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REVIEW ARTICLE

Role of Nanotechnology in Techniques in Fingerprints Enhancement

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ABSTRACT

Fingerprints have been utilized in criminal and judicial investigations for establishing the identity of the accused/suspects for a long time. Fingerprints are an effective tool for determining who committed a crime. Nonetheless, easily detectable or visible marks are infrequently found at a crime scene; most of the time, they are latent, requiring the use of special methods to identify them. Fingerprint comparison should be cost effective and time bound to quickly obtain results with quality assurance. In this case, nanotechnology and its continued development have resulted in a range of applications in forensic science. Nano particles have been proposed as a solution for fingerprint detection and enhancement due to their versatility and smaller particle size. Because nanoparticles do not alter the composition of evidence, they can easily aid in the detection of high-resolution prints, and these evidences, unlike conventional techniques, can be re-used for any other chemical treatment. In most legal science research facilities, traditional methods such as black powder, fluorescent powder, and white powders are used. This review paper summarizes the various types of nanoparticle techniques that can be used for fingerprint identification and comparison, such as Camphoric-based Nano carbon, Acetylated cashew gum based silver nanoparticles and so on.

KEYWORDS | Nanoparticles, Fingerprint Analysis, Conventional techniques

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INTRODUCTION

Fingerprints have been for ages the most important evidence collected from a crime scene. They are extremely useful in connecting the three dots of every crime: victim, author or individual, and object or location.[1] As LPs are constituents of natural secretions secreted from friction ridges and contaminants present on a surface, crime scene investigators regularly deal with the development and extraction of latent fingerprints from a crime scene.

Powder methods, silver nitrate methods, and iodine fuming are the general methods used in the enhancement of latent fingerprints. The method of choice is determined not only by the nature of the fingerprint but also by the substrate or supporting matrix on which the print is present.[22] The powder technique is the most widely used strategy in fingerprint development. Its mechanism is based on the sweat and oil components that have settled in the print's ridges. Powder is deposited in the ridges, and the print appears as a result of pressure and electrostatic forces between the powder and the oily components.[18] These methods, however, have less sensitivity, toxicity and, above all, the low contrast. Thus, nanoparticles are used to resolve this problem.[10]

Ultrafine or minute particles between 1 to 100 nano meters in dimensions are defined as nanoparticles. These particles constitute nanotechnological components. Due to their smaller size, nanoparticles can be used in different industrial applications. In forensic science, their vital role and impact can be seen and this area is known as nano-forensics and is the most recent progress in forensic science. One of the major roles is seen in the development of fingerprints as they are very helpful in developing impressions of fingerprints regardless of their substrate.[26] Due to their smaller particles, they are incorporated into the ridge spacing of prints, and these particles are also non-reactive which is very useful in developing old-age finger marks. In recent years forensic researchers have developed different methods including nanoparticles, which have advantages such as high sensitivity, low toxicity, and high-contrast images, some of which are also cost-efficient.[5] As nanotechnology improves over time, new instruments have also been developed to keep pace with the progress. In the past years, nanotechnology has made a lot of advancements and these advancements need to be brought to notice so that forensic experts can use it to get results with more efficiency and accuracy. This review paper establishes a summary of different nanotechnology methods to develop and enhance fingerprints.

METHODS

As nanotechnology is still evolving, several techniques have been implemented to detect fingerprints. Each technique has distinct and significant advantages for detecting fingerprints, which are discussed below:

Acetylated cashew gum based silver nanoparticles

Cashew-gum is a gum secreted from the Anacardium occidentale L. tree, which is found in north eastern Brazil. This polymer provides steric hindrance to nanoparticles and occupies the surrounding surface due to charged particles that provide electrostatic repulsion. Cashew-gum separate is additionally blended in with silver nanoparticles to diminish the harmful and destructive nature of silver nanoparticles and further increasing the development power. Cashew gum diminishes the corrosive nature of AgNP (Silver Nanoparticles) as it synthetically comprises of β-D-galactose (72%), α-D-glucose (14%), arabinose (4.6%), rhamnose (3.2%), and glucuronic corrosive (4.7%).

A suspension of silver and cashew-gum was developed for the production of latent fingerprints, for which acylated cashew-gum was distilled and synthesized. It was further separated by different amounts (0.5, 1.0, 5.0 mg/mL) and blended separately for approximately 30 minutes with 1 mM AgNo3 solution. The solutions at low temperature were then mixed drop wise with a freshly prepared borohydride solution (NaBH4), a molar ratio of 1:10 silver. These were passed onto a falcon tube and left for 24 hours on the formulation of these solutions. They were centrifuged for 15 minutes at 3,600 R.P.M. Hence, forming acylated cashew gum silver nanoparticle suspension has been further analysed with Atomic Force Microscopy (AFM) and Transmission Electron Microscopy (TEM).

