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Original Article

Nano-Fingerprinting: A New Future Prospective for Developing Latent Fingerprints

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ABSTRACT

Early latent fingerprint detection techniques included silver nitrate, ninhydrin, cyanoacrylate and iodine fuming which were less effective in developing fingerprints in robust condition as well as less stable for prolong period of time. With the upcoming advancements nanoparticles are now used for fingerprinting because of their great properties of surface area and optical properties. The quality of fingerprint development is found much better using nanoparticles. Therefore, this article summaries the broad application of different nanoparticles in the development and identification of latent fingerprints on various surfaces. Currently gold, silica and zinc oxide nano-particles have captivated the fingerprinting technology with their finest properties.

Keywords: Latent fingerprints, Nano-particles, Nano-properties, Surface

INTRODUCTION

At any crime scene, the utmost physical evidence found are latent fingerprint, since they are abundant and have durability for a longer period of time as they are transferred to any surface through bodily secretion and contaminants from the environment. From many years latent fingerprints has been developed by various techniques such as silver nitrate, ninhydrin, cyanoacrylate and iodine fuming, but when it comes to fingerprint effectiveness and stability these methods fails to avail fingerprint developing method as they are less effective in developing aged fingerprints as well as has less stability and fades away over time. To overcome such problems of older techniques, nanotechnology has been introduced to better identify the fingerprint development by their amazing properties like surface area and optical properties. Larger surface area provides more area for developing fingerprint left on any surface and optical properties can help in visualisation of fingerprints even at room temperature.

In the current scenario of forensic fingerprinting, the use of nanoparticles has shown a great impact in the area of latent fingerprint development in enhancing visibility of fingerprint on various surfaces. Such nano-materials and their application in development of latent fingerprints have been schematised in Figure 1.

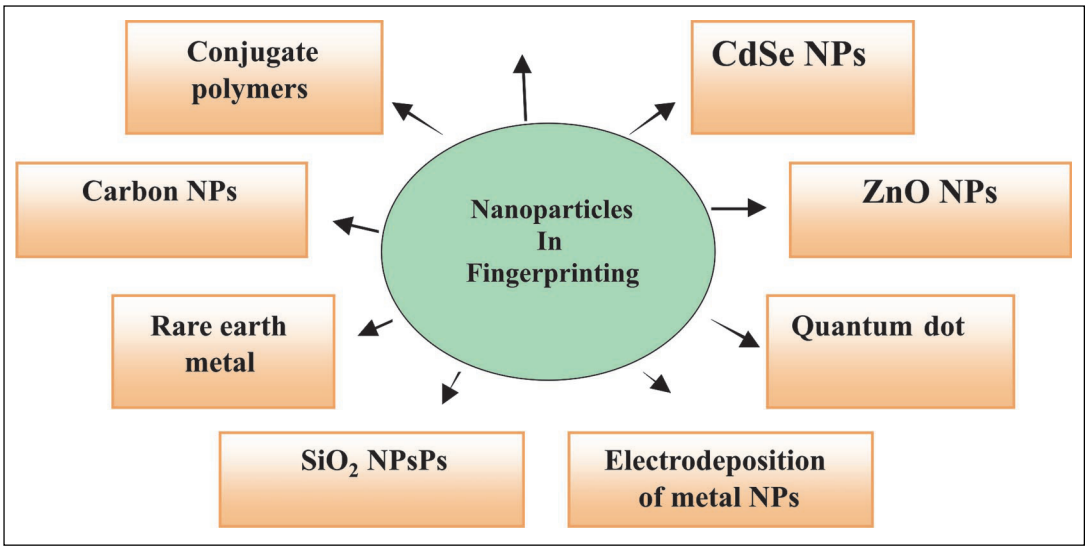

Figure 1: Application of Nano-particles in Forensic Fingerprinting

APPLICATION OF NANOPARTICLES IN THE FIELD OF FORENSIC LATENT FINGER PRINTING

Application of different nanoparticles in the area of forensic latent fingerprint development and detection has been discussed under the following section:

