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Nanoparticle-reinforced biopolymers for applications in orthopedic regenerative engineering

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Synthetic and natural biopolymers, such as polylactides/polyglycolides or chitosan, are increasingly replacing steel or bone cement as biomaterials for orthopedic surgery and regenerative engineering. Amongst the major issue is the dichotomy between mechanical strength and bioactivity of these biomaterials. Synthetic materials often exhibit sufficient mechanical strength, but lack bioactivity to promote tissue regeneration, while some of the natural materials, specifically chitosan, have excellent bioactive features, but lack the necessary mechanical strength to serve as useful materials in bone tissue engineering. In this presentation we will discuss the critical role that nanoparticles can play in modulating the mechanical properties and bioactivity of biodegradable biopolymers. As first examples we will describe the incorporation of hydroxyapatite (HA) nanoparticles into electrospun chitosan fibers, which renders this material mechanically suitable for non-weight bearing applications in maxillofacial orthopedic surgery. Specifically we will demonstrate that HA-containing chitosan scaffolds are both osteoinductive in vitro and osteoconductive in vivo and catalyze the de novo bone formation tissue regeneration in a mouse model of critical size calvarial defects. As a second example, we will describe the use of carbon nanodiamond (CND) particles to modulate the mechanical properties of polylactides, such as PLLA, used as biodegradable biomaterials for interference screws that are commonly employed in the surgical repair of tendons and ligaments. Inclusion of CND reinforced the mechanical properties PLLA and specifically reduced its brittleness and improved its ductile properties. Surprising, addition of CND also significantly enhanced the bioactivity of PLLA, as inferred from the acceleration and increased levels of biomineralization.

Biography

Peter I. Lelkes, PhD, FAIMBE, is the Laura H. Carnell Professor and Founding Chair of the Department of Bioengineering in the College of Engineering at Temple University and the Inaugural Director of the Institute for Regenerative Medicine and Engineering (TIME) at Temple University's School of Medicine. From 2000-2011 he was the Calhoun Chair Professor in the School of Biomedical Engineering at Drexel University in Philadelphia. Dr. Lelkes, who received is PhD in 1977 from RWTH Aachen Germany, has published more than 175 peer-reviewed papers and 45 book chapters and made more than 400 presentations nationally and internationally.

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