

Designing A Biodegradable Biomaterial for Controlled Drug Delivery in Orthopedic Surgery

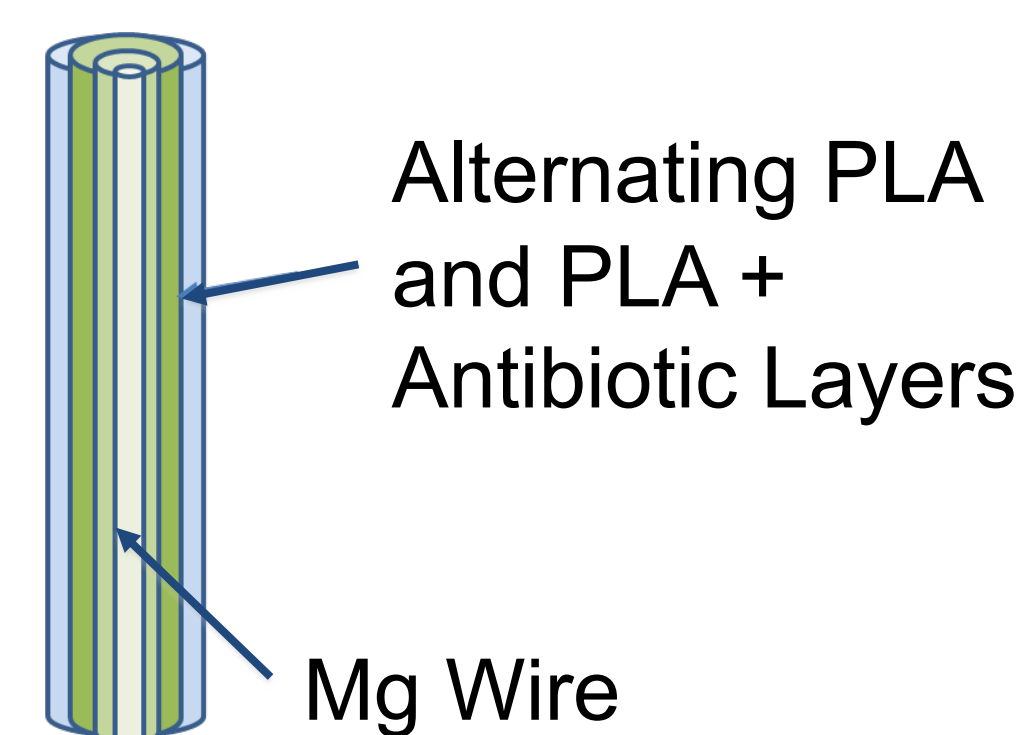
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Objectives

The objective of the research was to design a biocompatible, biodegradable magnesium + PLA biomaterial for controlled drug delivery to replace the current standard stainless steel + PMMA:

- 1) Deliver antibiotics at a desired elution rate
- 2) Reduce inflammation at the wound site
- 3) Favor bone growth
- 4) Provide structural support



Background and Methods

Background.....

What is Osteomyelitis?

It is an infection within the bone caused by staphylococcus aureus.



PMMA as a Drug Delivery Systems

Polymethyl methacrylate (PMMA) is non-biodegradable polymer which is mixed with the antibiotic, Vancomycin. In current systems, PMMA tends to burst release the antibiotics and it is very difficult to remove.

What Can We Do?

By switching from Stainless Steel rods and PMMA/Vancomycin beads to Magnesium rods coated with PLA/Vancomycin layers, we can enable a single surgery and a more consistent local delivery of antibiotics.

