

Occupational Exposure of Nanoparticles In Forensic Science: A Need Of Safe Use

Review Article

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Abstract

The rapid advancement in nanotechnology sets new paradigms in science and technology, but simultaneously increased apprehensions about the health risks of nano-objects. Recently, various types of nanoparticles used in several areas of forensic including paint, inks, security document and to develop the latent fingerprint.

Objective: Despite bright outlooks of nanoparticles used in various fields of forensic science, an increasing occupational as well as laboratory exposure of nanoparticles to workers and lab personnel, respectively, may lead to significant adverse health effects in the form of serious diseases.

Conclusion: Therefore, in this review, an attempt was made to discuss the positive and negative consequences of nanoparticles, to resolve their adverse effects which make them safer for forensic applications.

Key Words: Occupational; Forensic Science; Nanoparticles.

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Introduction

Nanotechnology is a rapid growing field which sets new paradigms in science and technology. It has been applied to various fields of science including electronics, engineering, physical sciences, materials sciences, biomedical sciences and many others. Nowadays, forensic science is also not untouched with Nanotechnology. Nanotechnology contributes to forensic sciences in two ways. Since it can detect and analyze samples in the nano-scale, vital evidence that could not be collected and analyzed before due to the detection limits of the instruments can now be analyzed and used to support the investigations. In addition, nanoparticles possess novel physical and chemical properties that can assist the collection and detection of evidence which cannot be acquired previously. Recently, various types of nanoparticles are used in several areas of forensic science including as an ingredient in ink formulation for individual characterization, authentication of official documents and currency notes known to have NPs

as a security features, analysis of gunshot residues (GSR) used as probe and also aid in the development of latent fingerprint (1) on various surfaces. These nanoparticle containing materials are thus subject to forensic characterization (in case of ink, official documents and currency notes) and also used as a tool of forensic examination (in case of GSR analysis, fingerprint development). In fingerprint science, Nanoparticles have introduced to develop the latent fingerprint on different surfaces by reducing background color which make good contrast image and improve the quality of the print [1,2].

In the case of ink, ink jet printing inks and the recent arrival of gel inks are known to incorporate nanoparticles for a unique characterization. In the case of documents, it is now well known that nanotechnology is being, or is hoped to be used in official documents as a security printing such as in passport and currency notes. Such nanotechnology includes quantum dots [3].

Nanotechnology has great potential to benefit the society and forensic science; however those nanoparticles with unknown novel properties can also cause risks to the environment. When these NPs are used in various applications to improve the quality of products and results then the chances of occupational exposure to the workers may also increased. Very little is known about how they behave in the environment or how they interact with and affect humans (especially the worker). "Unfortunately, only a very small portion of research on nanoparticles is focused on health and safety risks, or on threats to the environment. Therefore, despite bright outlooks for the future of nano forensic, there is an increasing concern that intentional or unintentional human exposure to different size, shape and composition of nanoparticles may lead to significant adverse health effects especially on DNA as many previous studies are reported [4-9]. In this paper, first time an attempt was made to discuss the positive and negative consequences of uses of nanoparticles in Forensic science and try to resolve their adverse effect to the Forensic personnel and

environment and make them safer for forensic applications.

Positive Aspects of Nanotechnology in Forensic Science

Formulation of Ink

From the ancient time different manufacturers of Ink are used various sets of colorants in ink formulation for their individualization. The colorants of ink are normally either pigments or dyes or both. The major components of the ink formulation are the solvents while the minor, but important components include surfactants, viscosity adjusters, preservatives, corrosion control agents, and driers. The nature of the colorants and solvents depends on the type of ink being made.

The forensic examination of inks consists of optical, physical, and chemical examinations. The results from the optical, physical and chemical examinations create the analytical profile of the ink. This profile is compared with those of in a standard reference collection and when a match is found, one can infer who the manufacturer of the ink is, where it is sold, when the ink first became commercially available, in what pen or pens the ink is used (in the case of writing inks), and in what printers they are used (in the case of printing inks). NPs play an important role in all three types of examination of ink. It may help to make a profile of ink more unique and precise. In the recent development Ink jet inks have been introducing nano-sized pigments to their normally dye-based inks to give them added light fastness. Nowadays, some fluorescence tagged NPs are also used in ink formulation.

Security features in Official and confidential documents

Security of official and confidential documents is always a big issue for a country regarding to their national security. Therefore, time to time ruling government of the countries are making, or attempting to make a document secure and counterfeit proof. These include watermarks, fluorescent inks, security fibers, optical variable ink and holograms. There are three main reasons for executing security features on objects of value (including documents) is for product labeling, document security, and object identification.

The uses of nano-sized particles in documents as a security features are not new. These are used in most of the paper as fillers such as TiO_2 , CaCO_3 , and BaSO_4 , all of which can be ground to submicron size. Also, most printing inks and whiteners are containing pigments which can also be ground to submicron size. Fillers and pigments are normally not part of a document's suite of security features. However, if one wants to mark (tag) a document with an invisible code that is luminescent, one normally uses inorganic luminescent phosphors or organic luminescent fluorophors. Decrease the size of the inorganic phosphors to submicron size reduces their luminescence efficiency. This is where the attention in using nanoparticles as security features comes in, particularly, luminescent nanoparticles such as quantum dots or nano-sized luminescent phosphors and up-converters. Thus quantum dots and other nanoparticles are being considered as replacing the more traditional micron-sized luminescent materials.

