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Nanocurcumin: A prominent tool for swift enhancement of latent finger-marks to aid the justice delivery system

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Abstract: *Forensic investigation is a vital tool in both criminal and civil proceesings. In both the cases identification of suspect, victim and culprit can be individualized based on forensic scientific techniques provide evidence. This article it is attempted to evaluate evidentary value of latent fingermarks on the basis of standards set by the judiciary and also suggest the tool for prominent detection of the same. The numerous methods have been successfully applied in the field of latent fingermarks detection on different surfaces. Driven by the need to detect latent fingermarks, this article demonstrates highly sensitive and cost-effective curcumin nanoparticles based finger marks detection with excellent ridge detail clarity on multicolored surfaces. This technique is shown to be most effective not only on porous surfaces such as paper, hard surfaces like wood but also on water-washed articles with remarkable sensitivity and expose the enhanced latent ridge details with good visual contrast on different surfaces within few seconds.*

Key Words: *Nanocurcumin; Forensic science; Fingerprints; Surfaces: Powdering method.*

1. INTRODUCTION:

1. Statutory Recognition Of Fingerprint Evidences

1.1 Indian Evidence Act, 1872

The identification of criminals through fingerprints was the first important breakthrough in the scientific investigation of crime. The importance of fingerprints due to its uniqueness, permanence, universality gave statutory recognition and the legislators held fingerprint evidence as a valid piece of evidence. The Indian Evidence Act, 1872 contains provisions wherein fingerprints are considered as a valid piece of evidence. Section 45 of the Indian Evidence Act says that when the court has to form an opinion on a point of law which includes foreign law, science or art, handwriting, finger impression, the opinion of persons skilled in that particular area will be accepted. Originally the term finger impression was not included in the section. The Amendment Act of 1895, added the phrase finger impression. This was the result of the decision of the Calcutta High Court in R. v. Fakir", wherein it was held that the comparison of thumb impressions must be made by the court itself and that the opinion of an expert was not admissible under Section 45 of Indian Evidence Act. So this section says that an expert in fingerprint science can be called by the court to form an opinion.

Another section that included the scope of finger impression is Section 73 of the Indian Evidence Act, 1872. The phrase finger impressions were also added to this section by the Amendment Act of 1899. The section contains two parts. The first part of the section provides for the comparison of signature, writing or finger impression purporting to have been written or made by a person with others admitted or proved to the satisfaction of the court to have been written or made by the same person. Even though the section does not specifically say by whom comparison has to be made, by reading Sections 45 and 73, it can be said the comparison is to be done by an expert. The second part of the section empowers the court to direct any person present in the court to give his specimen writing or finger impression for the purpose of enabling the court to compare it with others alleged to have been written or made by him. Section 73 can be said to be an enabling provision under which the court may direct any person present in court to give a finger impression. While reading Section 73 in the light of Section 45 of Indian Evidence Act, 1872 it is clear that the court can direct an accused appearing before it to give his finger impression to be compared by the fingerprint expert chosen or approved by the court.

1.2. Code of Criminal Procedure, 1973

Section 293 of "Criminal Procedure Code" provides that any document purporting to be a report under the hand of a government scientific expert for examination or analysis and report in the causes of any proceedings under this code may be useful as evidence in any inquiry, trial or other proceedings. The report of the Director of the Fingerprint Bureau, which shows that his opinion, based on his observations and which leads to a conclusion is accepted as evidence. If there is any doubt arising from the report the court can always summon the persons who have made the report. This section has included the report of the Director of the Fingerprint Bureau for increasing the importance and also giving statutory recognition to the fingerprint evidence."