Gold Nanoparticles

Gold nanoparticles (Au NPs) act as a strong template whereon variety of molecular hosts can bind spontaneously. In addition to this, gold can also act as a powerful reactant which can bind metallic surfaces too due their relative chemical inertness and resistance to oxidation. As per literature survey, the gold nanoparticles are functionalised with thiolated cyclodextrin, followed by the addition of dye which was used to trap the cavities of cyclodextrin. The final solution was used for developing latent fingerprints; it was observed that the technique was very competent in developing fingerprints on various porous and non-porous surfaces.[1]

The same research work with gold nanoparticles has been reported in year 2007, where gold nanoparticles is functionalised with anti- cotinine antibodies in order to identify metabolites present in fingerprint which showed individual identity by fingerprints and even helped in reducing the time spend on testing drug.[2] Other researcher have also reported that the gold nanoparticles can be used as a one step single metal nanoparticles deposition in a wide pH range. It produces fingerprints with sharp and clear visibility on non-porous surfaces like glass, metal etc. [3] Gold nanoparticles are attached with a bi-functional reagent (Tetrabutylammonium bromide) followed by silver physical developer [involves an oxidation-reduction couple where an iron salt reduces an aqueous solution of silver nitrate to metallic silver] for the development of latent fingerprints. This technique also produces good contrast fingerprints on porous surfaces like paper.[4]

Zinc Oxide Nanoparticles

ZnO nano-particles (ZnO NPs) have a large value of wide band gap about 3.37eV as well as high excitation binding energy (60 MeV) which allows its transition even at room temperature[5,6] hence it has been used as fingerprint developing powder. As per literature survey, a combination of ZnO with SiO_2 metal oxide nanopowder was used for the development of latent fingerprints, which showed clear and sharp images with two digit details on various non-porous surfaces.[5] Other researchers have also reported that nanostructured zinc oxide produces a good fluorescent image of fingerprint under long-wave UV light[7].

Recently, a study has been done by Punjabi University, Patiala, India and National Institute of Technology (NIT),

Hamirpur, Himachal Pradesh, India, where zinc oxide nanopowder and tin oxide nanopowder were compared for developing latent fingerprints, it was obtained that ZnO nanopowder was the better metal oxide for developing latent fingerprints on non-porous surfaces then tin oxide nanopowder.[8]

Silica Nanoparticles

Amphiphilic silica nanoparticles (SiO_2 NPs) have been employed for developing latent fingerprint. Amphiphilic silica is the nanoparticles which has hydrophilic and hydrophobic properties in a single compound. For developing latent fingerprint amphiphilic silica nanoparticles were synthesised using 4-(chloromethyl) phenyltrichlorosilane. It was obtained that the technique has affinity towards amino acids of fingerprint residue due to its amphiphilic nature which result in development of good fingerprint on non-porous surface.[9] Other researchers have reported that due to their ease of synthesis as well as its coating ability to dyes which prevents photo-decomposition, silica nanoparticles has been functionalised with dye-doped particles to detect latent fingerprints on nonporous surface.[10] In a recent study it has been reported that silica nanoparticles were used as an imaging agent for detecting fingerprints. Silica nanoparticles were incorporated in fluorescein isothiocyanate dye. In addition to it was conjugated with 3-aminopropyl triethoxysilane (APTES) to the silica matrix in the presence of an adhesive agent polyvinylpyrrolidone (PVP). It was obtained that the technique is efficient in developing latent fingerprints on non-porous surfaces.[11]

CdSe Nanoparticles

CdSe nanoparticles (CdSe NPs) have unique optical property which has drawn attention in various field of science. In Forensic Science it has shown a greater impact in the area of latent fingerprint development method. According to review, CdSe NPs suspension has been used for developing latent fingerprints on adhesive tape surface. It was observed that due to its optical property, fingerprints fluorescence under wavelength range of 380 nm with a good quality of fingerprint image.[12]

