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Ph.D. DISSERTATION DEFENSE

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Date:	December 7th, 2026
Time/Location:	1:00 – 3:00 pm, Academic Gateway South 121
Title:	Fabrication of Composite Scaffolds for Bone Tissue Engineering Applications
Chairperson:	Dr. Hongjun Wang, Department of Biomedical Engineering, School of Engineering and Science
Committee Members:	Dr. Jinho Kim, Department of Biomedical Engineering, Charles V. Schaefer, Jr. School of Engineering and Science Dr. Shang Wang, Department of Biomedical Engineering, Charles V. Schaefer, Jr. School of Engineering and Science Dr. Saul Weiner, Emeritus Professor, Rutgers School of Dental Medicine

ABSTRACT

Repairing large bone defects that exceed the natural bone regenerative capacity remains a significant clinical challenge. Although autologous bone grafting is considered the gold standard for treating such defects, limitations associated with donor site morbidity, restricted availability, and additional surgical procedures have motivated the development of alternative approaches. Bone tissue engineering (BTE) has emerged as a promising strategy through the development of biomaterial-based scaffolds capable of supporting osseous tissue formation. Polycaprolactone (PCL) has attracted considerable attention for BTE due to its biocompatibility and slow biodegradability. However, the limited intrinsic bioactivity of PCL restricts its osteogenic potential, necessitating the incorporation of biologically active components. Furthermore, conventional 3D-printed scaffolds may not adequately accommodate irregularly shaped bone defects, highlighting the need for adaptable scaffold systems. To address these challenges, this dissertation research explored frontier technologies to fabricate polymer–ceramic composite biomaterials for BTE: 3D-printed PCL–Laponite (LAP) scaffolds and polymer–ceramic composite microspheres. The first approach focused on the incorporation of high concentrations of LAP into PCL while ensuring its dispersion uniformity and printability. Upon systematic investigation, composite formulation containing up to 50 wt% LAP demonstrated to be effective in regard to dispersion uniformity, high mechanical properties, favorable degradation, and osteogenic activity. Favorable osteogenic tissue formation was also observed with 3D printed scaffolds with 50 wt% LAP-PCL composite. Building on this material-development strategy, the second approach investigated polymer–ceramic composite MSs as injectable scaffolding materials, particularly for bone defects with irregular geometries. Pristine PCL, PCL–hydroxyapatite (HAp), and PCL–LAP MSs were fabricated and compared for their morphology, structural difference and biological activities. Collectively, the two approaches demonstrate strategies for tailoring inorganic composition, fabrication methods, and scaffold architecture to address different requirements in BTE. The development of high-LAP-loading PCL composites and PCL-based MSs containing different inorganic additives contributes to the

development and evaluation of composite biomaterials with potential applications in bone tissue regeneration.