2. Techno-Legal Assessment :

In a forensic investigation, finger-marks recognition is vital and extremely important as no two prints are identical. To establish contact and generalize the proof of identity, it is essential to develop the impressions left by the ridge deposits present on the grasping surfaces of the hands in the criminal investigation [1]. Latent finger-marks are produced due to contact residues resulting from skin secretion (glands-eccrine, apocrine), which are invisible by naked eye and therefore, require development techniques by the aid of chemical or physical treatment to visualised the finger marks [2-6] depending on the surface on which the fingermark lies (porous, semi-porous or non-porous), the composition of the secretions, the age of the fingermark, if the surface has been wet or dry. Significant effort has been made towards the development of nano techniques and small particle reagent (i.e. charcoal powder, molybdenum disulfide) for the enhancement of latent fingermarks. An advantage of nanotechnology is often a vast increase in the ratio of surface area to volume. The article shows the utilization of eco-friendly developed techniques to image the fingermark that can establish the identity of an individual within a few seconds and can substitute for current techniques. This is essential for trace detection at the scene of the crime. The sweat deposits components such as fatty acids, organic matter, vitamins, urea, etc. play an imperative role in the establishment of technique. This helps to study the concerned properties which can yield innovative techniques for the enhancement of evidence. Fatty acids are water-insoluble and hence promising results can be achieved even from articles recovered from water resources.

In forensic investigations, rapid analysis and identification are essential [7,8]**.** Certain distinct properties of gold nanoparticles have been taken into consideration for the past several years for visualization and imaging of latent fingermarks[9-12].In addition, certain dyes like methylene blue and metal nanoparticles are an attractive option for fingerprinting as these are analogous to fingerprint powder – an enhancer that is currently used for the visualization of fingermarks in forensic investigations [13-16]. The involvement of costly chemicals like gold, silver and zinc metals raises cost-effectiveness. An attempt is signified by curcumin nanoparticles which are an affordable, safe and efficient agent for enhancement of latent fingermarks which is executed by the preparation of curcumin nanoparticles from turmeric extraction. Further, the nano form of curcumin is prepared by ball milling technique [17]. As a result, when it applied on fingermarks distinctly appear as yellow and fluorescence prints and revealed clear ridge details with visual contrast on multiple surfaces.

2. MATERIALS:

2.1 Materials:

Acetonitrile, dichloromethane used for the preparation of nanoparticles was of analytical grade. Curcumin and solvents were purchased from Sigma-Aldrich Company. Thin-layer chromatography (TLC) analysis was performed on silica gel 60F254 (Merck, Germany) coated on an alumina sheet, and 1% methanol in chloroform was used as the developing solvent.

2.2 Preparation of Curcumin Nanoparticles:

Curcumin (100 mg, 0.13 mM) was taken in dichloromethane (20 mL), and 1 mL of this solution was sprayed into boiling water (50 mL) dropwise with a flow rate of 0.5 mL/min in 10 min under ultrasonic conditions, with an ultrasonic power of 100 W and a frequency of 30 kHz. After sonication for 10 min, the contents were stirred at 200-800 rpm at room temperature for about 20 min when a clear orange-colored solution was obtained. The solution was concentrated under reduced pressure at 50^0 C to get an orange powder. The selection of the solvent was critical because spraying of curcumin solution prepared in other organic solvents, such as methanol or acetone, resulted in particle aggregation and nanoparticles could not be isolated. Further, maintaining the drop flow was important for both the formation of nanoparticles and uniformity in their size. It was seen that the addition of the whole curcumin solution to water in one lot led to particle aggregation. The curcumin structure is characterized by FT-IR spectroscopy in which FT-IR spectrum shows frequency of aromatic –(OH)3354 $cm^{-1,}$ (-C=O)1675 cm^{-1}

2.3 Particle size analysis:

The mean particle diameter of curcumin nanoparticles was measured by dynamic light scattering (DLS) performed on the Malvern Zetasizer S90 series. The sample was prepared by taking 1 mg of the nanocurcumin powder in 10 mL of methanol. Transmission electron micrograph (TEM) analysis was performed on a Morgagni 268 D from FEI. The sample was prepared by placing a drop of the aqueous dispersion of curcumin nanoparticles on the copper grid and allowing it to air dry. A scanning electron micrograph (SEM) of the aqueous dispersion was recorded on a Jeol JSM

840 microscope by spreading the nanoparticles dispersion over a carbon tape and drying it under a nitrogen stream. The sample was then coated in a sputter coater (EMITECH K 550x) with a gold layer in a vacuum condition.