Quantum Dots

QDs has been known for developing latent fingerprints due their magnificent fluorescence properties[13] under that category CdTe a semiconductor quantum dots which are broadly used in biological fields has shown a remarkable advancement in forensic fingerprinting as a fluorescent agent. As per literature survey, a combination of CdTe QDs with SiO_2 nanoparticles have been used as a fluorescent labeling marks for identifying latent fingerprints. Surface stability of CdTe QDs was improved by encapsulating SiO_2 a non-toxic nano-material. A core-shell structure was formed of CdTe@SiO_2 quantum dots. The combination of CdTe@ SiO_2 powder was applied on non-porous surface. The fingerprints developed showed good ridge detail on non-porous surface with less background interference.[14]

Electrodeposition of Metal Nanoparticles (EDMNPs)

Deposition of one metal on the other by electrolysis is known as electrodeposition. According to review, the above process has been applied in developing latent fingerprint where Au-NPs and Ag-NPs have been used as electro deposition metals. It was observed that the technique is efficient in developing latent fingerprint on non-porous coin substrate.[15]

Rare Earth Metal (REMNPs)

Rare Earth (RE) ion doped materials have ability to luminescence as it has good quantum efficiency and better photochemical stability.[16] Under this community aluminium oxide (Al_2O_3) is known for having amazing properties like chemical inertness and photochemical stability, which makes it suitable host for RE ions.[16] As per literature survey, α-Al_2O_3 nanoparticles doped with inorganic europium has been used in developing latent fingerprints. It was observed that latent fingerprints were developed with good contrast due to its intense luminescence property on different non-porous substrates.[16]

Carbon Nanoparticles

Fluorescent carbon nanoparticles (NPs) are abundantly

used in various bio-chemical devices such as sensors, biological probes, photovoltaic and solar cells [17] as it is having eco-friendly nature and biocompatibility. But it have some drawback, it loses its luminescent property readily in solid-state. Therefore, to make it fluorescent a minor amount of starch powder is added to the fluorescent carbon NPs which provide a noticeable colour-durability. As per literature survey, the above combination has been used as fluorescent marks carbon NPs for the developing latent fingerprints. A good fluorescent image of fingerprint was obtained under UV light excitation.[17]

Conjugate Polymers

Conjugate polymers are known from the optical imaging society as a candidate of contrast due their chemical and optical properties[18] which makes it suitable fluorescent material in forensic fingerprinting. As per review fluorescent material based conjugated polymer, that is poly- p-phenylene vinylene (PPV), nanoparticles were synthesised in aqueous colloidal solution for developing latent fingerprints on both transparent and coloured adhesive tape surface. It was observed that by this technique fingerprints on transparent adhesive tape surface were developed with clear ridge pattern details and they fluorescence under UV light of 385 nm. In case of coloured adhesive tape no such pattern details were observed, although the fingerprints were fluorescence on the coloured adhesive tape surface under 365 nm illumination of UV light. It was also observed that PPV nanoparticles in colloidal solution have a stability which can be used after 6months for the same.[19]

EVOLUTION OF NANOPARTICLES IN THE FIELD OF FORENSIC FINGERPRINTING

Figure 2 shows the emerging growth of nanoparticles in the area of forensic latent fingerprints development and detection. During the period from 2007 to 2009, a few nanoparticles like Au, CdSe and zinc oxide were only known for the development of latent fingerprints and such techniques were diminished for about couple of years (2010-2011). Since 2012 onwards till now many other

