University of New Haven
HENRY C. LEE COLLEGE OF CRIMINAL JUSTICE AND FORENSIC SCIENCES

Vibrational Spectroscopic Analysis of 3D Printed Polymers Pre- and Post- Manufacturing

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Introduction

3D printing technology has become increasingly affordable and accessible in the past decade. This allows a much more diverse population access to the technology. 3D printing has a wide range of productive applications from at-home hobbyists to the medical field. Unfortunately, the ability to manufacture illegal items also exists. Among these items are ATM skimmers, firearm components, and IED components. Currently, there is not a known and validated method for comparing manufactured items to a pre-manufactured spool of filament.

The goal of this research is to:

- Determine if there are measurable chemical difference pre-and post- manufacturing in 3D printed polymers;
- Assess the significance of any changes observed.

Methods and Materials

- MakerBot brand Polylactic Acid (PLA) was the polymer studied
- Samples produced in 8 different colors, 3 different temperatures (200°C, 215°C and 230°C)
- 3 areas sampled per sample for a total of 9 observations per color for post-manufacturing
- 5 samples taken at 24-inch increments for each color for pre-manufacturing
- Samples analyzed using both Fourier Transform-Infrared (FT-IR) and Raman spectroscopy
- Data was graphically plotted and statistically analyzed with ANOVA

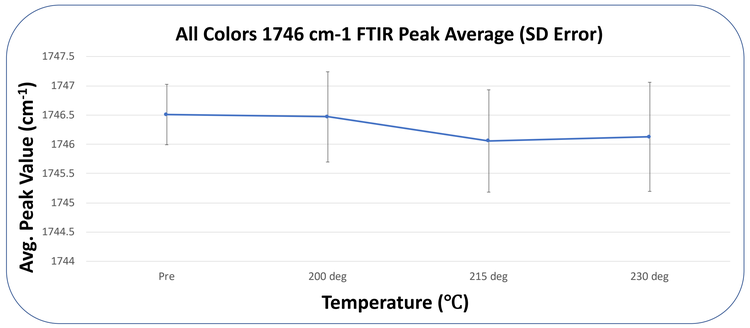
Figure 1: Rolls of PLA filament used in the research

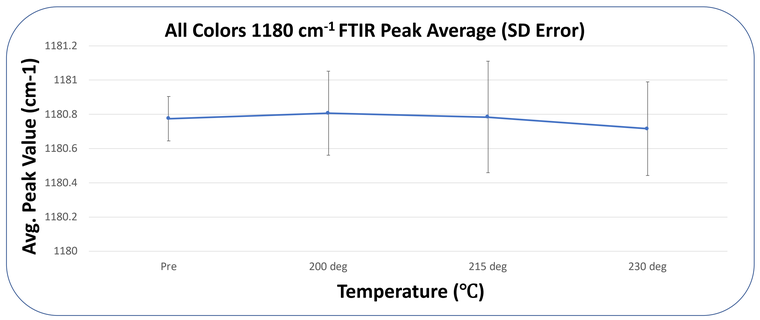
Results

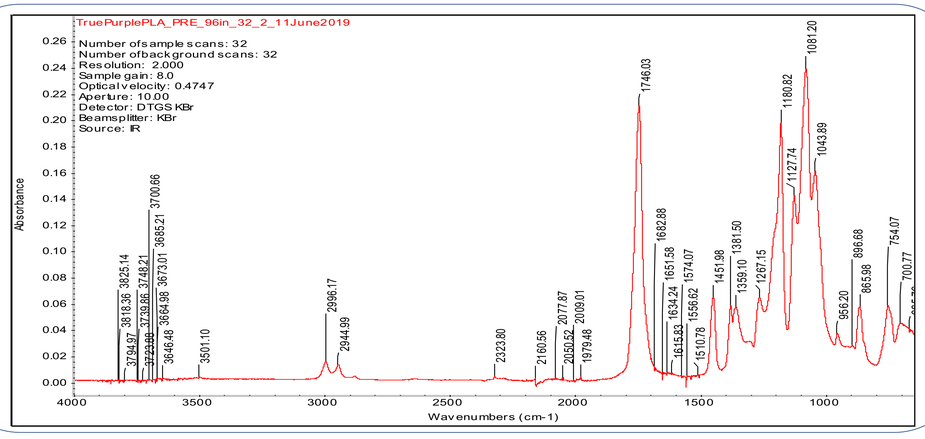
The main results of the research were:

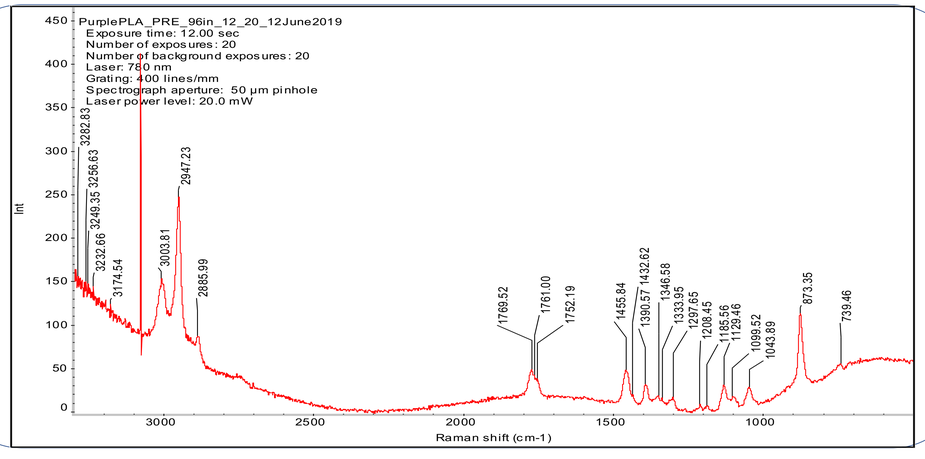
- A majority of data did NOT show significant changes pre- and post-manufacturing;
- No one temperature showed more significant changes than any other temperature;
- Natural (Clear) PLA exhibited less significant changes than other colors;
- Orange PLA exhibited more changes;
- Peak 1452 cm-1 showed the most significant changes for FT-IR analysis.
- 64.58% of analyzed peaks did NOT show significant changes.

Changes which were observed were analyzed using ANOVA to determine statistical significance. For FTIR, 64.58% of analyzed peaks showed NO significant changes.









Discussion & Conclusions

It was concluded that there are no consistent statistically significant changes in the vibrational spectra of PLA pre- and post- manufacturing. This indicates that if a 3D printed object is evidence in a crime, it can be analyzed and directly compared to a pre-manufactured spool of filament because there is no chemical change in the polymer due to the 3D printing process. Future research will consist of similar analysis of other polymers (e.g., ABS). Also, the discrimination potential of FT-IR and Raman spectroscopy for 3D polymers will be explored. Vibrational spectroscopy will be useful for identifying not only the polymer, but also additives and pigments which have the potential to discriminate between different blends used by different manufacturers.

Figures 2, 3, 4 and 5: The top graph shows peak 1746 cm^{-1} average location for all colors at various temps. The top-middle graph shows peak 1180 cm^{-1} average location for all colors at various temps. This illustrates the lack of consistency. The top spectrum shows an example of an FTIR spectrum for Purple PLA and the parameters used. The bottom spectrum shows an example of a Raman spectrum for Purple PLA and the parameters used

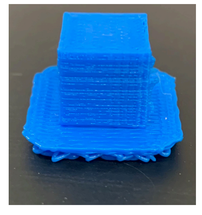


Figure 6: Example of a post-manufacture 3D printed sample, made with blue PLA.

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