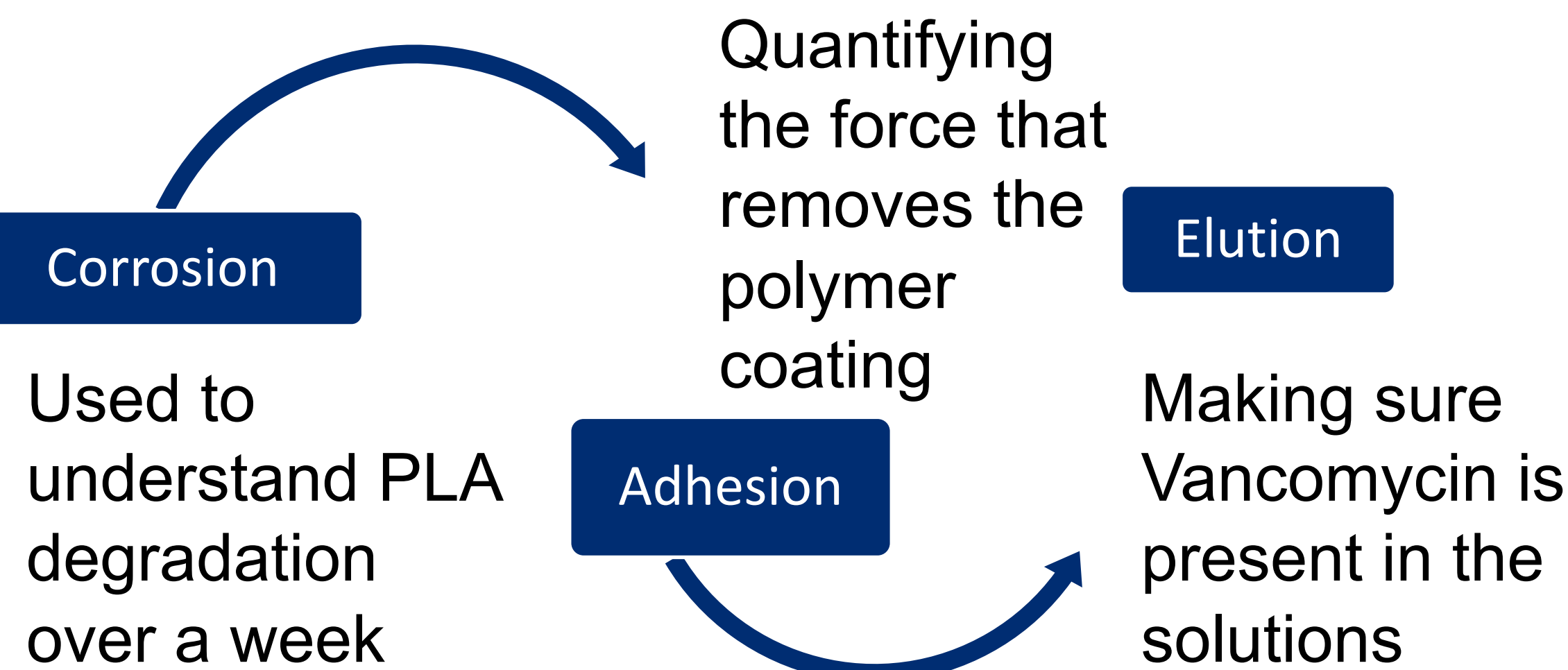
Methods.....

Initial Plan

Dip coating was used to apply PLA layers onto the rods but the coatings were inconsistent in thickness and could not layer effectively.

Current Plan

Creating samples with different concentration of PLA and Vancomycin



Electrospinning



Figure 1. Side by side of different electrospun stainless steel rods of a diameter of 0.0031 in. From left to right, PLA 5%, PLA 8%, PLA 10%, PCL 10%, PLA 5% with 1 w.t. % Vancomycin, PLA 5% with a 4:1 ratio of DCM to Isopropanol with 1 w.t. % Vancomycin, PLA 5% with a 1:1 ratio of DCM to Isopropanol with 1 w.t. % Vancomycin.