Recently, various types of nanoparticles are developed that can be used into a new generation of anti-counterfeiting inks. These NPs are not only replacing the ancient fluorescent dyes that can be used in currency notes but also gives more precise and up-

grade security features than previously. NPs as a security tags are also used in Passport and credit cards to upgrade in their security features. These nano-based security features cannot be easily counterfeit because due to nano in size cannot be visualized by naked eyes magnifying lens or any of the normally used techniques such as transmitted light, oblique light. It can be visualized only by the instruments which are highly precise and throughput (in magnification and various light sources) not found easily and present only in laboratories. Therefore, chances of counterfeiting are much less than previously.

Latent Fingerprint Enhancement

First time, Menzel 2001 has usage of photoluminescent CdS semiconductor nanocrystal capped with dioctyl sulfosuccinate to enhance latent fingerprint. The concept behind that was to apply nanocrystal fluorescent dye on articles that have been pre-fumed with cyanoacrylate ester and also on the sticky side of electrical tape without pre-fuming. Thereafter, many other studies have shown that various size and type of nanoparticles are used to enhance the latent fingerprint on different surfaces that has been given not only better contrast image of fingerprint but also reducing the background color that cannot be done previously [1,10,11]. These tremendous successes in the field of latent fingerprint development attract the forensic scientist and researcher towards fingerprint development on bloody fingerprint.

Bloody Fingerprint

Blood is commonly encountered as a transfer medium for fingerprints at crime scene. Sometimes, the residue retains enough color to allow it to be photographed directly, but, more often, the residue is so faint that its color (and thereby its contrast) is so slight that ordinary light photography is ineffective except on transparent or highly reflective sources.

Chemical methods for the enhancement of residual blood fingerprints have been successfully used for years. Leucomalachite green, amido black, and ninhydrin chemically react with components in blood to form a dark-colored dye complex and have all been used successfully on light-colored or transparent surfaces. Leucomalachite green and ninhydrin have low background colors but are unsuitable for non-porous surfaces as they run off, and either distorts the print or fail to react before detail can be photographed [12]. Amido black is very sensitive and works well on non-porous surfaces but its high background color (light to medium blue) compromises contrast on porous surfaces from which the stain cannot be removed by rinsing. On dark surfaces, none of these color-producing reagent stains could be guaranteed to produce detectable prints. Attempts to use luminol had reportedly been of limited success since the brief chemiluminescence created was weak, hard to photograph, and failed to resolve fine ridge detail. Recently get success in development of latent fingerprint on various surfaces using Nanoparticles [1,10,11] encourage to the forensic scientist and researcher for the enhancement of faint blood prints on various surfaces by using these nanoparticles.

Negative Aspects Of Nanotechnology In Forensic Science

Occupational Exposure

Increasing production and use of nanoparticles result in an esca-

lating number of workers and consumers are exposed to nanoparticles. In the forensic science, forensic personnel are exposed to these nanoparticles mostly via inhalation during usage of these nanoparticles for forensic examination of samples. Small size of particles after inhalation may be able to translocate from the alveolar region in the lung to the extra-pulmonary organs (liver, heart, spleen, etc.) via systemic blood circulation. There is some toxicological evidences of nanoparticles translocating in the body organs of humans [13] and in animals [14,15] are reported. Oberdörster et al. (2005) [16] found that the central nervous system (CNS) could be targeted by airborne solid ultrafine particles through deposition on the olfactory mucosa in the nasopharyngeal region and subsequent translocation via the olfactory nerve. Therefore, nanoparticles may cause adverse effects on the whole body as well as the respiratory organs. Nanoparticles exposure is mostly chronic, so peoples are not very much attentive regarding to its procurement and finally suffer to some severe diseases.

Degradation of biological sample

Although nanoparticles are enhance the development of latent fingerprints on various unusual surfaces (wet, nonporous and semi-porous surfaces), yet this method could not be useful on blood bearing surfaces (blood fingerprint), because that surface containing biological materials especially DNA that can be damaged by NPs [17]. This is well known proved that powdered nanoparticles when encountered with human cells, due to small in size they have entered into the cell and attached with different organelles including nucleus[8,9]. Nucleus is containing Genetic materials (DNA) and once NPs attack on DNA, they break the DNA strands, resulting DNA damage/degradation[8,9]. In forensic science DNA degradation/damaging is a common problem which affects the DNA yield, amplification and loss of larger alleles [18]. A variety of different mechanisms have been suggested to account for DNA degradation, including the release of nucleases from putrefying cells, bacterial decomposition, and cross linking. Furthermore, oxidation, deamination, depurination and other hydrolytic processes can also lead to destabilization and breaks in DNA molecules. In above all of those mechanism Nanoparticles especially metal oxide are producing breaks in DNA molecules due to oxidation process forming a DNA adduct 8-oxo-7,8-dihydro-2'-deoxyguanosine (8-OHdG) (7). This oxidative DNA damage was possible to damage the DNA sufficiently to cause a standard autosomal short tandem repeat (STR) profile to be lost and finally false or inconclusive results would be obtained during DNA fingerprinting [19]. These results would be misleading to personal individualization. Therefore forensic expert should be cautious when applied those nanoparticles for forensic applications. He or she must be known about the toxic effect of those particular nanoparticles on DNA and also on him/herself and the environment. Hence, in this review I have emphases on the precaution which should be necessarily taken during handling, applying and disposal of nanoparticles and also suggest some recommendation which would not only be better and safe for forensic applications but also for forensic experts, researchers and our surroundings.

