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# A Review of nanotechnology in forensic science

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**Abstract**

Nanotechnology, like DNA profiling, has had a profound impact on the evolution of contemporary technology. Forensic science uses natural scientific knowledge and procedures to discover, isolate, and assess evidence. Forensics, investigations, and prosecutions will all be guided by this evidence. These are some of the uses for nanotechnology. One of the most often used nanotechnologies is nano-analysis, which uses instruments like transmission electron microscope (TEM), atomic force microscopy (AFM), and Raman micro spectroscopy to examine samples (Micro- Raman). Nanotechnology, instruments, and recognized forensic applications will be discussed in this presentation. We'll also talk about nanoparticles' toxicity and potential uses in the future.

**Keywords:** Nanotechnology; Forensic science; Criminalistics; Atomic force microscopy (AFM); Scanning probe microscopy (SPM); Raman micro spectroscopy; Nanotoxicology.

## Introduction

"Nano" is derived from the Greek word for "dwarf," which refers to a billionth (109). There are new materials and gadgets that are fewer than 100 nanometres in diameter, which are the focus of nanotechnology. According to these terms and definitions, the study and control of matter at the atomic and molecular level is what is meant by the term "nanotechnology." Nanotechnology is now having a significant impact on a wide range of sectors in science and technology, including electronics, engineering, physical sciences, and materials science, and it has also found use in medicine. Forensic scientists have adapted and modified nanotechnology used in other fields to study nanomaterials, including High performance liquid chromatography (HPLC), Scanning Probe Microscope (SPM), Infrared Radiation (Fourier Transform Infra-Red Radiation (FT-IR and Raman-IR), Differential Scanning Calorimetry (modulated DSC), Xray Photoelectron Spectroscopy (XPS), and Time-of Flight Mass Spec (AFM). Owing to the nanoscale detection and analysis capabilities of these instruments recently, vital evidence

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previously unavailable due to the detection limitations of earlier devices may now be studied and utilized to assist investigations with the aid of these instruments.

The unique features of nanoparticles may also help in the gathering and identification of evidence previously unavailable. Trace quantities of gunshot residue, heavy metals, explosives, DNA on fingerprints or palm prints, and so on are examples of this kind of evidence. As a result, there is a wealth of information available to support the use of nanotechnology in forensic investigations, and this article makes an effort to summarize some of that information.

**Review of literature**

(Tambo and Ablateye 2020) studied "A review on the role of emerging revolutionary nanotechnology in forensic investigations" discovered this and Nanoparticles have risen to prominence in several sectors because to the substantial study being conducted on them because of their unique features. When it comes to nanotechnology applications, Forensic science seems to be one of the fastest-growing sectors. In forensic investigations, the expanding and broad use of nanotechnology is advancing and might soon represent the tipping point in the field. It has been used in a wide range of Forensic Science fields, including explosives detection using CdS nano slabs, the detection of organophosphorus chemical warfare agents with the functionalized TiO2 nanorods, and the visualization of latent prints with Na-no powders. In recent years, nanotechnology has also been used in the detection of illicit drugs. When it comes to evaluating evidence, the use of Nanotechnology allows for faster and more accurate findings because of the restricted tools that can be employed, as well as the ability to utilize sensitive and selective techniques to identify evidence. The use of nanotechnology to identify and detect evidence in forensic investigations has the ability to enhance and provide efficient and speedy tools for investigations and unraveling leads into crimes. An examination of how nanotechnology, new procedures, and innovative equipment are having an influence on forensic sciences is presented here, along with some of the obstacles that the technology faces and some of the opportunities that it has for the future.

(Prasad, Lukose, and Prasad 2016) studied "Emerging Forensic Applications of Nanotechnology" discovered this and Forensic science relies heavily on nanotechnology, and this study examines its importance. In addition to discussing the use of the Atomic Force Microscope (AFM), a classic tool of nanotechnology, this paper also discusses the use of HPLC, X-ray photoelectron spectroscopy, and other cutting-edge nanotechnology instruments in forensic investigations. All three of these tools have been shown to be useful in forensic investigations. Other examples include quantum dots as luminous materials for security features on official and confidential documents, Au-NPs used in latent fingerprint development and DNA fingerprinting, as well as a nano sensor that is utilized for explosive detection. As a result, the purpose of this study was to introduce and analyze nanotechnology's use in forensic science, as well as the instruments utilized in nano-analysis.

(Chen 2011) studied "Forensic Applications of Nanotechnology" The development of DNA pro-filing on biotechnology in the last 50 years has had a significant impact on current technology, as has nanotechnology. Forensic science uses natural scientific knowledge and procedures to discover, isolate, and assess evidence. Forensics, investigations, and prosecutions will all be guided by this evidence. These are some of the uses for nanotechnology. Nano-analysis is most typically used in forensic science using instruments such as transmission electron microscopes (TEM), scanning electron microscopes (SEM), atomic force microscopes (AFM) and Raman micro spectrometers (Micro Raman). Nanotechnology, instruments, and recognized forensic applications will be discussed in this presentation. We'll also talk about nanoparticles' toxicity and potential uses in the future.