3. RESULT & DISCUSSION:

Finger marks are not absolutely reproducible and so it is important to establish a system of assessing the quality of developed finger marks that take into account their variable nature [19,20]. Variability in the quality of developed fingermarks can arise due to different skin secretion compositions, the presence of contaminants on the hands and variation in the pressure applied when leaving the deposit. The development of fingerprint by powder method is a commonly used technique for the detection of fingerprints on non-porous surfaces at the scene of the crime. Powdering is the simplest, inexpensive method and satisfactory results may be achieved with proper training. But the drawback of the powder dusting method is that they are carcinogenic and their particle size differs. So an attempt is made to overcome these problems as small & fine particles adhere more easily than large coarse ones. The curcumin nanoparticles interact with the fatty acids and organic matter present in finger marks. Further, that leads to the sharp adherence to the latent fingermark ridges and achieve the high stability that can also be stored at room temperature for instant use.

3.1 Characterization and particle size analysis: The curcumin nanoparticles have been studied by UV –visible spectroscopy which shows absorbance at 429 nm (Fig.1A). The particle size analysis and distribution of the nanoparticles were performed by DLS, TEM, and SEM, and analysis. DLS of an aqueous dispersion of nanocurcumin revealed the formation of nanoparticles with an average hydrodynamic diameter of ~110 nm (Fig. 1B). TEM of the aqueous dispersion showed the particle size to be in the range of ~80 nm (Fig. 1C), and SEM of the powdered sample showed the particles to be approximate ~110 nm (Fig. 1D). Dry, powder of nanocurcumin was found to have good physical and chemical stability and could be stored at room temperature for over 6 months without any decomposition or aggregation.

3.2 Fingerprint enhancement on hard and water washed surfaces: This technique constitutes a great advantage on various porous, hard and soft surfaces including the articles which are washed inside or treated with water. Fatty acids are water-insoluble and hence promising results can be achieved even from articles recovered from water resources.