Adhesion Testing

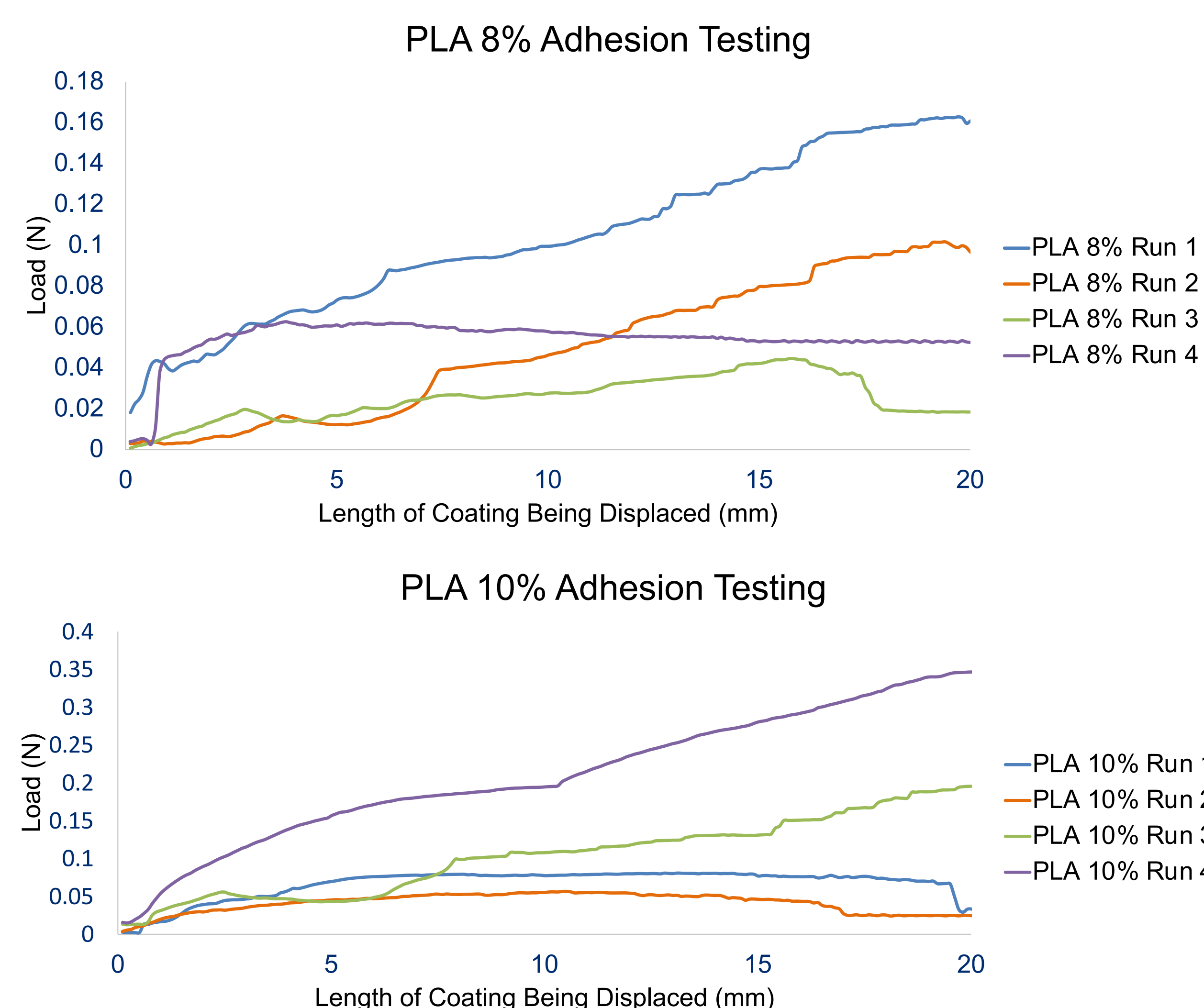


Figure 2 (a) & (b). To mimic the act of inserting the rod into the femur, a 3D block was printed with a hole of diameter of 1.25mm. Using the MTS we pulled an uncoated end of the wire through the hole to strip the coating off of the coated end of the wire. There was variability between the samples but the maximum load ranged from <0.05N to 0.4N.

