Gunshot Residue Nanoparticle Spray Pattern Analysis Using an Atomic Force Microscope

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Abstract:

The main objective of this research is to discover gunshot residue nanoparticle spray patterns that are specific to a particular barrel length of a firearm. This research would enable investigators to determine the barrel length of a specific caliber gun used in a crime and ultimately narrow down the possibilities of potential firearms.

Introduction:

Every day, forensic technology is advancing and new methods of analyzing data are being discovered. An essential aspect of forensic investigation lies in gunshot residue (GSR) analysis. When a gun is fired, a pin is released and hits the primer of the bullet, which causes an explosion of gas that ejects the bullet out of the barrel of the gun. In this process, powder is dispensed from the barrel in a cloud that can travel up to 20 feet, depending on the firearm. This powder along with smoke, soot, and lead, barium, and antimony shavings is what GSR is composed of. When the powder is released and comes in contact with a surface, a particular nanoparticle pattern is formed. A nanoparticle is an ultrafine particle sized between 100 and 1 nanometers. This pattern can alter in shape, distribution, uniformity, etc. [1][4]

In order to examine nanoparticles, an investigator might use a scanning electron microscope, (SEM), or an atomic force microscope, (AFM). An SEM recognizes and reads various types of metals in a sample and can be very costly. The SEM also requires meticulous pre-setup steps that need to be followed. Since it is established that what is being analyzed is in fact GSR, the SEM would not be informative in this aspect of the research. Since ammunition is composed of various chemicals, it is not guaranteed that every batch is exact in its chemical composition. An SEM focuses mainly on the chemical make-up of a sample and, since our sample is GSR and is chemically inconsistent in its make-up, this microscope is ineffectual.

An AFM, however, can be used to give 3 dimensional shapes of any sample and doesn't cost nearly as much as an SEM. The AFM contains a very small probe, usually less than 10 microns long, that passes over a surface and moves up and down every time it passes over a particle. The vertical heights of the probe are then calculated with a laser and this generates a 3 dimensional image of the sample. This image can be magnified up to 100,000,000x, which is far greater than a regular light microscope. One of the primary reasons that the atomic force microscope is the best microscope to analyze GSR nanoparticle spatter is because the three-dimensional array of numbers can be displayed and analyzed in many formats and there is less preparation to run samples through this microscope. [1][3]

The current studies in analyzing GSR focus mainly on the pattern formations that can be seen with the naked eye. However, examinations of the GSR nanoparticles are increasing. AFMs have been used by investigators to determine factors such as the distance the gun was from the target when shot, the caliber gun that was used, and the ammunition that was used. What has not been examined using the AFM is the nanoparticle spray pattern created by firearms of the same caliber with different barrel lengths. The AFM will allow for a 3D image of the nanoparticles for each GSR sample from each gun. This will ultimately help investigators to distinguish specific patterns created by various barrel lengths and aid in proving what barrel length was used to create said patterns. [2]

Results and Discussion

During the course of this experiment, several difficulties arose that delayed the continuance of the research. When attempting to collect the gunshot residue, it was learned quickly that copper sheeting does not hold the particles left by the gunshot. It was also realized that the larger caliber shot at the close range of 2 inches would tear apart the copper sheeting. The method of collecting the samples was altered, such that copper tape would be used. This method was more practical and the gunshot residue could be seen after the gun was fired, allowing for more successful collection. Each sample was mounted on a glass slide using a double sided tape to ensure that the sample remained flat during the examination under the AFM. This also allowed for easy storage for each of the samples.

Once the samples were collected, it was time for the observation and analysis stages of the experiment. The first few weeks consisted of training to guarantee ample knowledge of the atomic force microscope. Gold tipped probes were selected and purchased due to their better quality and performance. It was unknown at the time that these probes would arrive individually, not mounted to the magnetic strips as was expected. This resulted in the probes then having to be hand glued onto the magnetic strips. This was due to the lack of equipment needed to accurately and precisely mount them. Ultimately, the probes were mounted askew and resulted in faulty scans that could not be used to represent accurate results. Once this issue was addressed, an automatic probe mounter was purchased, but failed to arrive before the deadline of this research. Unfortunately, no useable scans were received over the course of this research, resulting in no beneficial results pertaining to the primary objective of this experiment. However, the foundations of this research have established an advantageous understanding of the mechanics of this microscope.

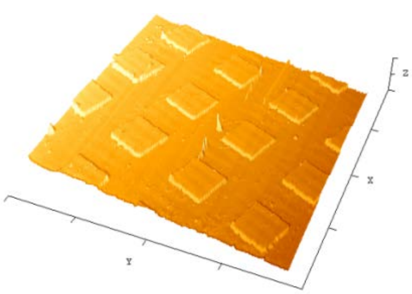

Figure 1. A scan of the optical reference with the training probes.

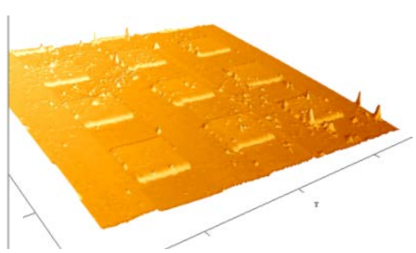

Figure 2. A scan of the optical reference with incorrectly mounted probe.

Conclusions

It is important to understand that although the main objective of this lab was never fully explored, valuable experiences have come of it. The steps and methods utilized to acquire the gunshot residue nanoparticles needed for the experiment proved to be problematic in the first few attempts. However, once the problems were assessed, a better method for obtaining the samples was established. Also, spending countless hours working with the atomic force microscope provided a serviceable experience considering knowledge of this instrument can be used in further research. It is well understood now that proper techniques must be applied in order for this microscope to function properly. In the future, probes will be mounted correctly to ensure that the data found is accurate and reliable. Sadly, time was short and the resources were simply not available in time. If they had been, it is very likely that valuable data would have been the outcome of this experiment. As an extension of this experiment, additional barrel lengths would be tested, as well as, various gun powders that burn at different rates.

References:

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Biography

Shawnee Sullivan is a junior at the University of New Haven, majoring in forensic science with a concentration in chemistry. Shawnee hopes to continue her research with the atomic force microscope next summer. After graduating from college, she aspires to attend graduate school to continue her studies in science.