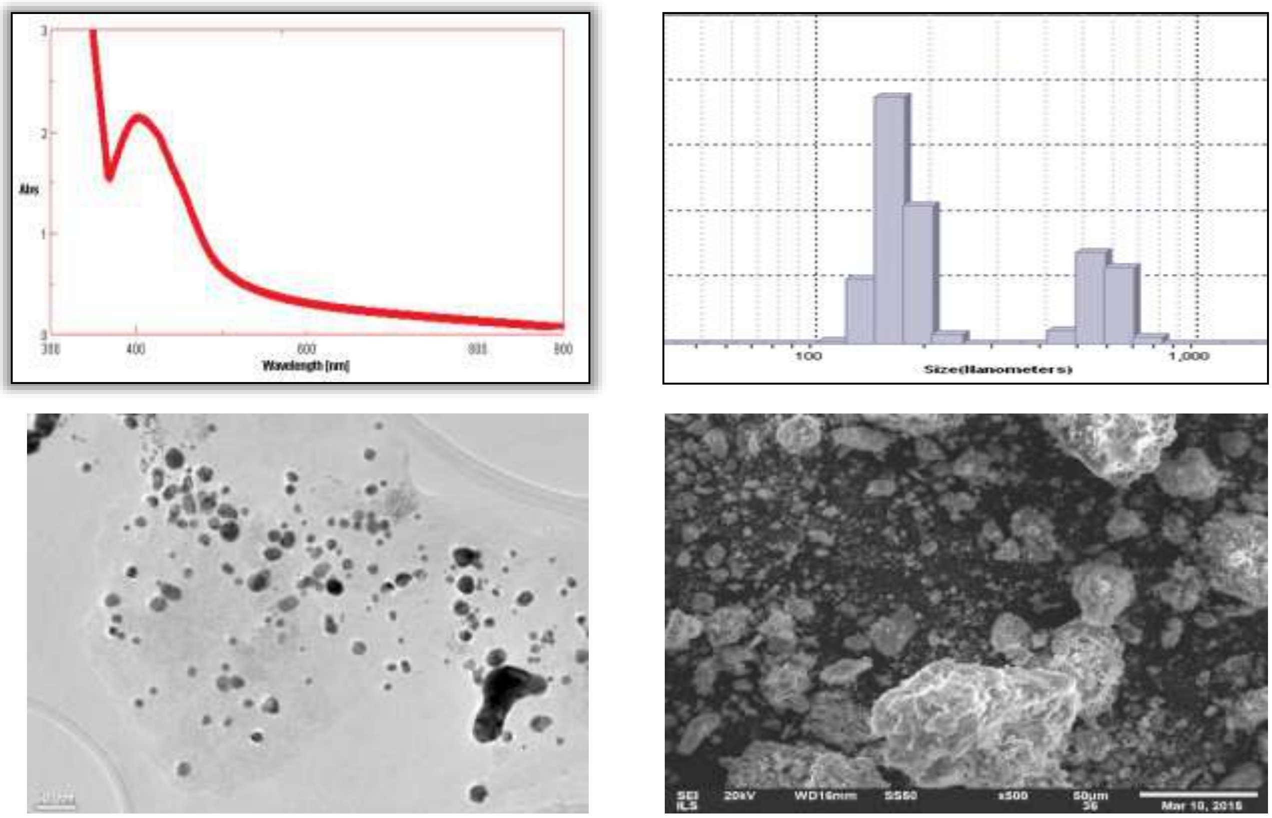

Fig.1 (A) UV-visible spectra obtained from the solution of 0.13 mM curcumin nanoparticles **(B)** Dynamic light scattering(DLS) measurement of curcumin nanoparticles illustrate that the nanoparticles have an average hydrodynamic diameter of ~ 120 nm; Size characterization of curcumin nanoparticles: (C)TEM image, and (D) SEM Image

For precise studies, large numbers of volunteers were asked to provide the fingerprint on different surfaces. The single donor was asked to donate the latent finger-marks at a regular interval of 5 h period for the replicate impression. The donor was instructed not to wash their hands before collecting the impressions or to "charge" by rubbing their fingers on their faces or hair. The donors were asked to rub hands together prior to the deposition of latent marks and then allowed to touch on the surfaces lightly. Samples were treated with the developed assembly for 1 to 20 days to check the accuracy. This procedure is schematically depicted in [Fig. 2]

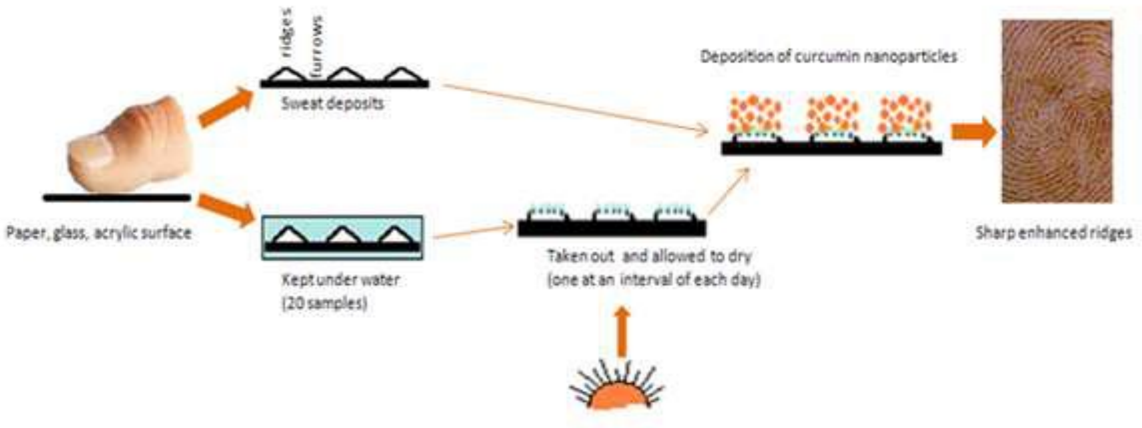

Fig. 2 Schematic diagram showing enhancement of latent fingermarks on sweat deposited articles and water washed articles by curcumin nanoparticles

