da Vinci's notebook

da Vinci's Notebook, vol. 6 (2014)

Nano Technology and Latent Fingerprint Detection

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To this day, one of the most important elements of crime scene investigation remains the detection of fingerprint evidence. Even in the face of the rise of DNA identification, the analysis and processing of fingerprints is still the key to the identification of a suspect at the crime scene. Every person in the world has a unique set of fingerprints that are unchangeable and can be effectively matched with confidence. At any given crime scene, all potential prints are never gathered, primarily because most are invisible to the human eye. This is referred to by forensic scientists as being latent. In order to maximize the police's chance of a positive identification, as many fingerprints as possible must be gathered. It is thus the job of the modern forensic scientist to work on the development of more sensitive detection techniques in order to achieve this goal. Along with many other branches of science, forensic science has started to explore the possibilities of the realm of nanoscience. Over the course of the past few years, forensic nanoscientists have been using increasingly sophisticated techniques to exploit the effects of nanoparticles in order to better identify latent fingerprints.

Currently, there are a multitude of techniques which police utilize in detecting latent fingerprints, including optical methods, physical methods (such as dusting), and chemical methods. While these methods are effective, there is still much room for improvement. The first technique that uses nanoparticles for fingerprint detection is called multi-metal deposition (MMD) and involves a two-step chemical process (Choi *et al.*, 2008). First, an object would be placed in an acid bath containing gold nanoparticles, in which the gold attaches itself to the ridges of the finger print left on the object. Next, the object is soaked in a bath of silver nanoparticles, where the gold layer acts as a nucleation site for the silver to build onto, thus forming a visible print. This technique can be augmented by the addition of functional groups onto the gold particles. One interesting example was created by Leggett et al. in which a specific antibody that is related to nicotine is attached onto the gold nanoparticles (Legget *et al.,* 2007). During experimentation, the solution could not only effectively reveal fingerprints, but the fingerprints themselves would also fluoresce under UV light if the donator of the prints was a smoker. While this study focused specifically on smoking, there is no reason to think that this technique could not be adapted to incorporate other indicators for a variety of drugs or other sweat-secreted chemicals. MMD is a highly versatile technique because it has been shown to be effective on both porous and non-porous surfaces as well as surfaces that are wet. However, it is limited by the fact that it requires the object with the fingerprints on it to be bathed in an aqueous solution of the gold nanoparticles. It is thus not useful for finding prints on surfaces such as walls or floors at the scene of the crime or for any object too large to be soaked in a desk top bath (Choi *et al*., 2008).

Another technique that scientists are testing involves improving the conventional method of applying a fine dust to the site and then brushing away excess, leaving only the particles that adhere to the ridges of the print. Scientists are now experimenting with dust that has nano-scale particles rather than the classical micron-range sized particles (Choi *et al*., 2008). These studies have shown that when gold is used as the metal for the nanoparticles, nano-dusting has been able to produce higher resolution prints on a variety of surfaces. Having high resolution prints is important because the detail of a print is very fine, and slight imperfections can dramatically affect the ability of the police to use them in an investigation. This is especially true in the case of partial prints, when only a portion of the fingerprint is found. Tests with other types of nanoparticles such as zinc oxide and iron oxide have also been successful at producing high resolution prints through dusting (Choi *et al*., 2008). The zinc oxide was shown to be able to effectively lift prints on non-porous surfaces even when the prints have been aged for longer than a month. Tests have also been conducted on titanium dioxide particles and have revealed that it generally has the same effectiveness as conventional dusting methods. Interestingly, this method is very good for lifting prints off of the sticky side of tape when dissolved in a solution of methanol.

In the last few years, another approach that has garnered a lot of attention is the use of quantum dots (QDs) for fingerprint detection. QDs are interesting because they fluoresce strongly under UV light and have varying emission spectra based on their particle size (Liu *et al*., 2009). The type of QDs most studied in the context of fingerprint detection are ones that derive from cadmium, namely cadmium sulphide (CdS), cadmium selenide (CdSe), and cadmium telluride (CdTe). Focusing on CdTe, this type of QD can be made to be water-soluble, so it can be applied to the prints in an aqueous solution. It can also it can be made to fluoresce at different colours based on the size of the particle. As a result, it can be an effective detecting agent on surfaces of all different colours. After being rinsed with the water-soluble CdTe for a number of minutes, the prints produced are of far higher resolution than anything that can be produced by conventional methods. Similarly to the gold nanoparticles, these QDs can also be functionalized with a variety of chemicals (Choi *et al*., 2008). In a newer study, CdTe QDs were capped with mercaptosuccinic acid (MSA) and this resulted in a much shorter time for the image to develop (Cai *et al*., 2013). Formerly, using CdTe QDs would require approximately 15 minutes of bathing in solution to produce a visible product, but the MSA capped CdTe QDS was able to produce visible prints after a mere second with a greater resolution than the best chemical print developers currently used. With such a fast development speed, there is the potential in the future to create a CdTe QD spray that could be applied to fingerprints on-scene and enable them to be seen right away (Cai *et al*., 2013).

