



Nanotechnology in Forensic Science: Extensive Applications and New Perspective

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Rapid advances in nanotechnology are setting new paradigms in science and technology. This field of investigation has its particular substantial importance as the developments in the area of nanotechnology has been integrated in the area of forensic science. Nano-forensic offers a fresh perspective for real-time investigation of crimes with established advanced nano-imaging tools for visualization, nano-manipulators and nanosensors. The great quality sequence data and huge assemblage of strains from all around the globe will offer the foundation for relevant outcomes in microbial forensic examinations. International as well as inter-disciplinary co-operation can advance our skills to interpret the origin, quickly recognize the causes and offer these consequences as proof in court. Past few decades, fingerprints from pollen have been developed as the power of various forensic scientists all over the world, and confirmed to be the key element of one of the greatest influential practices in the uncover and interaction proof- Forensic Palynology. Nano-based strategies hold enormous future in detecting latent fingerprinting, for illicit drug screening and security features. In future, nanotechnology is expected to have a key part in the area of forensic science to offer extra receptive and additionally discriminatory methods to identify and expose lawsuits beside reliable proofs.

Keywords: Crime, Detection, Evidence, Nano-forensic, Nanotechnology

Introduction

Over the past few decades, nanotechnology has begun to enter forensics and has gradually proven to be a game changer as it has become so easy to collect, analyse and uncover complex nanoparticles and hidden evidence at the scenes of crime. As an enabler of real-time evidence analysis speed, nanotechnology has been used in forensics in various aspects of genetics, medicine, and analytical chemistry¹.

Today nanotechnology is contributing valuably to the scientific field, "Generally, it is defined as the study, design, creation, synthesis, manipulation, application of functional materials, devices, and systems through control of matter at the nanometer scale"². An important advantage of using nanotechnology in the field of forensics is the uncovering of hidden evidence that can prove useful in helping forensic scientists reach investigative conclusions. New developments in forensics In addition to the use of advanced analytical techniques, the incorporation of nanotechnology has

played a key role in getting defendants into prison without leaving traces of investigation³. The development of latent fingerprints, the detection of nerve gases, the measurement of alcohol in cases of drunk driving, the identification of inorganic pigments in hit-and-run cases, the identification of illegal drugs, and a plethora of other similar situations all benefit from nanotechnology⁴. Conventional methods that have been used in the past or present also for crime scene investigation such as the smidge method used to expose fingerprints or the use of fluorescent X-ray tubes can be replaced by using new scientific techniques such as microbiological forensics, classical technology forensics as well as nanotechnology⁵. As nanotechnology is free from human bias, it helps in increasing the speed and accuracy of investigations.

Application of nanobiotechnology in forensic investigation

Rapid advances in nanotechnology are setting new paradigms in science and technology, but are also raising concerns about the health risks of nano-objects⁶. Recently, many different types of nanoparticles have been used in several areas of forensics, including paints, inks, document security,

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and the development of latent fingerprints⁷. Technological advances in forensic science have also changed the characterization of particle properties, increasing the proportion of "nano-particles" nanosized particles and expanding the variety of chemical species. Forensics has a wide range of sub-specialities that use techniques adapted from the natural sciences to gather criminal or other legal evidence⁸. Advancements of nanotechnology in the field of forensics have involved the use of nanoparticles to uncover different aspects used in investigations to reveal the truth behind the screen.

Latent fingerprinting- revealing invisible evidence

In addition to making sample analysis simpler and more accurate, this latent fingerprinting approach increases the importance of nanoparticles in forensic science. The analysts dip the brushes in fingerprint powder made up of black particles, aluminium flakes, black magnetism and other materials before spotting the latent fingerprints⁹. If an impression appears, take a picture of it first, then gently lift it with tape and record slowly using a latent light card. However, fingerprint powder has the potential to contaminate evidence, undermine analysts' expectations and hamper results. Contaminated by the evidence, analysts turned to other methods to reveal results. Investigators can examine the area using a different light source or apply a super glue called cyanoacrylate before applying powder to avoid contamination¹⁰. The analysis involves examining the impression to find the correct answer that the analyst needs. The analysis is complete and if the printout lacks sufficient characteristics, the analyst will notify the governing body that the printout is not suitable for comparison. However, if the print is appropriate, the analysis will indicate the features to be compared, their tolerances, and the amount of variation that will be observed. The application of latent nanoparticles in this method of latent fingerprinting has significance for forensic science. It is indistinguishable from the standard approach to crime scene analysis. We can now see the fingerprints that were washed off of the surfaces at the crime scene thanks to latent fingerprinting¹¹. The examiner determines whether or not the prints come from the same surface or the same source during evaluation. The quality of the samples, the absence of comparable areas, or an insufficient number of corresponding or dissimilar features may account for the variation in the prints obtained from various sources¹².

