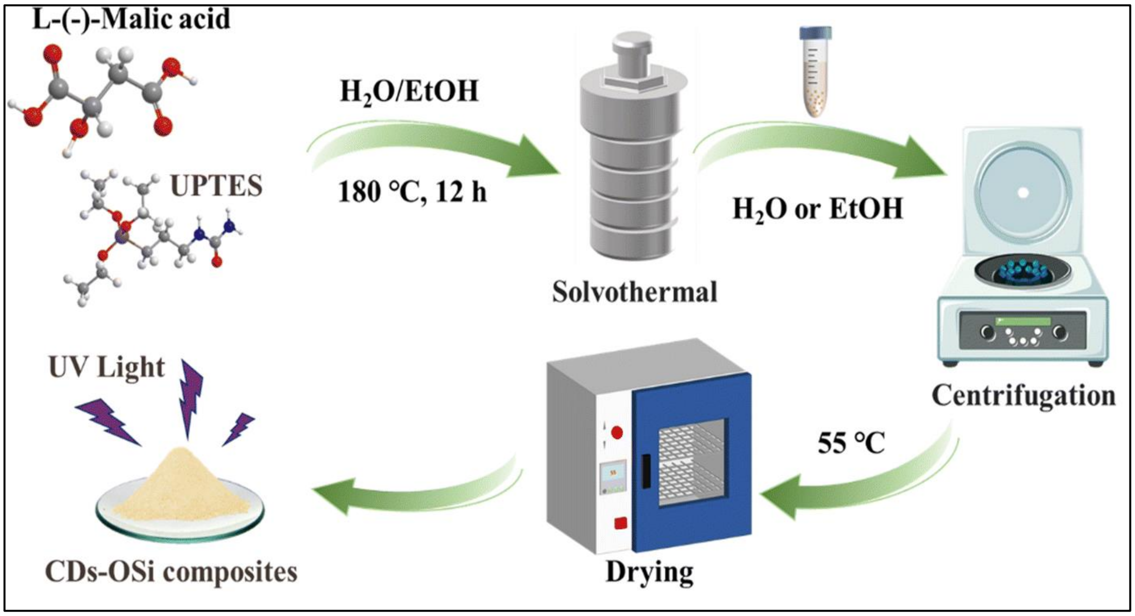

Fig 5: The Steps of Synthesized CD-OS Composites.

E. Carbon Dots Powder

Red emissive (CDs) powder [12] was synthesized by safe and convenient novel method from phloroglucinol and boric acid in solid-state. The advantage for these method was not requiring for high-pressure reactors or complicated post-treatment procedures. The as-prepared carbon dots powder exhibited strong fluorescence behavior in the red color and that was analyzed by XPS and PL spectra. To avoid the aggregation that causes induced fluorescence quenching CDs powder, the process required dispersing CDs into a large amount of inert substrates. As a result, as shown in figure 6, such CDs powder works well for a smaller amount of aggregations with higher efficiency for photoactive to the best LFPs identification on different material surfaces.