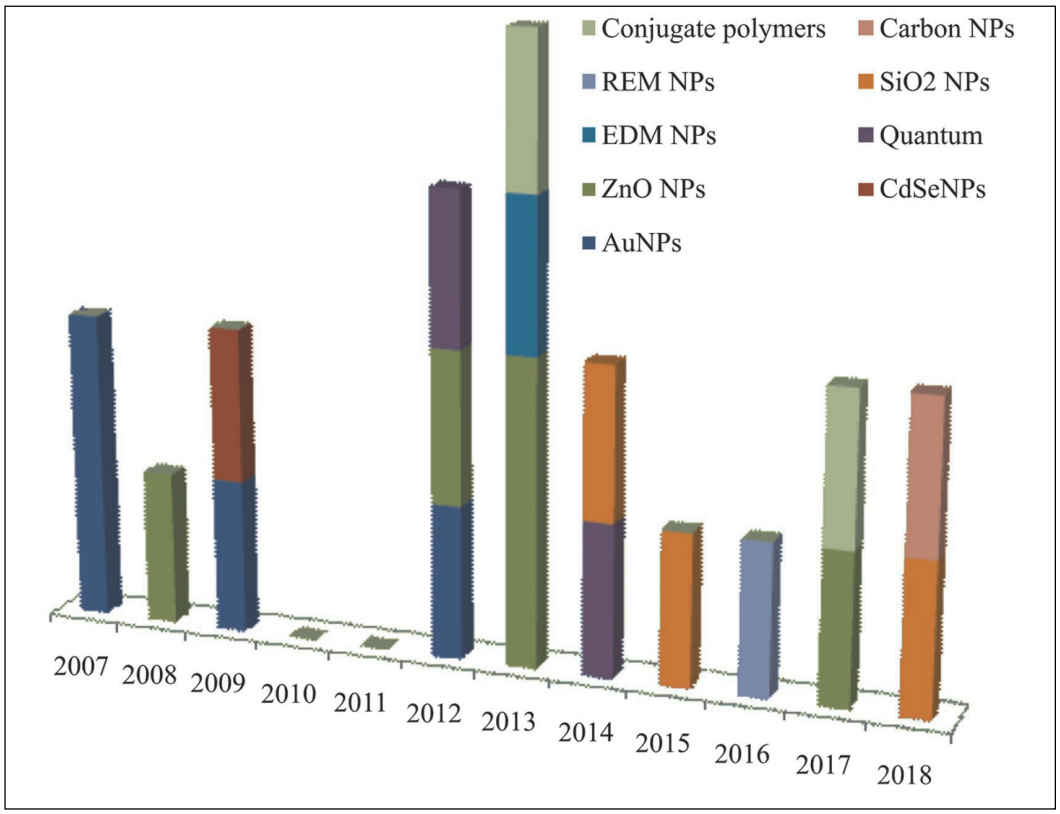

Figure 2: Chart Showing the Yearly Evolution of Nanoparticles in the Development of Latent Fingerprints

nanoparticles such as SiO_2, Quantum dots, REM NPs, EDM NPs, carbon NPs and conjugate polymers have shown a great impact which fuelled a boom in forensic fingerprinting. Among all these nanoparticles AuNPs, ZnO and SiO_2 nanoparticles have been found to be the most used nanoparticles for the enhancement of latent fingerprint quality.

CONCLUSION

Latent fingerprint detection in forensic science is more challenging evidence to be reveal by currently used conventional techniques as they are poor detector in context of stability which lapse over the time period. With this review article, we aimed at presenting the broad spectra of nanotechnology based techniques applied for the development and detection of latent fingerprints. Currently, gold nanoparticles have shown a new possibility in detection of fingerprints as a reactant as well as bi-functional reagent along with this it can be used as a single metal deposition solution for developing latent fingerprints which can also provide identity of an individual.

Metal nanoparticle like CdSe nanoparticles can be used as suspension, whereas silver and gold nanoparticles as an electro deposition metals which showed an efficient development of latent fingerprints. Quantum dots work as an effective fluorescent labeling powder; metal oxide nanoparticles like zinc oxide was found better than tin oxide in producing good fluorescent image of the latent fingerprints. An effective combination of ZnO-SiO_2 nanopowder was also found for developing latent fingerprints. Along with them (RE) ion doped materials, fluorescent starch-based carbon nanoparticles, and conjugate polymers produces good contrast of fingerprints on non-porous surface. With this a brief description of evolution of nanoparticles from 2007 to 2018 has shown the amelioration of nano-fingerprinting and it was found that gold, zinc oxide and silica nanoparticles were the most preferred nonoparticles used for the development and detection of latent fingerprints. Hence, these advanced nanoparticles-based techniques can be applicative for present as well as future latent fingerprints detection.

ETHICAL CLEARANCE

In this review article no physical samples were collected therefore it should not be applicable

SOURCE OF FUNDING

Self

CONFLICT OF INTEREST

Nil

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