Corrosion Testing

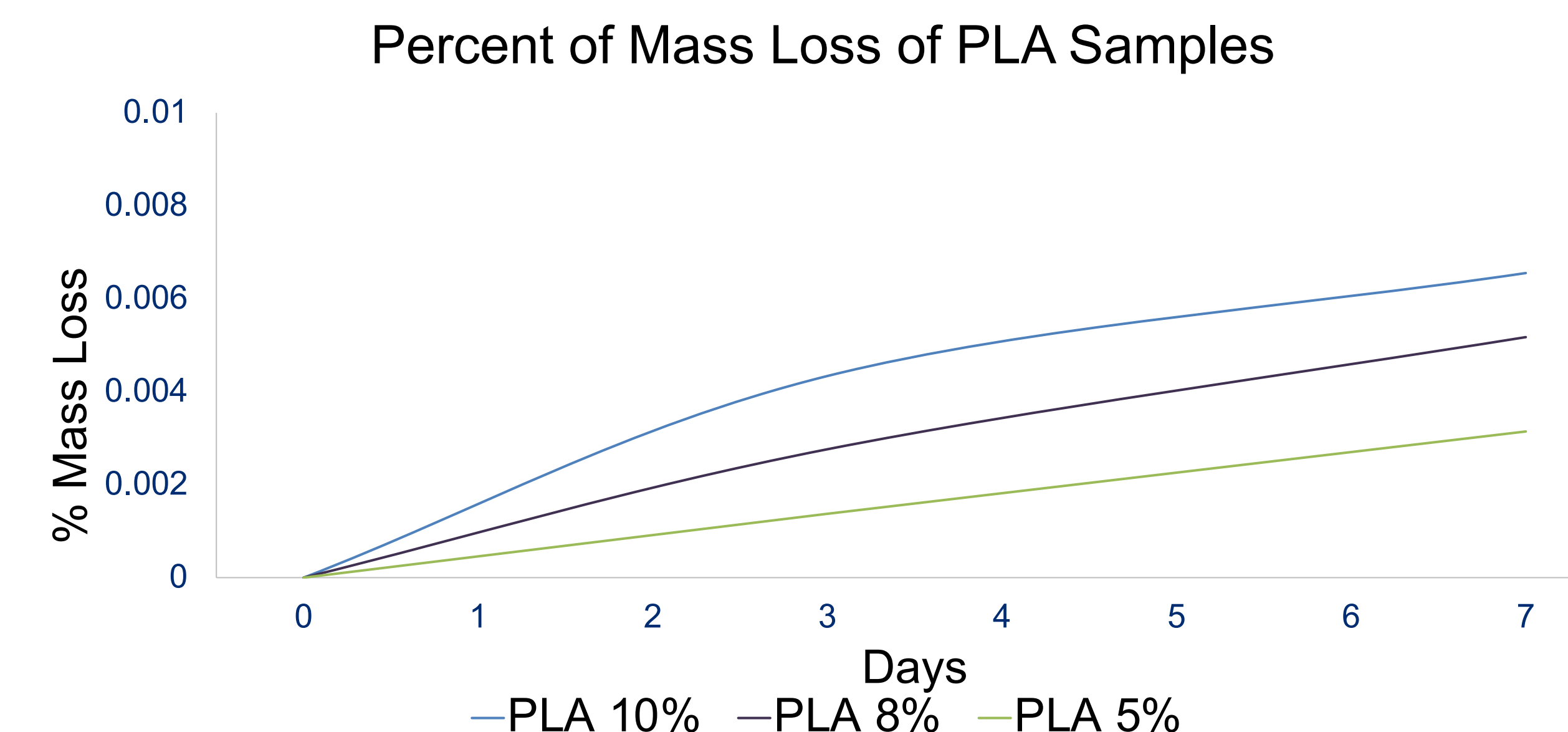


Figure 3. Data was collected over a 7 day period in a water bath with modified SBF for PLA 5%, 8%, and 10%. The corrosion rates ranged from 0.014828 g/mm²·hr for 5%, 0.015091 g/mm²·hr for 10%, 0.016903 g/mm²·hr for 8%.