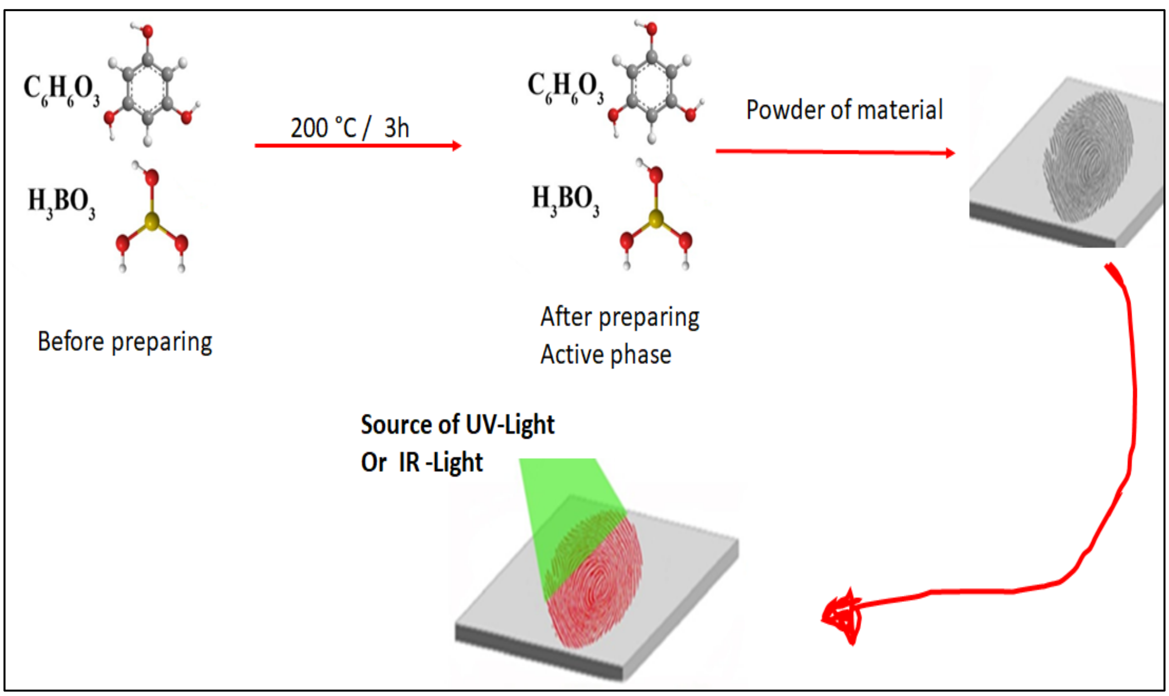

Fig 6: the steps of synthesized of carbon dote/active materials with UV-light and applications to developer fingerprint.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24JUL1675

F. Silica Nanoparticles

After identification of nanomaterials and understanding [13] the physio-chemical properties, their application in the detection of FPs has become a major focus for the forensic sector. This synthesized process of silica nanoparticles (Si NPs) was done by cost-effective green methods (oil-water mixed micro-emulsion templating approach) and used it for detecting a latent fingerprint on a non-porous surface. The synthesized Si NPs with sizes of 100–150 nm were tested on, plastic, soft plastic, glass, and steel, for the detection of FPs. Results show that synthesized mesoporous Si NPs were able to detect LFPs at 395 nm.

G. Coordination of Inorganic Material

LFP fluorescence (FL) visualizations [14] are enhanced when replaced with Eu(III) ions by direct doping Eu(TTA)3phen with SiO2 microspheres. Without coordination, the Eu3+ with microspheres SiO2 were defeat to identified Level 2,3 of FPs, while after modification the synthesized $Eu(TTA)_3phen\text{-}SiO_2$ microspheres, which can be recognized under 365 nm of UV-light irradiation up to Level 3. The explanations for the new behavior for synthesized $Eu(TTA)_3phen\text{-}SiO_2$ microspheres can be related to the coordination effect, which succeeded in increasing the asymmetry around Eu^{+3}. The increase in nature of structure causing the ultrasensitive transition from 5D0 towards 7F2, with increasing the FL intensity, and the uniform doping of SiO2 within the Eu^{+3} also reduced the surface FL quenching due to shielding from oxygen.

H. Magnetic Nanomaterials

The magnetic nanomaterials [15], which are the specific types and specific qualities in the identification of LFP, have become very important for forensic scientists.

Fe_3O_4-NP were first synthesized, then encapsulation of nano-Fe_3O_4 by the “facile coprecipitation” method (3-mercaptopropyl) triethoxysilane was covalently embedded. The Fe_3O_4-NP core was encapsulated by the Ag-NP to prepare novel magnetic nanomaterials (P-MNP@Ag) with the core-shell configuration. The synthesized nanocomposites were characterized by SEM, TEM, XRD, IR, XPS, and VSM. Compared with commercially available products Au-NP powder, Ag-NP powder, magnetic powder with bare properties, and prepared S-MNP@Ag, the modification/prepared effect of LFP on synthesized P-MNP@Ag had better performance. In figure 7, the new synthesized NMs were shown low background interference, high sensitivity, and clear secondary details in LFP.