The optimization studies of porous surface fingermark, the dry curcumin nanoparticles were poured slightly onto the surface of the paper document (sample) in a very small quantity towards one end of the paper. The document was carefully lifted from one side and rolled towards the other. The rolling of the document will allow the powder to spread equally on the whole surface. The fine particles of curcumin will adhere to the sweat secretion components of fingermarks. The evaluation of influence shows the adherence which evidently enhances the finger ridges. The application can be revealed on the hard surfaces by the method, curcumin nanoparticles are dissolved in volatile solvents such as acetonitrile. Articles seized with latent fingermarks are dipped into the acetonitrile solution and kept until complete evaporation of solution takes place. These results the particles to adhere to sweat secret of latent fingermarks enhancement. Despite this, it develops remarkable and apparent yellow fluorescence pattern contrast with background surface [Fig. 3].

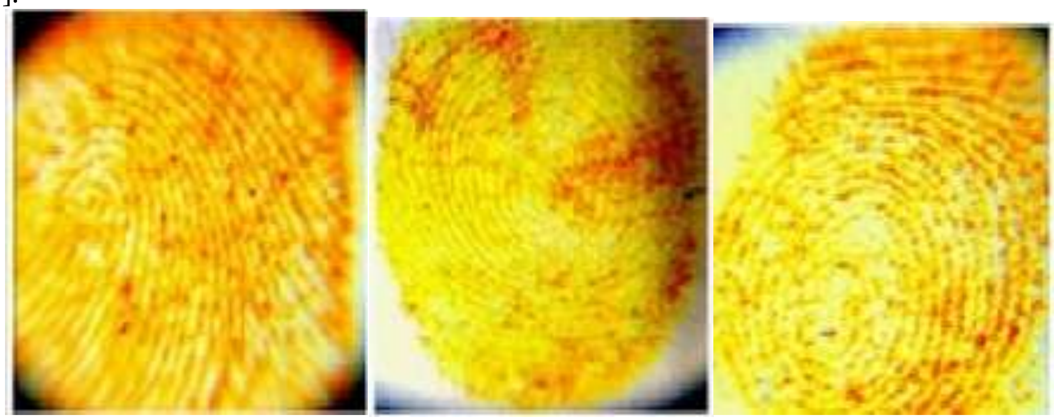

Fig. 3 Photographic images of latent fingermarks from a donor, developed on paper and wood surfaces by curcumin nanoparticles

To investigate the selection of other studies, finger marks were routinely developed by the surface of water washed articles. In this process, 20 samples of fingerprints were prepared on acrylic slides of different color and all 20 samples were kept underwater in a glass trough. The articles (sample) were taken out from the water, one sample each per day and allowed to air dry. For the enhancement of latent fingermarks, fine strokes were made using Camlin feather brush with a small amount of curcumin nanoparticles rubbing slowly on to the surface. The area in fingermarks left will produce sharp ridge details (Fig.4).

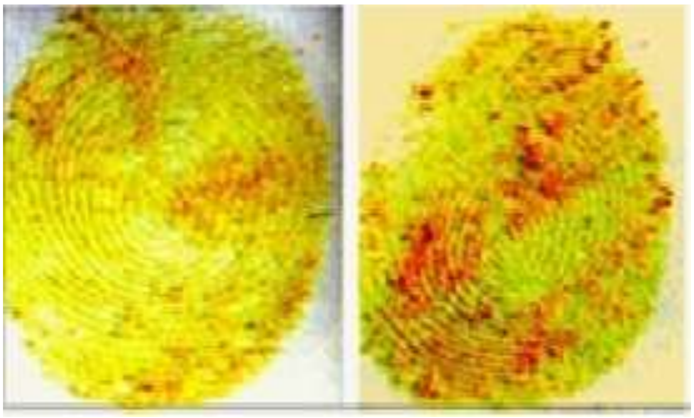

Fig.4 Photographic images of latent fingermarks from a donor, developed on water washed articles by curcumin nanoparticles

3.3 Efficacy of nanocurcumin:

In order to investigate the efficiency, we also studied the adherence of turmeric powder on different surfaces to develop finger marks. Interestingly, we found that the turmeric powder shows poor enhancement of finger impression ridges because of uneven particle size as also the moisture content in turmeric powder is very high which does not allow the particles to adhere freely(Fig.5).

