Seyda Mona *et al.LGU (IJECI) 2022*

LGU (IJECI)
ISSN: 2522-3429 (Print)
ISSN: 2616-6003 (Online)

LGU International Journal for
Electronic Crime Investigation

Research Article

Vol. 6 issue 2 Year 2022

Nanotechnology: An applied and extensive approach in solving crimes

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Abstract:

Nanotechnology has great influence on modern technology. In order to identify, individualize, and assess evidence, forensic science applies knowledge and methods. Then, with the aid of evidence, crime scenes will be rebuilt, investigations will be directed, and offenders will be prosecuted. Nano-analysis is one of modern technology that is most frequently used in forensic science. The characterization can be done by using tools like the atomic force microscope (AFM), aman micro spectroscopy, scanning electron microscope (SEM), and transmission electron microscope (TEM) (Micro-Raman). Nanotechnologies might be essential in current forensic investigation issues like forensic toxicological analysis, explosive detection, detection of explosive residue, finger print analysis, forensic DNA analysis, forensic nano trackers, and drug-facilitated crime.

Key words: Nanotechnology, Security purposes, Drug facilitated crime, Explosive weapons.

1. Introduction

The topic of nanotechnology is rapidly expanding and opens up new avenues for research and technology. Electronics, engineering, physical sciences, materials sciences, health sciences, and many other scientific domains have all used it. Forensic science and society stand to gain greatly from nanotechnology, yet those nanoparticles with novel undiscovered qualities can also be hazardous to the environment (Chauhan, Singh, & Tiwari, 2017). An essential benefit of adopting nanotechnology in forensic science is that it makes hidden evidence visible, which can help the forensic scientists conclude their investigations (Chen, 2011). With the aid of new scientific techniques like microbial forensics, forensic science, and nanotechnology, the novel methods that were used in the past or are still used today for investigating a crime scene can be replaced. Examples include the smidgen method that was used to reveal finger prints or the use of fluorescent x-ray tubes (Pandya & Shukla, 2018). In the field of forensic sciences, the application of cutting-edge nanotechnology technology can help in investigation (Bhatt, Pandey, Tharmavaram, Rawtani, & Mustansar Hussain, 2020).

Nanotechnology is useful with the creation and solicitation of organizationally-featured arrangements and devices within a scale of around 100 nm, where unique properties emerge in contrast to bulk materials. It means the ability to manipulate molecules and atoms to create customized nanostructures and gadgets for specific purposes. This is due to the merging of science in the fields of materials science, biology physics, chemistry, and engineering at the Nano scale as well as the significance of matter control in nearly all technologies (Hulla et al., 2015).

Chemical or biological methods can be used to create nanoparticles. Due to the presence of some harmful chemicals absorbed on the surface, chemical manufacturing processes have been linked to numerous negative effects. Biological techniques of nanoparticle manufacturing involving microbes, fungi, plants or plant extracts and enzymes are eco-friendly alternatives to physical and chemical approaches. Fe_3O_4 (magnetite) and FeO (maghemite), are two types of magnetic nanoparticles. They have been actively analyzed for guided medication administration, gene therapy, magnetic resonance imaging (MRI), targeted cancer treatment (magnetic hyperthermia) and DNA analysis (Hasan, 2015).

Nanotechnology, which eventually raises the risk to human health and the environment. There has been a rise in interest in creating ecologically friendly processes for creating metallic nanoparticles. A useful strategy in green nanotechnology is the utilization of various biomaterials for the creation of nanoparticles. Metallic nanoparticles that are energy-efficient, nontoxic, inexpensive and beneficial to the environment have been produced using biological resources like bacteria, algae, fungi, and plants. An overview of numerous studies on iron oxide (FeO/Fe_3O_4) and zero valent metallic iron (ZVMI) nanoparticles illustrates its important uses in reducing environmental pollution (Saif, Tahir, & Chen, 2016).

2. Iron Oxide Nanoparticles

Iron oxides are typical natural substances that are also simple to create in a laboratory. Including oxides, hydroxides, and oxide-hydroxides, there are 16 different types of iron oxide. These minerals are the end product of aqueous reactions occurring in a variety of redox reactions (Campos et al., 2015).

Iron oxide nanoparticles, which have sizes between 1 and 100 nanometers and are used in drug administration, magnetic data storage and bio-sensing. The surface area to volume ratio greatly rises in nanoparticles (NPs). This enables NPs to have a superior dispersibility in solutions and a significantly larger binding capacity. Super paramagnetism is a property of magnetic NPs with diameters ranging from 2 to 20 nm, which indicates that they are externally magnetizable and have a magnetization of zero in the absence of a magnetic field (Palanisamy & Wang, 2019).

3. Synthesis and Characterization of Iron Oxide Nanoparticles

Iron oxides typically consist of a surface layer and a crystalline core that stabilizes the core's characteristics and may also be used to avoid aggregation. The process of synthesizing the iron oxide's crystalline core, which is composed of ferro- (Fe^{2+}) or ferri- (Fe^{3+})

magnetic material, often involves the precise precipitation of iron oxides in an aqueous solution or an organic solution while also incorporating a base. Due to their polymorphism involving temperature-induced phase transition, the three most widely used iron oxides are hematite (-Fe_2O_3), maghemite (-Fe_2O_3), and magnetite (Fe_3O_4). These minerals have special catalytic, magnetic, biochemical and other properties that make them suitable for particular technical and biomedical uses (Sangaiya, Jayaprakash, & Magnetism, 2018).

