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Golden Opportunities: Transforming Fingerprint Analysis

It is a procedure documented every day on television: take a brush, dip it in black powder, rub it on a surface, and instantly uncover a pristine and useful fingerprint. Unfortunately for law enforcement officials, dusting for fingerprints in real life is not nearly so simple. In reality, obtaining prints that are both clear and valuable to a case can be quite difficult. Porous surfaces, such as paper, make lifting prints particularly tricky because people leave varying amounts of sweat or fatty oils on the surface after they touch it. Prints that can be lifted may not be of great use to officials if they are trying to prove that a suspect was ingesting certain drugs, because fingerprints can only prove that a suspect was at the scene in question, not that they were engaging in any specific behaviors while there. Additionally, aged prints from cold cases have minimal chance of ever being recovered because current methods are poor detectors of marks that have faded over the years. Luckily, developments in nanotechnology implementing gold nanoparticles may render all of these problems irrelevant. With their abilities to highlight prints on porous surfaces, identify chemical compounds present in prints, and detect dried or degraded prints from older crime scenes, gold nanoparticles have the potential to revolutionize techniques used to analyze fingerprints by decreasing the amount of time, energy and money spent on latent fingerprint analysis and increasing the number of cases closed and criminals brought to justice.

During a crime, there is ample opportunity for criminals to leave fingerprints on paper: checks, documents, currency, tissues, and other paper products may yield important evidence. Latent fingerprints are mainly composed of water, sweat, amino acids, and fatty acids (Hadlington, 2012). However, because some individuals excrete these materials more than others, the clarity of a print can vary greatly depending on by whom it was left. Thus, prints left by individuals who do not have particularly sweaty or oily hands have a very low chance of detection, especially on paper. Realizing this problem, Israeli researchers used gold nanoparticles to develop a system of dusting for latent prints independent of sweat composition. Conventionally, gold nanoparticles and a silver physical developer bind to the print, leaving a dark gray color where there is fingerprint material (Jaber et. al., 2012). However, the researchers attached a bifunctional reagent to the gold nanoparticles and silver developer. One end of the reagent is attracted to the cellulose in the paper, and the other end is attracted to the nanoparticles (Jaber et. al., 2012). Instead of binding to the print as usual, the gold nanoparticles bind to the paper itself due to the reagent's high affinity for cellulose. In this way, an individual's sweat composition is no longer a factor, meaning that the number of latent prints able to be detected at a crime scene can greatly increase. Surprisingly, this technique can even further improve fingerprint analysis, as it enables detection of prints on wet surfaces as well. Another problem commonly encountered when collecting latent prints is that water on a surface has dissolved the amino acids present in the print's structure, making lifting the print extremely difficult as these amino acids are the main substrate in current techniques (Jaber et. al, 2012). Since

the bifunctional reagent causes paper to be the substrate, not sweat secretions, it does not matter if a surface is wet. Clearly, this development is beneficial to all involved in a case, as collection and analysis of evidence becomes easier and prosecutors have a stronger case against a suspect. If this technique can be widely used to detect latent prints on paper, both dry and wet, important evidence present at a crime scene will no longer go unnoticed, leading to a higher degree of certainty as to whether a suspect is innocent or guilty.

While determining if an individual was present at a crime scene is a crucial step to reaching this heightened degree of certainty, the objective of some cases is not only to pinpoint the location of a suspect, but to identify chemicals they have recently ingested, as well. For example, a woman's fingerprints on her own kitchen table may not be suspicious, but traces of cocaine metabolites found in the prints certainly would be of interest to an investigator. If a drug has been ingested and metabolized by an individual, traces of the metabolites specific to that drug will be sweated out in their fingerprints (Limer, 2011). British researchers used this knowledge to successfully differentiate fingerprints of smokers from nonsmokers by targeting cotinine, a metabolite of nicotine (Leggett, Lee-Smith, Jickells, and Russell, 2007). Antibodies specifically designed to bind to cotinine metabolites were applied to gold nanoparticles in a solution that was then coated on the print. A different antibody, containing fluorescent dye and also designed to bind to cotinine antibodies, was then added ("Nanotechnology fingerprint," 2007). Due to this dye, the prints taken from smokers glowed brightly in fluorescent images (Leggett et. al., 2007). The same concept can be used to identify a variety of metabolites, meaning

