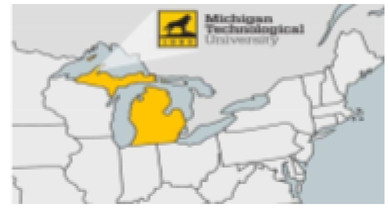
Michigan Technological University
Materials Science and Engineering



Richard Witte Endowed Professorship
2025 Annual Report

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In the 2024/2025 academic year, our research focused on the formulation, processing, and characterization of magnesium (Mg) and zinc (Zn) alloys using a novel rapid solidification technology developed at Michigan Technological University. The aim was to improve this technology while producing high-quality samples suitable for biomedical applications. Additionally, we explored the formulation and characterization of bioactive mussel-inspired polydopamine coatings that incorporate metal ions.

Significant progress was made following the recruitment of a visiting professor with extensive experience in biodegradable medical materials and implants. We also welcomed two new PhD students: one focusing on the rapid solidification of Zn alloys for medical applications and the other working on the development and testing of new bioactive polymeric coatings. Their research activities received partial funding from the Richard Witte Endowed Professorship.

We prepared two Mg-based alloys using our innovative rapid solidification (melt spinning) technique and characterized them to assess their suitability for bioresorbable cardiovascular implants. The melt-spun alloys displayed a significant reduction in grain size, as well as a decrease in the size and content of secondary phase particles compared to cast samples. The particles in the melt-spun alloys measured between 50-100 nm, a size not achievable through traditional casting. Additionally, the melt-spun alloys exhibited greater yield and ultimate tensile strength.

Our research also investigated the application of melt spinning, followed by hot extrusion, for Zn-based alloys. The alloys produced have fine-grained, homogeneous microstructures that offer superior mechanical properties and improved corrosion uniformity. The melt-spun alloy demonstrates a significant increase in ductility while maintaining high strength, as well as reduced corrosion rates and more uniform degradation compared to cast counterparts. Achieving this synergy of properties in Zn-based alloys represents a significant advancement for biodegradable applications.

Bioactive polymer-metal ion coatings on biodegradable implants can significantly enhance biocompatibility and support vascular remodeling through controlled metal ion release. In our study, we applied mussel-inspired polydopamine (PDA) coatings loaded with copper ions (PDA-Cu^{2+}) to Zn implants using an immersion method. Copper ions catalyze the generation of nitric oxide from donors, which helps reduce platelet and inflammatory cell activation. We optimized and characterized coating conditions such as pH and solution composition to produce a homogeneous PDA-Cu^{2+} layer, enhancing the surface properties and corrosion resistance of the metal. This suggests improved control over degradation for vascular stenting implant applications.

In the 2025/2026 academic year, we plan to further refine the melt spinning and consolidation process to enhance the corrosion properties of alloys produced through this rapid solidification method.