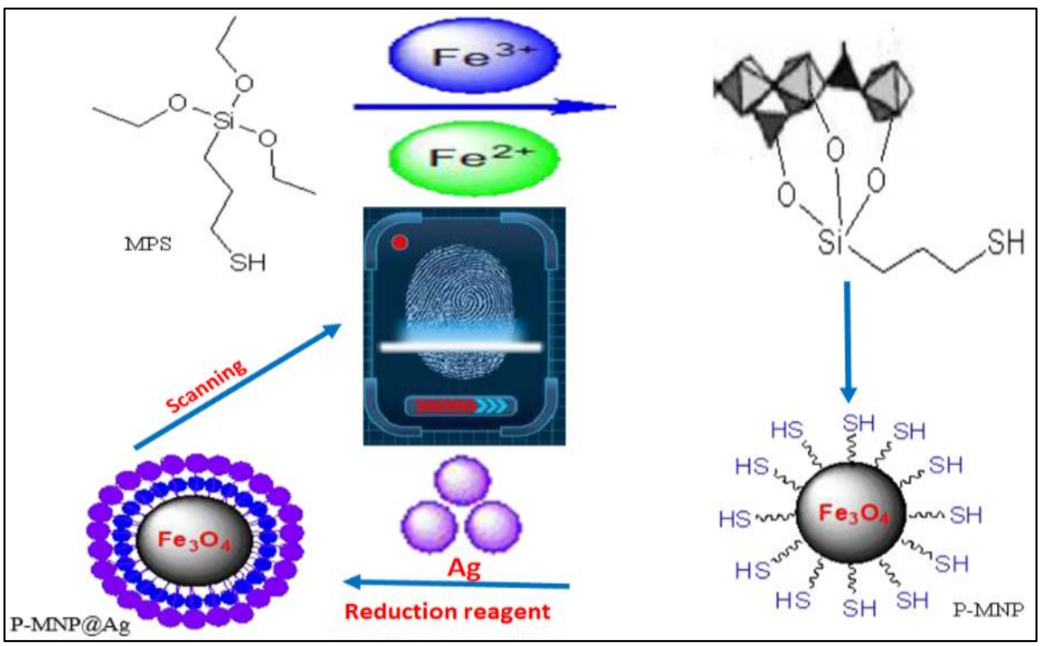

Fig 7: The steps of synthesized P-MNP@Ag for developer fingerprint

I. Fluorescent Molecular Rotor

A fluorescent molecular rotor, FMR, was [16] developed for facile in situ visualization of LFPs. FMR was synthesized in three steps and demonstrated a polarity-responsive emission as shown in figure 8. The optical properties of LFP are particularly able for the identification of LFPs to achieve a selective and sensitive turn-on response upon adhering to lipid components of FPs, and these effects are even increased in aged (when left print finger for many days) fingerprints.

The synthesized FMR could be applied to various surfaces, such as glass, coins, and ceramics, and the developed FPs can be further processed by the taping method. The developed FPs succeeded in providing reliable information for personal identification shown when all details of three levels,

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24JUL1675

like ridge patterns, shapes, bifurcation, and sweat pore distributions, may be the most important characteristic for FMR can be related to the processing is routinely performed in crime labs, with the safety (not cytotoxic up to 50 mM), toxicity, and simplicity of the used procedures (can be dissolved in ethanol and sprayed). The most important thing for FMR was illumination by blue light to give clearly developed FPs with level 3.

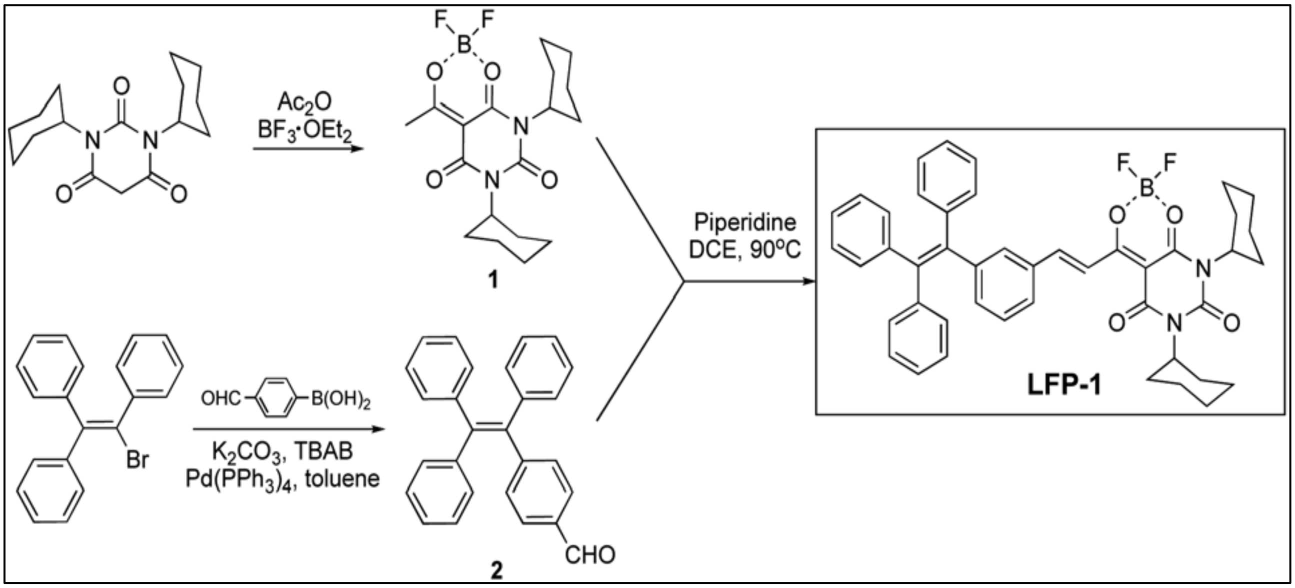

Fig 8: Skim for Synthesis of LFP-1. (FMR)

II. CONCLUSION

Forensic science is needed for many sciences to solve many cases or to achieve safety and security for civil society. fingerprint critical requirement, which needed for technicians to be able to appearance and identification in different conditions. The chemical compound was succeeded in reaching selectivity and sensitivity to identify fingerprints. The efficiency for characterized fingerprints as shown previously can be succeeded by using organic or inorganic materials at classic or nanolevels with many derivatives. Maybe the synthesized compounds succeeded in solving many fingerprints, but it is still needed for more research into the various types of identification. It can enhance the evidence role on trace fingerprint capabilities as a type of evidence in analyzing crime scenes.

