**Ryan Tomcik**

*IAI Liason to the NIJ*

# Smart Dusts: Creating a Stealthy, Stable and Statistically Uniq

I recently contacted Dr. Ming Su at the Worcester Polytechnic Institute to talk about his NIJ-funded research on covert metal nanoparticles, a class of molecular taggants, and the possible implications for crime scene investigators. Taggants are physical or chemical markers that are conventionally deployed in anticounterfeiting measures, such as microfibers, microscopic labels and security inks. Security professionals use taggants in an application-specific manner based on desired authentication strength, level of multiplicity or "code space," sensitivity, cost, ease of detection and visibility. The analysis of statistically unique taggants in forensic science is a fundamental idea with respect to the interpretation of trace evidence that is collected from crime scenes. If scientists could identify a paint chip from a vehicle, to the exclusion of all other vehicular paint formulae, based on the taggant added to the paint mixture, then taggant analysis could potentially become as accurate a measurement as DNA analysis.

Ming Su obtained his Ph.D. in materials science and engineering and has been working on nanotechnology and nanomedicine for about seven years. His interest is in a new type of nanomaterials, called phase change materials (PCM), which can change their phases from solid to liquid at melting temperatures. When Dr. Su used nano-PCMs in heat transfer, thermal energy storage, and biological sensing, he realized that nano-PCMs could be assembled to form a new type of barcode system that will have extremely high capacity.

Project Title: **Encapsulated Phase Change Nanoparticles as Thermally-readable Covert Taggants**
Award No: 2012-DN-BX-K021

***Ryan Tomcik:*** *What is the basic, fundamental science behind nanoparticle creation and detection, and how can it be applied to forensic science?*

**Ming Su:** The fundamental science behind this project is that nanoparticles can be made to have different and discrete melting temperatures by controlling their compositions. A panel of such nanoparticles can form a "barcode" that can be added into an object. The barcode can then be read out from the object by detecting melting temperatures of nanoparticles. Instead of being visible like normal barcodes, such invisible thermal barcodes can be added into many objects such as explosives, drugs, paints, inks or any objects.

*What are some scenarios where your technique would be useful in a forensic context?*

A unique thermal barcode can be added into the paint of a particular vehicle. If there is a hit-and-run incident, law enforcement can collect paint fragments from the scene and identify the thermal barcode in the mixture to find out the source of the paint. Such a barcode can also be mixed into explosive materials with only manufacturers or vendors knowing the precise taggant formula. If someone assembled an explosive and used it in a public area, police would be able to identify the manufacturer of the components.

*What does the phrase "high coding space" mean in reference to thermal particles?*

The coding space means the number of different barcodes that can be formed. By using 100 different types of nanoparticles, the total number of thermal barcodes that can be formed will reach 10 to the power 30, which is sufficient to label all human-related objects.

*How will the nanoparticles be selected and prepared for this experiment?*

The nanoparticles are selected based on stability, toxicity, cost, as well as knowledge on their phase diagram behaviors.

*How would these nanoparticles be administered or applied to surfaces or materials in a practical forensic context?*

The surfaces of nanoparticles can be modified to have high affinity to specific object surfaces. These taggants can also be added into paints, glues, or simply mixed with materials.

*How does your proposed method compare with currently*

## ue Taggant

*available commercial taggant techniques or other techniques that are in development?*

Compared with normal taggants, thermal barcodes have an extremely large coding space and are practically invisible. Many existing identification techniques (e.g., serial number, optical barcode, intaglio feature, microscale features, radio frequency devices) are not appropriate for covert operations due to large size, visibility, high cost, and the possibility of losing integrity. Chemical and fluorescent taggants have a low level of multiplicity (i.e., a small coding space), low sensitivity and secureness and are only suited for simple authentication rather than serialization application. Glass and plastic microbeads lack sensitivity, secureness, and covertness, and have a small coding space. Microfibers or chemicals are too large to offer large coding capacity, and their morphological signature cannot be read out directly. Compared with DNA taggants, thermal barcodes are cheaper, much easier to use and extremely robust. DNA taggants are not stable and need polymerase chain reaction (PCR) for detection.

**For bad guys without an advanced science degree, this technique will be extremely difficult to understand...**

*What limitations or pitfalls exist with your proposed technique?*

Currently, it takes approximately 20 minutes to read one thermal barcode, but we are working on rapid thermal analysis to complete the readout in minutes. The collection of thermal barcodes from explosion debris may require the collection of nanoparticles in a microsphere together with magnetic nanoparticles.

*How difficult would it be for bad guys to detect these particles, and is there any concern about reverse engineering?*

For bad guys without an advanced science degree, this technique will be extremely difficult to understand and copy. People with advanced knowledge (for instance, a Ph.D. in materials science) would have to have many different chemicals and access to sophisticated synthesis and characterization facilities.

*How would an investigator detect these covert particles in the field, and how would they be collected and analyzed?*

An investigator can collect and analyze particles directly in the field. They can use a magnet to further enrich particles and then directly analyze the “smart dust” with differential scanning calorimetry using a handheld thermal reader.

*How expensive will the detection and analysis equipment be, and what type of training would be required for normal use?*

A normal state-of-the-art differential scanning calorimeter costs roughly $50,000. A handheld version that will be developed from this project is expected to cost $2,000. The equipment will be very easy to use with simple loading and push-button analysis.

*If successful, do you envision these encapsulated nanoparticles will be made available commercially?*

Yes. We have started to file a patent on this.

To learn more about this project, contact Dr. Ming Su at **msu2@wpi.edu** or Mr. Todd Keiller at WPI’s tech transfer office at **tkeiller@wpi.edu**.

Pick the next NIJ research interviewee! Navigate your favorite Internet browser to the NIJ R&D web page and scroll through the list of projects. If you find one that you’d like to learn more about, then send me an email at **tomcik_ryan@bah.com**.

Link: **www.nij.gov/nij/topics/forensics/forensic-awards.htm**

*Ryan Tomcik*