Prior to usage of nanoparticles in forensic application especially in case of latent fingerprint development (bloody fingerprint) following safety measures may be undertaken to mitigate and manage the risks arising from handling of nanoparticles,

Precautions

1. Field usage of nanoparticles for latent fingerprint development should be avoided. Nanoparticles will spread quickly and remain in the surrounding air for a long time. Therefore, Nano-powders should be open under closed fume-hood or in an enclosed vessel (glove box) to avoid the formation of aerosols. If a closed fume hood is not available and the material is handled in an 'open' fume hood or other controlled 'open' environment, a suitable masks (FFP3, which correspond with the American P100) should be worn.
2. If field use of nanoparticles is contemplated, the following actions are being taken,
 - a. All personnel applying the formulation and subsequently handling the evidence (target substrate) should wear appropriate personal protective equipment. This would include disposable, lab coat, respiratory mask, protective gloves, protection goggles with side protection and protective clothing; face shields, and closed-toed shoes to prevent direct contact of nanoparticles to skin.
 - b. The respiratory protection is used when the formulation is applied and the evidence handled in the 'wet' or 'fresh' state. If air-purifying respiratory protection is selected, HEPA filters should be used.
 - c. All personal protective and evidence handling equipment which is visibly contaminated or reasonably anticipated to be contaminated with the applied formulation, is to be bagged and disposed of as hazardous waste, or subsequently cleaned in a controlled laboratory environment.
 - d. The law enforcement agency in charge of the crime scene is to post the scene, clearly providing notification of the type and kind of nanoparticles used in the processing of evidence and the general hazards associated with their exposure.
3. Hand washing and the avoidance of hand-to-mouth activities are to be stringently enforced.
4. Appropriate containers should be used for transporting bottles containing NPs safely, from the storage room to the testing laboratories or crime scene.
5. Disposal of nanoparticles is a most important process by which nanoparticles directly comes in to the environment. If disposal procedure is not properly done then it may pose threat to the human beings and environment. Any material that has come into contact with dispersible manufactured nanoparticles should be considered as belonging to a nanoparticle-bearing waste stream.

Prior to disposal, Nanoparticles wastes should be stored in any sealable waste container or in plastic bags. Label the waste container with a description of the waste and include available information characterizing known and suspected properties of nanoparticles. When the bag or container is full, close it and sealed it.

Whenever possible, nanoparticle powders should be made into suspension, thereafter, disposed by immobilizing them in 1% Agar. All other solutions coming in contact with the nanoparticles should be collected in containers and disposed at the radioactive waste disposal pit.

Recommendation

1. The above mentioned precautions are basic ones and simultaneously, it would be necessary to follow the primary level of toxicity assessment of nanoparticles, prior to use in forensic application.
2. Rather than use of bare nanoparticles, surface coated nano-

particles should be preferred.

3. For the coating materials, those compound or materials would be preferred which make the nanoparticles biocompatible and give stability.
4. Nanoparticles in suspension form should be preferable as compared to powdered form.

Conclusion

Every technology has its own advantages and disadvantages. With the help of this review, I have made an attempt to point out those areas of Nanotechnology which was still unseen and untouched. Although the use of nanoparticles for enhancing latent blood impressions, security features in documents and using in ink formulation for individualization appears to be an efficacious tool from a forensic analysis perspective, yet their concurrent effect on DNA and occupational exposure on workers and forensic personnel cannot be denied which may further caused serious diseases. Therefore, information on possible health and environmental effects of nanoparticles should be essentially needed prior to their application.

The forensic community has an ethical and legal obligation to protect the health of both its own forensic professionals, and the public that is environment, it serves. To this end, the methods, procedures, and investigative tools used to process evidence should be selected and employed in such a manner as to maximize the health and safety of the aforementioned groups.

The available toxicological information indicates that nanoparticles has some hazards which makes its' use at crime scenes or other uncontrolled environments problematic to both law enforcement (forensic professionals) and the samples (eg. Blood fingerprint). Therefore, before using Nanoparticles for enhancement of blood fingerprint necessary precaution should be taken by Forensic Scientists and researcher to avoid not only false or inconclusive results but also to safe their selves and environments from indirect exposure of these Nanoparticles.

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