REFERENCES

[1]. X. Si, J. Feng, J. Zhou, Y. Luo, Detection and rectification of distorted fingerprints, IEEE Trans. Pattern Anal. Mach. Intell. 37 (3), 555–568, 2015.

[2]. R. Wang, C. Han, T. Guo, A novel fingerprint classification method based on deep learning, in: 2016 23rd International Conference on Pattern Recognition, ICPR, IEEE, pp. 931–936, 2016.

[3]. Suwaidi, M.A. et al. . "Significance of Fingerprints in A Brutal Travel Bag Murder- A Case Report". Medico-Legal Update, 20(1) Institute of Medico-Legal Publications Private Limited, 2020.

[4]. Forensicsciencesimplified.Org,2022,http://www.forensicsciencesimplified.org/prints/Fingerprints.pdf.

[5]. K. Abdel and A. Ziad, "Analysis of Fingerprint Minutiae to Form Fingerprint Identifier". JOIV: International Journal on Informatics Visualization, 4(1). 10-15, 2020.

[6]. Q. Gao., "A Preliminary Study of Fake Fingerprints". International Journal of Computer Network and Information Security, 6(12) 1-8, 2014.

[7]. S. Lothar, and I. Klenke. "Improvement In Latent Fingerprint Detection on Thermal Paper Using a One-Step Ninhydrin Treatment with Polyvinylpyrrolidones (PVP)". Journal of Forensic Sciences, 55(4), 1076-1079, 2010.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24JUL1675

[8]. H. Zhou, W. Shi, J. Liu, et al. Enhanced developing property of latent fingerprint based on inclusion complex of β-cyclodextrin with natural berberine extracted from Coptis chinensis. Chem. Pap., 76, 4893–4905, 2022.
[9]. J. Lee, M. M. Joullié,'' Fine-tuning latent fingerprint detection on paper using 1,2-indanedione bi-functional reagents,''Tetrahedron, 71(40), 7620-7629, 2015.
[10]. K. Upendranath, T. Venkatesh, M. Vinuth,'' Development and visualization of level II, III features of latent fingerprints using some new 4-(4-substitutedphenyl)-6-(4-substitutedphenyl)-2-oxo-1,2-dihydropyridine-3-carbonitrile derivatives: Synthesis, characterization, optoelectronic and DFT studies,'' Journal of the Indian Chemical Society, Volume 99, Issue 3, 2022, 100388,.
[11]. X. Cao, J. Chen, Y. Chen, X. Jiang, W. Fan, H. Ma, Z. Sun and Y. Zhan,'' Simple synthesis of carbon dots/organosilicon composites with tunable solid-state emission and size for accurate latent fingerprint identification'' J. Mater. Chem. C, 12, 187-196, 2014.
[12]. X. Niu, T. Song, H. Xiong,'' Large scale synthesis of red emissive carbon dots powder by solid state reaction for fingerprint identification,'' Chinese Chemical Letters, 32(6),1953-1956, 2021.
[13]. K. Bhati, D. B. Tripathy, V. Kumaravel, H. P. K. Sudhani, S. Ali, R. Choudhary and S. Shukla,'' Sensitive Fingerprint Detection Using Biocompatible Mesoporous Silica Nanoparticle Coating on Non-Porous Surfaces'', Coatings,13(2), 268-277, 2023.
[14]. K. Zhang, M.-Jiao Zhu, Y.-Wen Zhou, X. Liu, F. Chen, Y.-Yang Zhou, W.-Fei Li, S. Liu, Y. Jiang, S.-Qing Liu,"coordination effect enhanced visualization of latent fingerprint with Eu (TTA)3phen-SiO2 microspheres". Analytica Chimica Acta, 1279, 341774, 2023,
[15]. J. Wan, L. Chen, W. Li, S. Cui, and B. Yuan,'' Preparation of Novel Magnetic Nanomaterials Based on "Facile Coprecipitation" for Developing Latent Fingerprints (LFP) in Crime Scenes'', ACS Omega ,7 (2), 1712-1721, 2022.
[16]. N. E. Choi, E.-Ji Kim and J. Lee,'' A fluorescent molecular rotor for the in situ imaging of latent fingerprints,'' RSC Adv., 12, 33180, 2022.