Elution Testing

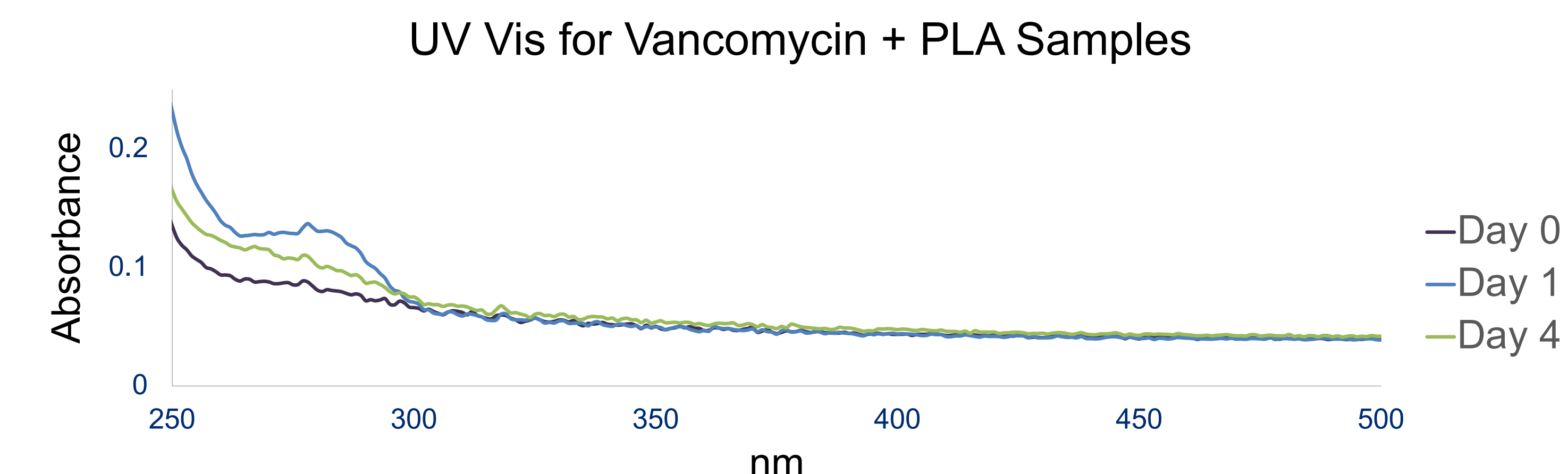


Figure 4. UV Vis was utilized to analyze the elution rates of Vancomycin from the electrospun samples. Vancomycin intensity peaks at 281nm according to previous studies. Comparing the samples, Day 1 has the clearest Vancomycin peak indicating that the release of antibiotics is present.

Conclusions and Future Directions

- The percent mass loss for the PLA samples ranged from 0.002% to 0.006% over a week period
- Forces to remove the coating ranged from <0.05N to 0.4N
- Vancomycin was present at Day 1 in the m-SBF and our methods did not deactivate Vancomycin

Overall, this study provides a baseline for future experiments and out methods require further optimization. Initial steps would be decreasing PLA concentrations to 1 and/or 2%, conducting future studies with the layering technique, and translating studies to magnesium.

References

"Osteomyelitis: Medlineplus medical encyclopedia image," n.d.
M. Ascencio, M. Pekguleryuz, S. Omanovic, "An investigation of the corrosion mechanisms of WE43 MG alloy in a modified simulated body fluid solution: The influence of Immersion Time," 2014.