

## Emerging branch of Nanotechnology: NANO- FORENSICS

The Editor-in-Chief,  
International Journal of Education & Research in  
Health Sciences, Plot No.16, Gut No.106, Sangram  
Nagar, Satara Parisar, Aurangabad - 431010,  
Maharashtra.

Institute of Forensic Science,  
University of Mumbai,  
15, Madam Cama Rd,  
Mumbai – 400032.

Nanotechnology is, in recent time, gaining a lot of fame in various fields. We often come across its achievements in science journals and magazines as it is an upcoming source for innovations that can be very helpful in future. Nanotechnology, involves the contribution of nano-particles and their physical properties like conductance or uniformity or any specific optical properties which, narrows down it to be a study of manipulating matter on an atomic and molecular scale. In general, it deals with developing materials, devices or other structures possessing at least one dimension sized from 1 to 100 nanometer.

With the increase in criminal activity worldwide, the technology is also being enhanced for obvious reasons, due to which nano-forensics came into the scene. It is a completely new area of forensic science which is associated with the development of nano-sensors for real time crime scene and terrorist activity investigations by determining the presence of explosive gases, biological agents and residues. Nano- forensics can also be widely used in drug trafficking, robbery, hit cases, building collapse, petroleum product adulteration, forgery, etc. This technology is modified to be used in different forensically used instruments High Performance Liquid Chromatography (HPLC), Scanning Probe Microscope (SPM), Fourier Transform Infrared Radiation (FTIR), Raman Infrared, Differential Scanning Colorimetry (DSC), X Ray Photoelectron

Spectroscopy (XPS), Time-Of-Flight-Mass Spectroscopy and Atomic Force Microscopy (AFM).

### **MAJOR APPLICATIONS OF NANO-FORENSICS:**

#### **1. Estimation of Post Mortem Interval (PMI)/Time since death:**

In the field of Forensic Medicine and Law, one of the important parameter is the estimation of PMI which includes the evaluation of physical along with the chemical post mortem changes. The pattern analysis of the bloodstains is done for antimortem and postmortem bloodstains. Moreover, cellular changes of blood cells provide the quantitative assessment of PMI. For resolving some of the typical hurdles in forensic science, the application of AFM is taken into consideration as it is a developing tool introduced for the determination of age of bloodstains, which eventually provide medical experts with the needed information that leads to potential investigation. This process is compatible to the rapid environmental conditions.

The AFM principle is based on the cantilever/tip assembly (probe) that interacts with the sample through a raster scanning motion. The up/down and side to side motion of the AFM tip as it scans along the surface is monitored through a laser beam reflected off the cantilever. This reflected laser beam is tracked by a position sensitive photo- detector (PSPD) that picks up the vertical

---

and lateral motion of the probe. The deflection sensitivity of these detectors has to be calibrated in terms of how many nanometers of motion correspond to a unit of voltage measured on the detector.

## **2. Examination of Bloodstain**

While investigating a crime scene, finding bloodstain is very common. Nanotechnology provides a reliable procedure for the detection and identification of bloodspots. Evaluation of bloodstains is mostly done by using the solutions such as phenolphthalein or tetramethylbenzidine due to the change in color experienced when they come in contact with either hemoglobin or peroxidase in blood.

Previously, the determination of age of blood spot was unsolved impossible until AFM was invented. AFM tests the elasticity of blood by recording force-distance curves as elasticity patterns decreases overtime due to drying and coagulation process which ascertain its age.

## **3. Enhancement of PCR efficiency / DNA Typing**

Polymerase Chain Reaction is often used method for manufacturing copies of specific fragments of DNA. Addition of gold nano particles is used to enhance the efficiency of PCR. Au-NPs shows electrochemiluminescence hence, combined with isothermal reactions of endonuclease and polymerase.

## **4. Development of Fingerprints**

Fingerprints can be found in almost every crime scene and plays evident role in precise identification of any human. Mostly found prints are latent in nature (invisible to the naked eye) and thus, needs to be enhanced before the collection. To search these prints various light sources are used in which fluorescence is observed at a certain wavelength, the reason of which is still uncertain.

The prints are left behind due to the transfer of sweat residue on porous as well as non porous surface. Relatively, to develop a print on non porous surface is easier than porous surface for which we can use either vacuum metal deposition technique or vapor staining procedure.

To avoid such a cumbersome process, nanotechnology has given birth to nano-powders which are usually coupled with SALDI-TOF2-MS to develop and examine a fingerprint. At first, a scientist named Menzel, in 2001, used photo luminescent CdS semiconductor nano-crystals masked with dioctyle sulfosuccinate for the enhancement of latent prints. The washed off surface also contains some amount of residue for a time interval which can also be recovered using these nano-powders. This clearly provides an indication for the huge achievement in the field of forensic science.

Moreover, bloody fingerprint gets transferred on different surfaces giving us prominent evidence. Those prints, in order to record, are quickly photographed with zoom in lenses. However, there are times when the bloody fingerprint gets faded or is found on a non contrast surface making it difficult for the examination. Nano-powder encourages the expert for the enhancement of fingerprint to proper study.

## **5. Examination of Questioned Document**

The disputed documents are often collected for determining its authenticity. Nano-particles used in AFM can precisely give us the required information about the sequence of strokes, opacity of the writing surface, the depth of absorption of ink on the paper. This instrument gives us the three dimensional morphological structure of molecules of the ink bonded with the molecules of paper, revealing the age of the ink and the paper, the number of writing instruments used, the sequence of strokes. Separately, ink examination is carried out which consists of optical, physical and chemical examinations after which a specific analytical profile is formed for different inks. These profiles are, then, compared with the standards that manufacturers provide. Nanotechnology helps us in finding a unique and precise profile. Recently, some companies have started adding fluorescence tagged nano-particles while the formulation of ink to make it unique in nature.

Security features have always been introduced in official and confidential documents such as watermarks, omicron marks, optical fibres, holograms, fluorescent inks to prevent counterfeiting and for product labeling

---

and object identification. It is very important to keep adding new feature as the old ones becomes known to people. Therefore, nano-sized particles ( $\text{TiO}_2$ ,  $\text{CaCO}_3$  and  $\text{BaSO}_4$ ) in document have also been used, ground to submicron, especially, luminescent nano-particles such as quantum dots. Due to their extremely small size, it is highly likely that they would not get replicated as they are invisible to naked eyes or even by a magnifying lens.

## 6. Examination of Explosives

In recent years, the explosive based terrorism activity has increased globally and

hence called for advancement in technology in the field of nano-forensics. The efficient detection of hidden explosives in luggage, vehicles, aircraft, mail, toothpaste which are found in trace amount was challenging. But, the modern research and development studies in nano-forensics have demonstrated the ability of nano- structures to function as sensors of various biological and chemical compounds including explosives. For example, the mixture of polymer particle and nano-

particle that bound to an explosive molecule change one of their measurable properties by providing high specificity detection which are associated with various nano-sensor devices such as electric noses, nano-curcumin based probe, lasing plasmon nano- cavity and nano-wire/nano-tube. Some nano-mechanical concepts are used to detect conventional bombs, plastic explosives & grenades.

## 7. GSR examination

Analysis of gunshot residue can be made possible through application of

nanotechnology. The microscopic particles present in GSR can be collected as evidence from the hands and clothes of a shooter, following discharge of a firearm. X-ray spectroscopy is used to determine composition of elements in GSR while High Resolution SEM helps locating the residue particles.

We would like to request you to publish this letter in your prestigious journal, so that this emerging field gets enough recognition.

Pragati Siddhi Kuperkar  
M.Sc. - II