When the evidence is presented to the court of interest and another examiner independently analyzes, compares, and evaluates the prints to either support or refute the conclusions reached by the initial examiner, this is the only scenario that qualifies as verification. The examiner may also check whether the decisions made during the analysis phase are appropriate. The majority of fingerprint analyses are carried out by criminal laboratories or law enforcement agencies; However, casework may be sent to private businesses if necessary, such as to handle high-profile cases, verify results, or reduce backlogs¹³.

Formulation of ink

Ink forensic examination includes optical examination, physical examination and chemical examination¹⁴. The results of optical, physical and chemical inspections create the analytical properties of the ink. Recently, several types of nanoparticles have been developed for use in a new generation of anti-counterfeiting inks

Micro- X-ray fluorescence (MXRF)

Micro- X-Ray Fluorescence (MXRF) is one of the most used techniques by forensic investigators in various investigations¹⁵. Generally, it is used to detect the presence of any type of undisclosed evidence at a crime scene. A new visualisation technique that quickly reveals the elemental composition of a sample by irradiating it with a thin X-ray beam without disturbing the sample

Forensic DNA analysis

The value of nanotechnology is reflected in its application in PCR examination of sample fragments. For example, if only a small amount of saliva is collected from a crime scene, PCR will produce enough copies of the sample for later analysis¹⁶. The use of microfluidic devices is a recent development in the field of forensic DNA analysis. These tools apply directly to crime scenes, reducing the risk of contamination and saving investigation time.

Forensic detection of explosives

Nanomaterials have the potential to make explosives-detection sensors. Advanced nano-sensor concept devices, such as electronic noses, nano-tube, and nano-mechanical devices, are utilized in the detection of conventional bombs, plastic explosives, and grenades to trace the explosives¹⁷. A chemical sensing system, such as an artificial neural network, typically owns an electronic nose¹⁸.

Gunshot residue analysis

In Gunshot Residue analysis, high-resolution scanning electron microscopy imaging can be used to locate residue particles and determine their elemental composition using X-ray spectrometry¹⁹.

Forensic fingerprint visualisation

New scientific methods in microbial forensics and nanotechnology are taking the place of certain conventional methods of investigation, such as the "Smidgen method," which is used to reveal fingerprints, and the use of fluorescent X-ray tubes. The fingerprint will be created and used for detection by using nanopowders developed in conjunction with SALDI-TOF2-MS²⁰. Researchers were able to target amino acids on non-porous surfaces with the help of gold nanoparticles, which will make it easier to analyse latent fingerprints.

Forensic toxicological analysis

Nanotechnology is used effectively in forensic toxicology for examination of different toxic materials from important forensic evidence like hair, bodily fluids such as blood, saliva, vitreous humour and even from remains of body skeletons and samples of evidence of fingerprints²¹. Gold, silver, and titanium oxide nanoparticles are used commonly to enhance the detection limit. The body fluid vitreous humour, in which Lidocaine hydrochloride is detected. The nanosensor which is developed with these innovative approaches can be utilised as an immediate on-the-spot test at the crime scene and a major substitute for the field test, their advantages are low-cost, active, stable and allows for timely screening for forensic toxicology drug screening in which timing plays an important role. Nanosensors have been effectively tested with real specimens to confirm their applicability for forensic toxicological analysis.

Forensic DNA typing

During Forensic DNA typing good quality PCR extraction is very crucial. To extract evidence of high quality from PCR-ready DNA samples from indicative fluids of the body and specimens of skeletal remains which are bought for Forensic analysis, various magnetic nanoparticles as well as silicon-based magnetic nanoparticles are used¹⁵. To isolate DNA, magnetite nanoparticles with carboxylic compounds are used as adsorbents for PCR amplification.

Conclusion

In this literature, the broad uses of nanotechnology in the field of forensic science (nano-forensics) is

proposed. This branch of science is primarily aimed on fingerprint recognition. The progress in the area of science and technology has caused the increased interest in the forensic science to investigate and nanotechnology has been performing an progressively significant part in this field. One of the significant benefit of using nanotechnology in the forensics is the longstanding depository of established fingerprints owing to its inert environment along with more discrimination and receptiveness of nanotechnology. The various fields of forensic science to be explored includes finding of explosive, liquor estimation in drunk drivers, finding of saliva, illegal drug detection, nerve gas identification, inorganic stains detection in hit and run cases, dormant fingerprint advancement and several others.

Each expertise has its individual gains and drawbacks. In this literature, we have tried to emphasize those fields of nanotechnology that are unaffected and unnoticed so far. Hence, the forensic researchers and scientists must take needed protections beforehand nanoparticles utilization for improvement of blood fingerprint to dodge untrue outcomes as well as to protect themselves and surroundings from unintended contact of nanoparticles. This has been established that the enormous use of nano-founded methods, nanoparticles and strategies in the area of forensics leads to quick, extra precise, receptive, discriminatory and effective approaches of crime scene examinations along with forensic proof investigation that eventually results in cracking crime. Hence, along with a key opportunity in other areas, nanotechnology, is also possibly to show a main part in the approaching future of forensics with additionally progressive and receptive methods of examination.

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Conflict of interest

All authors declare no conflict of interest.

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