that investigators can simultaneously obtain irrefutable proof of both a suspect's identity and their crime from a single test. In addition, routine drug testing for athletes or drivers can now be less invasive; a test requiring only a fingerprint from these individuals would prove their sobriety while still respecting their privacy. It would be extremely difficult to tamper with this type of drug testing, as drug metabolites in sweat cannot be manipulated. In coordination with drug antibodies and fluorescent dye, gold nanoparticles can reveal a great deal about an individual from their fingerprints, increasing the body of evidence for a case and decreasing time and money spent on drug testing.

Perhaps the greatest achievement regarding gold nanoparticles and fingerprint collection is the ability to detect dried, degraded fingerprints from old crime scenes. Although sweat and oils in a fingerprint break down over time, amino acids do not, leading researchers to develop a method of fingerprint detection involving these acids. Antibodies specifically targeting amino acids were attached to gold nanoparticles, which were coated onto the fingerprint's surface. Red fluorescent antibodies attracted to the nanoparticle-bound antibodies were then applied for development and analysis purposes (Birch, 2011). The researchers found that compared to conventional methods, their secondary method produced much better results on aged prints, even those up to several months old (Spindler, Hofstetter, McDonagh, Roux, and Lennard, 2011). This discovery could have tremendous implications – fingerprints from cold cases can be reviewed, prints of unknown age can be analyzed effectively, and prints that have piled up in evidence lockers can be evaluated although they are no longer fresh. Evidence backlog is a

major concern for crime labs, as lack of funding and employees leaves innumerable samples waiting to be tested (National Institute of Justice, 2013). If a way to process aged fingerprints is used by crime labs across the country, this backlog could be severely cut down. Additionally, scientists would not have to worry about the print's age affecting the validity of the test since amino acids do not degrade over time. The use of gold nanoparticles alongside antibodies targeting these acids can greatly improve the efficiency and productivity of crime lab employees.

While an increase in samples analyzed is a fairly straightforward result of better fingerprint detection and analysis techniques, involving gold nanoparticles in these techniques could have numerous unforeseen consequences for scientists, law enforcement officials, and society at large. Although most of the effects of gold nanoparticles in fingerprinting are positive, it should be noted that there have been some concerns regarding the toxicity of nanomaterials (Alkilany and Murphy, 2010). Therefore, the scientists who will likely work in extremely close quarters with these materials should be wary of any negative side effects, and caution should be exercised before introducing the particles to all law enforcement departments. However, the benefits of gold nanoparticles seem to greatly outweigh the risks. For one, analyzing more evidence, whether it is from current or cold cases, leads to proving more criminals guilty of their crimes. Labeling a suspect as such thus increases a police department's clearance rate (the ratio of closed cases to total cases processed).   A high clearance rate is extremely desirable to law enforcement officials; it signifies that their department excels at their work (Cronin and Wellford, 1999). This often prompts higher-ranked individuals such as police commissioners

or mayors to increase resources given to these departments, such as budget augmentations or newer technology. These tools can help boost a department's clearance rate even higher, creating a positive cycle of achievement. A high clearance rate is not significant only to law enforcement – the surrounding community will feel safe with an effective police department, as more criminals will be in jail.

Better fingerprinting techniques can also help bring individuals out of jail: the falsely accused. New evidence in a case can often exonerate those whom were deemed guilty under false pretenses, so the opportunity to review old fingerprints is invaluable to innocent people incarcerated for crimes they did not commit. Clearly, a great number of society members would benefit from fingerprinting techniques involving the use of gold nanoparticles.

Although science is still far from the advanced technology seen on television, gold nanoparticles have the potential to greatly improve current methods of detecting and analyzing fingerprint evidence. Using them to locate prints on porous substances, identify specific drug metabolites, and highlight degraded or aged prints can revolutionize fingerprint evidence for police across the world, leading to higher clearance rates and greater assurance that the correct people are in or out of jail. With this technology, detection, analysis, and implications of fingerprint evidence can be greatly transformed.

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