

Ryan Zdenek
Senior
Forensic Science and Chemistry
Forensic Analysis of 3D Printed Polymers Pre- and Post- Manufacturing

Brooke Kammrath, Ph.D.
Department of Forensic Science

Maria-Isabel Carnasciali, Ph.D.
Department of Engineering and Applied Science Education

The question that this research sought to answer was, “Is there a measurable chemical difference in 3D printed polymers pre- and post- manufacturing?” The answer to this question would further the knowledge on 3D printed objects as it pertains to forensic science. Knowing if there are changes in the chemical composition of 3D printed polymers before and after they are used could aid investigators in their analysis of a 3D printed object recovered from a crime scene. 3D printers can be used to manufacture a variety of items to be used in crime, from firearm components to ATM skimmers, and so, research in this field would prove beneficial (1-3).

To answer this question, several spools of Polylactic Acid (PLA) filament were purchased and used in the 3D printers available at the University. Eight different colors were used in this research project. An important variable that was examined was the influence of the printing temperature on the chemistry of the post-manufactured polymer. Samples were produced at three different temperatures (200°C, 215°C and 230°C). Three samples were produced at each temperature and three different areas from each sample were analyzed. This resulted in 9 post-manufacturing observations per color. For pre-manufacturing, the spool of filament was analyzed at increments of 24in for a total of 5 pre-manufacturing observations per color. These samples were analyzed using both Infrared and Raman spectroscopy. These are complementary techniques meaning that if one color did not work well with one method, it should work better with the other method. These instrumentation methods have been validated for this use and were selected to provide the most accurate results for the research (4-5). Once the data was collected, it was analyzed. Recordings of peak location on the spectra as well as full width at half maximum (FWHM) values were recorded for all samples and plotted to visually determine any consistent trends. Data was also analyzed using ANOVA tables to determine statistical significance of changes.

After plotting the data that was collected and examining the plots, it did not appear that there were any consistent trends in peak value changes or FWHM value changes. Between different colors and temperatures, no one temperature or color appeared to result in any more changes than any other color/temperature combination. The significance of the results analyzed through ANOVA tables showed that 64.58% of data did NOT show any significance in their changes. What this means is that if a 3D printed object is collected at a crime scene as evidence, it can be analyzed and be directly compared to a pre-manufactured spool of filament because of

the negligible changes. This makes it easier for investigators during their analysis, saving them valuable time.

In the future, I plan to publish a paper after additionally completing work on my honors thesis which will look at discriminating between different manufacturers filament of the same color. It is believed that Raman spectroscopy will be able to identify different pigments and additives which can be used to individualize different manufacturer's products. I also plan to present my research findings at professional chemistry and forensic science conferences. I have submitted abstracts to the American Academy of Forensic Sciences, Northeastern Association of Forensic Scientists, Pittsburgh Conference on Analytical Chemistry and Applied Spectroscopy, SciX, and the Eastern Analytical Symposium.

Citations

- 1) Gang Used 3D Printers for ATM Skimmers. (2011, September 20). Retrieved February 16, 2019, from <https://krebsonsecurity.com/2011/09/gang-used-3d-printers-for-atm-skimmers/>
- 2) Coyne, A. (2013, August 15). Criminals use 3D-printed skimming devices on Sydney ATMs. Retrieved February 16, 2019, from <https://www.itnews.com.au/news/criminals-use-3d-printed-skimming-devices-on-sydney-atms-353590>
- 3) Man jailed after found with 3D-printed gun and 'lawmaker hit list'. (2019, February 14). Retrieved February 16, 2019, from <https://www.bbc.com/news/world-us-canada-47243007>
- 4) Polymers and Plastics. (n.d.). Retrieved January 20, 2019, from <https://www.bruker.com/applications/chemical/polymers.html>
- 5) Snively, C., & Koenig, J. (2017). IR and Raman Spectroscopies, Polymer Applications ☆. *Encyclopedia of Spectroscopy and Spectrometry*, 365-371. doi:10.1016/b978-0-12-409547-2.11315-0