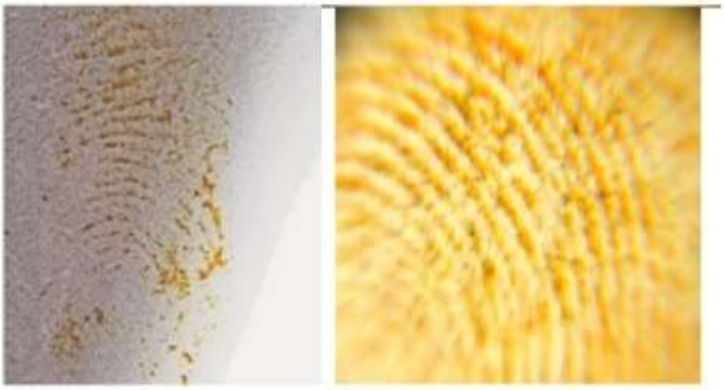

Fig. 5 Latent finger impression developed with (A) turmeric powder (B) curcumin nanoparticles

3.4 Comparative study of a dry and wet method to other methods:

A trial was used to compare the performance of dry and wet contact methods with existing techniques. For a different paper sample, different colored powders, luminescent and magnetic powders are used to develop the latent fingermarks. Both dry curcumin nanoparticles and powdering methods develop the prints but different types of powders are chosen for different colored and textured surfaces. However, the fine nanoparticles adhere more rigidly to the oily as well as dry surface marks whereas coarse, uneven, crystalline or amorphous powders do not yield good results [Fig.6A.B, C].

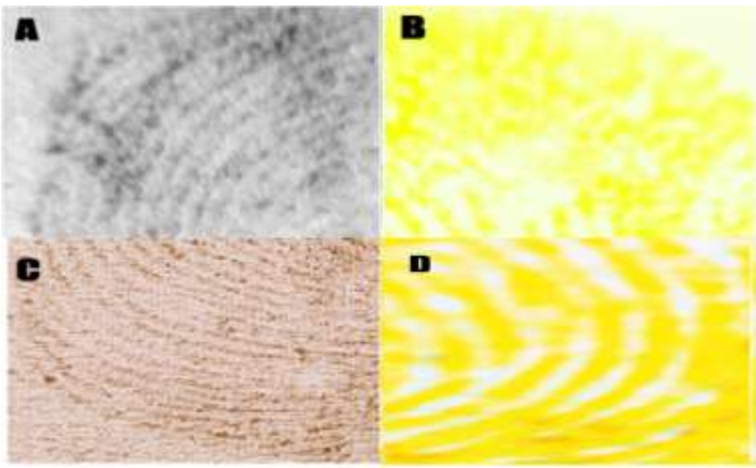

Fig. 6 Photographic images of latent fingermarks from a donor, deposited by (A) magnetic powder (B) luminance powder (C) colored powder and(D) curcumin nanoparticles

For hard surfaces like wood, leather, etc. get soften when curcumin nanoparticles dissolve in acetonitrile is poured on a hard surface in which the particles can easily adhere to the sweat secretions found in latent finger impressions (Fig 6D). Also, the particles lie the fluorescence effect on different colored surfaces which is visible under UV light, whereas other solutions are water-soluble which destroys the pattern of fingermarks. In water washed articles fatty substances and several organic components still remain in the pattern of finger-marks even after they are washed into the water, the free alcohol and acid group present in curcumin structure will bind with the fatty substances of finger-marks and resultant ridges are seen.

4. SUMMARY:

In the first phase, the forensic identification serves a critical evaluation at multiple instances for the determination of uniqueness. The examination is based on facts and therefore there is a need that it must be guarded by prominent scientific tools. In summary, for the first time, over curcumin nanoparticles are used as an alternative tool for the rapid detection of latent fingermarks which suggests the importance of this technique is not restricted to certain fields but it has a vast application and is sufficiently mature for routine implementation in various fields. The turmeric nanoparticles could detect finger marks in a short period of time and on different types of surfaces which is very accommodating while dealing with the physical evidence and generalized proof of identity despite the recent and expensive growth of DNA to authenticate in a court of law.

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