**Nanotechnology in explosive detection**

The use of explosive-based weapons in terrorist attacks has increased dramatically in recent years due to the ease with which they may be developed, deployed, and the devastation they can wreak. Terrorists have used explosives in more than 4400 of a total of 12000 incidents. The assaults killed more than 20,000 people throughout the globe and wounded more than 30,000. As a result of numerous factors including the wide variety of compounds that can be used as explosives, large deployments, and a lack of inexpensive sensors providing high sensitivity and selectivity simultaneously, detecting explosives is a major challenge for law enforcement agencies around the world. In order to defeat explosives-based terrorism, having sensors with great sensitivity and selectivity as well as the capacity to produce and deploy them at a cheaper cost is essential. Nanotechnology research and development has shown that nanostructures may be used as sensors for a wide range of chemical and biological chemicals, including explosives. Examples include the use of polymer and nanoparticles that alter their measurable properties when bound to explosive molecules, providing high specificity detection along with various Nano sensor devices such as electronic noses and nano-curcumin based probes. Other examples include the use of the laser plasmon nanocavity.

**Nanotechnology in the estimation of the time of death**

Forensic medicine and the law have a major challenge in determining the exact moment of death. When trying to determine the exact moment of death, both physical and chemical post-mortem changes are taken into consideration. Forensic science relies on the pattern analysis of ante mortem and post-mortem bloodstains, as well as the biological changes in blood cells, to accurately determine the time of death. An important problem in forensic science — determining when someone died – may be solved by the use AFM, according to a recent paper. AFM, a new technology for determining the age of bloodstains, may provide legal medical specialists with vital information for a forensic inquiry. AFM detections of changes in RBC shape and surface viscoelasticity that are time-, substrate-, and environment-(temperature/humidity)-dependent suggest a possible use in forensic medicine or investigations, such as calculating the age of bloodstain or the time of death.

**Nanotechnology in the examination of bloodstain**

During a crime scene investigation, forensic scientists often use blood stains as an important investigative tool. For the assessment of suspected bloodstains, solutions such as phenolphthalein and tetramethylbenzidine may be employed since they change color when they come into contact with peroxidase or hemoglobin in the blood. There is, however, an unresolved challenge in everyday work in forensics about the age of a blood spot. Since (AFM) is a fast emerging method for evaluating the age of bloodstains, legal medical professionals might provide helpful information for forensic investigations. Consequently, it has been used to record force-distance curves to evaluate blood's elasticity. Elasticity reduced with time, perhaps due to the drying and coagulation processes altering the bloodstain's structure. The AFM may be used to construct a calibration curve for the elasticity over time, which can then be used to determine the age of bloodstains.

**Nanotechnology for security features in official and confidential documents**

A country's national security is constantly jeopardized if its official papers and sensitive information are compromised. As a result, there are several approaches to creating a document that is safe and impenetrable by counterfeiters. Fluorescent inks, fiber-based security markings, optically changeable inks, and holograms are just a few examples. However, inorganic luminescent phosphors or organic luminescent fluorophors are often used to label (tag) a document with an invisible code that is luminous. Using luminous nanoparticles, such as quantum dots or nano-sized luminescent phorphors and up-converters, as security features is where the focus is. These nanoparticles include quantum dots and other luminous compounds. Anti-counterfeiting inks are being made using a variety of nanoparticles that have just been discovered. Additionally, these new NPs not only replace the fluorescent dyes used in currency notes but also provide more accurate and upgraded security measures than were previously available.

## Nanotechnology and fingerprints

The usage of nanoparticles has lately showed considerable promise in generating the next generation of fingerprint creation methods known as nano fingerprints. Detection of fingerprints is an essential part of crime scene investigation since fingerprints are the most common evidence in criminal investigations because they provide a generic proof of human identification. Latent, patent, or plastic fingerprints are the most common types. There are a number of factors that contribute to the fingerprint's uniqueness, including the body's natural secretions (mostly perspiration) and environmental contaminants. As a result, the kind of method used to produce latent fingerprints is dependent on the fingerprints' composition, the substrate used, and the order in which the techniques may be used. Iodine fuming, ninhydrin, silver nitrate, and cyanoacrylate are some of the current methods for developing latent fingerprints. Additionally old prints, on the other hand, may have their latent fingerprints contaminated by the environment, reducing their sensitivity to these technologies' detection. Therefore, nano-scientists have been utilizing more sophisticated approaches in the last several years to leverage the effects of nanoparticles such as Au-NPs (gold), CdS (cadmium sulphide) and ZnS (zinc sulphide) for the creation of latent fingerprints to better recognize fingerprints. Because nanotechnology may be used to build novel fingerprint procedures with higher selectivity, enhanced contrast with the backdrop, and increased sensitivity; this means that fingerprints can be developed with better qualities.

## Conclusion

Different forensic investigations may benefit from the nanotechnology approaches and experimental procedures presented in this study. If these approaches are correct, nanotechnology may be used to create a faster and better system for investigating forensic evidence. There are several advantages for investigators to use nanotechnology, such as providing more precise and more sensitive methods for solving crimes. Nanographene oxide in methamphetamine detection, single-crystalline semiconductor in explosive identification, and gold nanoparticles for improving DNA identification are just a few examples being discussed in forensic investigations. Post-mortem analysis utilizing silver nanocluster probes for K+ estimates has also been described, using modified cobalt oxide nanoparticles for morphine detection. Nano-based compounds utilized in the generation and detection of latent fingerprints have also been studied. It is clear from this assessment that nanotechnology has significant potential and benefits over traditional approaches in forensics, and these and many more discoveries and developments indicate how promising nanotechnology is. This discipline will revolutionize criminal investigations by reducing the time it takes to conduct analysis, improving the quality of those findings, and compiling evidence that previous methods lacked the ability to find. Despite the many advantages, further study is needed to address the issues of safety and cost.

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