For the enhancement of latent fingerprints from the surface of the alkaline paper, it is submerged in the suspension of varying focuses (0.5. 1.0, 5.0 mg/mL) trailed by withdrawal and prompt perceptions. The withdrawal and submersion were permitted to be saved for 3 distinctive time spans (1hr, 2hr, 24hr). This technique developed yellow colour prints, therefore increasing the contrast and ridges were more defined and clearer as compared to traditional methods.

Hence, this technique is quick, easy, low-cost, and uses biodegradable chemicals, Due to its fast functioning and non-toxic nature it can also be used at crime scenes making fingerprint production fast and secure.[1,25]

Camphor bases enhancement

Impurified camphor tablets ($C_{10}H_{16}O$) were used in this technique, which were burned into carbon soot and collected in a petri dish. Carbon sooth can be differentiated on the basis amount of carbon and size of the particles.

Camphoric carbon powder was synthesized and used on absorbent and non-absorbent surfaces such as plastic files, book covers, paper, coffee cups, and so on. The prints were said to be provided by rubbing the donor's finger on the forehead in order for the sweat to collect. The powder dusting method was used to produce fingerprints on different surfaces, and excess powder was extracted with the aid of a fiberglass brush. For the evaluation of developed fingerprints automated fingerprint identification system was used and for the evaluation of carbon soot particles SEM and EDX was used.

The outcomes were uncovered by AFIS (Automated fingerprint identification system) in view of different surfaces, for example, 27 minutiae were formed on metal and plastic surfaces. Further in the identical conditions the carbon soot showed more enhaced images of minutiae by showing 33 on plastic file surfaces and 36 on metal surface.

This method untangled the fact that the camphoric-based powder produced better results than the conventional black powder. This powder is minimal expense and harmless to the ecosystem, and it tends to be utilized at a crime location. This method revealed characteristics of carbon soot such as water solubility, cytotoxicity, and biocompatibility.[2,15]

Red emitting CaTiO3: Pr3+ nanophosphors

In this technique Red emitting CaTiO3: Pr3+ nanoparticles with persistence timing of 20 minutes have been synthesized so as to produce or develop latent fingerprints. CaTiO3: Pr3+ was first synthesized further used in development of latent fingerprints through facile dusting powder method. These long after glow nanophosphors luminescence particles are great source of developing the prints as they have high quantum efficiency. Due to the purkinje effect and scotopic vision the human eyes are less sensitive to red color. Hence, making phosphorus strongly desirable in CaTIO3 compound. This compound reacts with the sweat present in the minutiae and provides high contrast red color latent fingerprints.

For the synthesis of CaTiO3, the sol-method was used, and Ca (NO3)2Pr(NO3)3.6H2O was homogeneously dissolved in iso-propyl alcohol for this experiment. The solution was vigorously stirred for 15 minutes before being combined with Titanium Tetra-iso-propoxide (Ti (OC3H7)4). A 1:10:4 ratio of Titanium isopropoxide: IPA: water was used to make the suspension. As a result of the exothermic reaction, a gel-like structure was formed, which was then placed on a hot plate to form powder. An additional annealing step is performed at temperatures ranging from 6000 to 10000 degrees Celsius.

SEM (Scanning electron microscope) was utilized to examine the surface geography, and surface highlights of CaTiO3 incorporated by sol-strategy. Since ordinary nano phosphor blend techniques produce huge molecule sizes going from 0.2 to 2 nm, sweat pores are filled and fingermark affectability is decreased. Tiny particle sizes formed fingermarks with level-3 characteristics such as sweat pores and minutiae, according to Scanning electron microscope findings.

The test was also performed on fingerprints from a 28-year-old man who was asked to give fingerprints by rubbing his finger on his forehead and pressing it on a required substrate. CaTio3: Pr3+ was finely ground in a motor-pestle after being annealed at various temperatures. The excess powder was blown off after it was dusted over the fingermarks with a soft squirrel brush. The fingermarks were then excited for about 15 minutes in a UV chamber. The findings revealed that when the substrate is auto-reflective, the level-2 and level-3 characteristics of fingermarks are not apparent. Otherwise, the fingermarks were more noticeable and had a higher contrast, exposing the ridges, minutiae, and sweat pores.

The benefit of this approach is that by exciting the prints in a UV-Chamber, the fingermarks can be seen at any time depending on the requirement. Phosphorus can also be preserved for longer periods of time due to its organic origin. Since they provide high contrast images with specified characteristics, these long after glow nanophosphors are the best alternative to conventional powder methods. 8,12,

Greener synthesis of Copper oxide nanoparticles

Copper oxide nanoparticles (CuO) is highly specific metal oxide that possess difference ment promoting features such as electrochemical activity , high specific area, redox potential and most importantly stability in the solutions. But, due to its corrosive nature it needed to be synthesized by sol method with an organic compound. So, in this experiment Green tea extract is used to coat the Cuo nanoparticles so, thaty It could form non-corrosive nature and eco-friendly.

