Toward Precision Medicine: Designing Injectable, Conductive Graphene-Doped Hydrogels and Robust Computational Models for Post-MI Cardiac Tissue Engineering and Drug Discovery

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In 2017, over 8 million people around the world will die of cardiac diseases, most often induced by myocardial infarctions (MIs) and cardiomyopathies. Current treatment options, including heart transplants, are often inaccessible for the majority of patients and fail to remediate the significant loss of heart function that comes with post-MI cardiac scarring. The advent of induced pluripotent stem cells (iPSCs) has paved the way for patient-specific tissue constructs to be created in vitro; as these stem cells are differentiated into beating patches of cardiomyocytes (CMs), the most important constituent cells of heart muscle, they can be applied towards transplantation therapy and in vitro drug discovery. In this study, I engineered novel, low-cost gelatin-NIPAM-graphene (nG) and graphene oxide (nGO) hydrogels to support cardiac tissue engineering and drug discovery. Made of biocompatible and biodegradable gelatin, the hydrogels were enzymatically cross-linked to achieve physiological stability and tunable mechanical and tensile toughness. Due to the incorporation of nG and NIPAM, the gels were conductive, mimicking the heart's native environment, and fast-gelling, to support non-invasive, injection-based myocardial delivery of cells. iPSCs were highly proliferative on the hydrogels and were successfully patterned into uniform colonies, ideal for drug testing applications. Furthermore, I designed novel computational tools to rapidly analyze and classify calcium transients from normal and diseased CMs, as well as to evaluate the contractile phenotypes of beating tissue constructs using robust vector calculus models. Overall, I was able to engineer novel gelatin-NIPAM-graphene hydrogels and new, powerful computational tools to enhance precision cardiovascular medicine.

Awards Won:

Serving Society Through Science: Second Award of $500