For the creation of monodispersed nanoparticles, an effective synthetic method relies on the breakdown of organometallic precursors. This process produces iron oxide nanoparticles (magnetite/maghemite Fe_3O_4/-FeO). Typically, the maximum particle size for this approach was between 20 and 30 nm (Guardia, Pérez, Labarta, & Batlle, 2010).

The FT-IR (Fourier transform infrared spectroscopy), UV absorption spectroscopy, XRD (X-ray diffractometer), EDX (Energy Dispersive X-Ray spectrometer), and SEM (scanning electron microscope) were used to characterize the biosynthesized iron oxide nanoparticles. The forms were crystalline, Nanorod, and enormously stable, and the typical particle size was between 10 and 20 nm. (Rajiv, Bavadharani, Kumar, Vanathi, & Biotechnology, 2017).

4. Applications of nanotechnology in criminology

Fingerprint analysis

Since the beginning of time, criminologists have employed fingerprints as a distinctive form of evidence. Particularly useful in fingerprint analysis is nanotechnology. The use of considerably smaller nanoparticles in place of traditional materials like carbon black, aluminium flake, and gentian violet has greatly increased the sensitivity of the fingerprinting process. Even on complex surfaces like adhesive or textured materials, the nanoparticles are making it simpler to find and remove fingerprints that have been left behind (Prasad, Lukose, & Prasad, 2016). Nanotechnology is also being used to instantly and precisely disclose hidden fingerprints. Even on a damaged and faded print, the nanoparticles can enhance the fingerprints by adhering to the ridges and grooves (Pitkethly, 2009). In addition to the patterns, the fingerprint also contains the person's sweat and other metabolites. The nanoparticles are able to show whether the owner of the fingerprint is a cocaine addict or an alcoholic by attaching to such body fluids and metabolites infused in the print. They are also able to reveal his age, sex, and the ailments he would undoubtedly suffer from (Pandya & Shukla, 2018).

Fingerprint analysis

5. Atomic Force Microscope (AFM)

The Atomic Force Microscope (AFM) is an

instrument that forensic experts use to examine the paper's surface at the nanoscale. The investigator can use this information to identify whether the document is a counterfeit or was actually written by one or more people by knowing the pen, ink, and pressure/intensity. By disclosing the blood sample's age, AFM helps the investigating officer look into body offences. Over time, blood thickens and stiffens (Pandey, Tharmavaram, Rawtani, Kumar, & Agrawal, 2017). AFM can reveal the sample's age by measuring the viscosity or dryness of the sample. The detective is receiving assistance from AFM in identifying the compounds found in the urine. When urine is combined with nanoparticles and exposed to laser light, a signal is released that indicates the presence of chemicals or other things, such as pharmaceuticals, in the urine (Yadavalli & Ehrhardt, 2021).

6. DNA Analysis

The advancement and improvement of DNA analysis looks to be the most promising use of nanotechnology. DNA may now be extracted, amplified, separated, and sequenced more quickly and conveniently thanks to nanotechnology (Moller & Fritzsche, 2007). In addition to revealing the physical characteristics of the owner of the DNA, such as age, sex, and the colour of the hair, eyes, and skin, among other things, next-generation sequencing using nanotechnology is also assisting the detective in determining the origin of DNA, including whether the DNA lifted from the crime scene came from skin, blood, saliva, semen, etc (Kaur & Sharma, 2022).

DNA Analysis

7. Explosives Weapons

Explosives and weapons with explosive components are now frequently used by terrorists and in terrorist occurrences (Wang, 2004). Investigators can employ nanotechnology to determine the amount of intact or barely fragmented explosives at the crime scene during the course of the inquiry. Once more, nanotechnology is demonstrating its efficacy in the evaluation and detection of gunshot residue (Sree Satya Bharati, Byram, & Soma, 2018)

8. Nanotrackers

These days, using trackers and bar codes has become commonplace. Trackers can assist in locating lost or stolen objects. Nano trackers are also employed to keep convicts from breaking the law and to keep tabs on them after their release. Inmates that receive nano tracker injections are quite easy to find (Singh & Samal, 2021).

Nanotrackers

9. Forged Products (set-up)

Nanotechnology is also helping differentiate false products from originals. Police are able to detect crimes involving inauthentic aspects by using nanofibers and nanodots. Bio-Nanosensors are also being used to identify toxins and to detect narcotics, explosives and bioterrorist agents (Mandal & Mandal, 2015).

Forged Product Investigation

10. Security purposes

By lowering the time, expense, and level of skill needed while simultaneously improving the precision and accessibility of nano collecting and analysis devices, nanotechnologies in forensic science and security can revolutionize the way an investigation is conducted (Muro, Doty, Bueno, Halamkova, & Lednev, 2015).

Forensic investigation for security purposes

11. Conclusion

With distinctive qualities, nanotechnology have many uses in forensic science like evidence gathering and handling, sample analysis, and monitoring of products and unlawful activities. Utilizing nanomaterials with special electrical, optical, and magnetic properties allows for a wide range of forensic applications, including the processing of evidence, fingerprint recognition, the detection of illegal narcotics, explosives, and GSR.

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