CdTe and the other cadmium QDs do have some major drawbacks. Cadmium is a highly toxic heavy metal that poses a serious risk to all those who try to use it, especially if it was prepared into a spray form for on-scene print detection (Moret *et al*., 2012). Also, two of the other elements being fused with the cadmium, tellurium and selenium, are also highly toxic substances. In a study, tellurium was found to cause mice to lose their hair before death (Franke *et al.,* 1937). From this study, it can be derived that the tellurium would have a similar effect on humans. Fortunately, other alternatives are already being explored, including coating the QD in protective layers or applying the particles in an aqueous solution rather than a powder. Unfortunately, those methods still come with significant risk of exposure to carcinogenic cadmium (Moret *et al*., 2012). A solution has emerged recently, in which the core is completely replaced with non-toxic zinc sulphide (ZnS). In the study, these new QDs have been shown to be equal to or even higher in effectiveness then the CdTe and far more effective than a standard chemical detection indicator (Acid Yellow 7) on a variety of surfaces (Moret *et al*., 2012). One main issue is that ZnS lacks the ability to be sized-tuned to different colours and is naturally a shade of blue that is less visible to the human eye than the other indicators (Moret *et al*., 2012). This can be overcome by a process of doping the ZnS QDs with a copper compound which causes a red-shift in emission spectra. These copper-doped ZnS QDs are both very effective agents for seeing latent fingerprints and lack the toxic aspect that plagued the variety of cadmium based QDs.

Conclusion

Currently, none of the aforementioned mentioned technologies are being utilized in actual case work and currently only exist in the laboratory. In many cases, the advantage is overtly apparent. Many types of nanoparticles can be used in the process of detecting fingerprints, and utilized in a variety of methods. MMD with gold and silver particles can make very clear prints that have a long shelf life and can be functionalized to identify secondary properties of the person who left it (Choi *et al.*, 2008). An assortment of nano-metal oxides can be used in the classical method of dusting but with increased resolution on the basis of having smaller particles (Choi *et al.*, 2008). More recently, the development of size-tunable quantum dots has led to a number of new techniques that are significantly greater in resolution than conventional techniques currently in use (Liu *et al*., 2009). As further research makes these products cheaper and safer, they will surely be adapted as a superior tool in the arsenal of 21st century crime-fighting.

References

Cai, K.; Yang, R.; Wang Y.; Yu, X.; Liu, J. (2013). Super fast detection of latent fingerprints with water soluble CdTe quantum dots. *Forensic Sci. Int.*, **226***,* 240-243.

Choi, M.; McDonagh, A.; Maynard, P.; Roux, C. (2008). Metal-containing nanoparticles and nano-structured particles in fingermark detection. *Forensic Sci. Int.*, **179***,* 87-97.

Franke, K.W.; Moxon, A.L. (1937). The Toxicity of Orally Ingested Arsenic, Selenium, Tellurium, Vanadium, and Molybdenum. *J. Pharmacol. Exp. Ther.*, **61***,* 89-102.

Leggett, R.; Lee-Smith, E.; Jickells, S.; Russell, D. (2007). "Intelligent" Fingerprinting: Simultaneous Identification of Drug Metabolites and Individuals by Using Anti-Functionalized Nanoparticles. *Angew. Chem.*, **119***,* 4178-4181.

Liu, J.; Shi, Z.; Yu, Y.; Yang, R.; Zuo, S. (2009). Water-soluble multicolored fluorescent CdTe quantum dots: Synthesis and application for fingerprint developing. *J. Coll. Interf. Sci.*, **342***,* 278-282.

Moret, S.; Becue, A.; Champod, C. (2012). Cadmium-free quantum dots in aqueous solution: Potential for fingermark detection, synthesis and an application to the detection of fingermarks in blood on non-porous surfaces. *Forensic Sci. Int.*, **224***,* 101-110.