DREXEL UNIVERSITY
Materials Science and Engineering
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Department of Materials Science and Engineering,

PhD Thesis Proposal

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Complex Nanofiber Architectures for Directing Biomimetic Mineralization

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Bone is a complex composite tissue with a structural and biological function closely tied to its hierarchical nanostructure. It is composed of a matrix of collagen fibrils with evenly distributed, oriented hydroxyapatite (HAP) nanocrystals throughout. While the close interface between the organic and inorganic components lends bone its mechanical strength and toughness, these properties can be challenging to replicate in a synthetic bone replacement material. Current synthetic bone scaffold designs typically involve pre-fabricated HAP being added to a polymer matrix or a surface coating of mineral being deposited, neither of which lead to precise control over the mineral formation or a strong interface between the phases. Therefore, a promising solution is to design materials that can mineralize into a structure that mimics bone on the nanoscale. An architecture called a nanofiber shish-kebab (NFSK) has been shown to effectively control both the distribution and orientation of minerals on electrospun fibers. However, NFSKs have drawbacks such as low mineral content and HAP orientation perpendicular to what is found in natural bone. To address both concerns, the proposed work will seek to mineralize electrospun fibers into a biomimetic structure. When formed into NFSKs, we expect these hierarchical materials to have mechanical properties that exceed those of other fibers with a similar mineral content. The project will be broken into three major components: first, different polymer chemistries and electrospinning techniques will be used to form fibers and NFSKs with polyelectrolyte domains in a variety of geometries. Next, the mechanism of polymer mineralization will be explored using poly(caprolactone)-*block*-poly acrylic acid (PCL-*b*-PAA) single crystals, which will inform how the copolymer NFSKs are mineralized. Finally, the fibers will be mechanically tested to check the influence of mineral structure on scaffold strength and toughness. We expect that by increasing the NFSK mineral content and controlling mineral formation within oriented domains along the fiber *c*-axis, the mechanical properties can be improved. This work will increase knowledge in the biomineralization field about how polyelectrolytes can be controlled to direct mineralization, as well as designing a material that is easily processed and mimics the structure of natural bone.