In the initial phase Copper sulfate (CuSO4.5H2O) was used to form CuO without

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purification and a green tea from the market. For the preparation of green tea. 1 gm of it is mixed in distilled water (50 mL) in an Erlenmeyer flask. A yellow color solution was obtained after 20 min of stirring at 700c to 800c. The extracted solution is then stored at 40c in a refrigerator. In an ultrasonic bath 40 ML of CuSO4.5H2O is mixed with 20 ml green tea extract. The greenish-yellow color of the extract gets converted to brownish-black. Integrated CuO arrangement was centrifuged at 10,000 rpm and the supernatant was eliminated. The brownish-black crystals obtained from centrifugation were removed from the flask. Further, these crystals were crushed and converted to powder form.

The latent prints were established on various non-permeable surfaces like glass, white paper, margarine paper, and steel utilizing by powder dusting strategy. Green tea goes about as a balancing out, covering specialist and a decreasing specialist for CuO. Hence, for the characterization FE-SEM (Field Emission Scanning Electron Microscope) was used and it revealed the magnitude of nanopartilces from 500 to 900 nm and spherical in shape. The results were easily visible by naked eyes and the black color given by the crystals was defining the ridges, minutiae, and sweat pores.

This method for devlopement of latent fingerprints through CuOand green teas is eco-freindly, cost effective and majorily non- corrosive making it to use at crime scene. 4,11,17

Tetraethoxysilane (TEOS) and phenyltriethoxysilane (PTEOS) with silica gel

In a rotator tube, 30 ml ethanol, 5 ml deionized water, 2.5 ml each of tetraethoxysilane (TEOS) and phenyltriethoxysilane (PTEOS), and 2.5 ml each of tetraethoxysilane (TEOS) and 2.5 ml phenyltriethoxysilane (PTEOS) were joined. 2 mL ammonium hydroxide arrangement was applied to this, and the arrangement was turned for the time being. The suspension was centrifuged during this period (3 min at 3000 rpm). The main cycle included centrifugation and extraction of the fluid/fluid stage from water to dichloromethane, joined by dissipation of the natural stage to dryness. Subsequently grouping of wash methodology and centrifugation, the item was disengaged in the second workup measure.

The connected colour (25 mg) was broken down in the ethanol before the salinization reagents were added for the different colour doped particles. Prior to applying the salinization reagents, 25 mg of titanium dioxide was added to the rotator tube. A 1:100 weakening of the provided carbon dark arrangement in water was applied to the antecedent answer for carbon dark particles. Particulate magnetite was set up as indicated by distributed techniques for TEOS: PTEOS-covered attractive particles, and 5 ml of the suspension in water was applied to the antecedent arrangement again for 5 ml of TEOS: PTEOS-covered attractive particles.

New prints (roughly 20 minutes before tidying), just as matured prints (different conditions itemized inside), were examined. A 21-year-old lady and a 33-year-old man both Caucasians stored their fingerprints on unused non-permeable glass magnifying lens slides (VWR Int, Leicester, UK), which were utilized precisely as taught. The prints were applied in one of two different ways: the fingerprints were scoured on brow prior to pushing on a superficial level, or the fingers connected with the surfaces after the latex glove was eliminated. A falling pipette was used to apply a small amount of suspension to the print (500 ml of 10% (w/v) in 97:3 (v/v) water/ethanol). The excess suspension was gently washed away after 2–3 minutes with surplus water.

The print was then permitted to dry normally. The slide could likewise be lowered in the suspension for 5–10 minutes. By gravity, the abundance engineer was taken out, and the surface had the option to air dry as in the past. As tidying specialists, various sieving divisions were utilized. The fluorescent sifter sizes of 45–63 mm and toned particles and 63–90 mm for sub-atom embedded particles were the most straightforward to use and gave the best portrayal prints. Instances of prints made on glass slides with the fluorescent colour rhodamine 6. The fluorescent and colour doped particles would be advised to definitions when all is said in done, however the implanted particles actually furnished prints with great definitions. On a tempered steel sink top and a research centre benchtop, great outcomes were acquired, and the idea was practically identical to that seen with fluorescent modern powders and enhanced were visible with aluminium powder.5,23,28

Fluorescent Starch-based Carbon Nanoparticles

Malic corrosive and ammonium oxalate were utilized as crude materials in a one-pot pyrolysis course to make N co-doped carbon nanoparticles. The carbon-Nanoparticles of quantity wt1% were joined with characteristic starch to make a powder that fluorescent in dazzling blue in the dry strong state. These materials were joined with the uncommon benefits of the primary powder part's preeminent flowability and CNPs' remarkable photoluminescence.

The usage of nano-carbogenic powder as a novel UV fluorescent imprint for totally making whole fingerprints was the point of convergence of this research.

Conventional staining materials like iodine fume, industrially 502 cyanoacrylate stick fume, and TiO2 powder was utilized as controls to check the viability of fluorescent starch powder as fluorescence marks for the creation of inert fingerprints on the glass. Iodine fume, financially accessible 502 cyanoacrylate stick fume and TiO2 were discovered to be inadequate in creating dormant fingerprints on the glass side. The erosion edges of the fingerprints were hard to recognize from the foundation. fluorescent starch can be utilized as a successful powder for the advancement of inert fingerprints, with sharp edges, better goal, and less foundation obstruction, because of their improved solid blue iridescence. To analyse the affectability of the over four strategies, a progression of identifications on different substrates were performed. Iodine-fume, economically 502 cyanoacrylate stick fume, and Titanium oxide powder both have lower affectability than fluorescent starch powder.

The CNP-based nanocomposites had truly stable compound properties and tuneable photoluminescent results, and were effectively utilized as a novel fluorescent name for the creation of idle fingerprints on different substrates, demonstrating moderately all around created qualities for finger edge data and great differentiation for improved location. The investigation presents a novel technique for producing whole inactive fingerprints utilizing CNPs in the legal sciences.[6,3]

Silicon Oxide Nanoparticles

Silicon Oxide Nanoparticles are one of a couple of nanoparticles with the entirety of the attributes for inert finger-mark location and improvement. The reversed micro-emulsion method can be used to make SiO2 NPs with a uniform size distribution. During the combination of SiO2 NPs, profoundly brilliant colour atoms can likewise be typified in the centre. It has been demonstrated in the literature that SiO2-based NPs can be used to detect latent finger marks.

In this method Triton X-100 (TX-100), 1-hexanol, ammonium hydroxide (30%), tetraethyl orthosilicate (TEOS), tris(2,20-bipyridyl) dichlororuthe- nium(II) hexahydrate (RuBpy) and sodium chloride (NaCl) were used . With the exception of the NP precipitation, silver oxide nanoparticles were synthesized using the reversed micro-emulsion technique stated by Moret et al.19. Here's a quick rundown of the synthetic technique. In a round bottom flask, 3.54 mL TX-100, 15 mL cyclohexane, and 3.6 mL 1-hexanol were inserted, followed by 960 mL RuBpy (16.6 mM), 200 mL TEOS, and 120 mL ammonium hydroxide (30 percent). For surface functionalization, 100 mL of TEOS and 100 mL of CES were mixed to the response combination following 24 hours of constant attractive blending.

For another 24 hours, the mixture was stirred. To start the precipitation of the NPs, the miniature emulsion blend was moved to a hawk axis cylinder and 20 mL of acetone was applied to it. The nanoparticles were secluded by centrifugation at 2500 RPM for 3 minutes, followed by decantation of the acetone. The isolated NPs were then treated with 15 mL of acetone. The nanoparticles were shaken in a falcon rotator tube with a vortex blender, and at that point centrifuged at 2500 RPM for 3 minutes until the acetone was tapped. Finally, RuBpy-doped CES-SiO2 NPs (0.1 g) were collected and dispersed in 20 mL RO/DI water.

Now the collected nanoparticles were used on the finger-marks obtained from different individuals. The finger-mark specimens were divided into two halves. All the finger-marks were treated with SiO2 and depending upon the age of finger marks (3 months old and 7 days old) were divided into different batches. Total 288 finger-marks were taken into account and analysed.

Though the bunch-to-group change from the examination study was noticed, assessment of the viability of the location of finger signs by changed identification boundaries would not be

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influenced, as all fingerprints were handled and assessed in the significant half-finger marks. There were noticeable differences between the three donors from the results collected. However, there were improvements in the detection efficiency of three donors with regard to changed detection parameter. [17,3]

DISCUSSION

Technology in forensic science is improving day by day. And nanotechnology has played a major role in the field of fingerprints as they are enhancing the production. Some of the nanotechnology techniques are cost-effective as well as eco-friendly. For example, in red-emitting CaTiO3: Pr3+ nano phosphoric technique, the marks produced from this method can be maintained for longer periods of time. Because of their promising benefits and consistency of performance, nanoparticles have surpassed traditional methods.

CONCLUSION

Nanotechnology helps forensic science in two respects. Since it can identify and analyze samples at the nanoscale, vital information that could not previously be obtained and examined due to limitation of instruments can now be analyzed and used to support investigations. Due to its various advantages, nanotechnology has also became a branch of forensic science known as nanoforensic. This review summarizes how nanoparticles have created new advancements and branches in the field of forensic science. IJFMP

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