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Characterization of Carbon Nanotube Reinforced Polymer Scaffold for Bone Tissue Engineering

Paiyz Mekael, Joysurya Basu*, N. Syam, Cato Laurencin and C. Barry Carter*

Department of Orthopaedic Surgery, University of Connecticut School of Medicine, Farmington, CT, USA
* Department of Chemical, Materials & Biomolecular Engineering, University of Connecticut, Storrs, CT, USA

Bone is a mechanically challenged tissue. Efforts to repair or regenerate bone tissue via scaffold based bone tissue engineering approach require biodegradable scaffolds with bone compatible mechanical properties. Continued efforts in the field have resulted biologically compatible scaffold varieties, but none of them have shown bone matching mechanics. Therefore, we proposed to develop polymer scaffolds comprising of mechanically robust, water soluble carbon nanotubes in order to achieve biodegradable scaffolds with soft bone matching mechanical properties.

The object of this research work is to improve polymer graft mechanical properties by reinforcing them with functionalized carbon nanotubes. It is expected that functionalized carbon nanotubes released by the scaffolds are water dispersible and can easily get cleared from the body.

Even though the mechanical reinforcement via carbon nanotubes was evident through other studies [1-3], nondegradable nature of carbon nanotubes discouraged their use in biodegradable scaffolds. Therefore, we for the first time propose biodegradable polymer-water dispersible carbon nanotube composite scaffolds, which can show compressive modulus and strength in the range of human cancellous bone for tissue engineering applications.

The biodegradable polymer used in this study is poly(50 lactide-co-50 glycolide) commonly referred as PLGA 50/50. Polymer spheres of this material were made with reinforcement of carbon nanotube in varying volume fraction. The spheres were often etched with chloride solution for different length of time. The cell growth behavior has been studied on the nanotubes reinforced spheres and the behavior of the spheres has been studied in simulated body fluid. The spheres and the scaffolds have been characterized by FEI Strata 400s Dual Beam FIB. While characterizing the surfaces the FIB was operated in SEM mode under an accelerating voltage of 2keV. In order to characterize the cross-section of the spheres and the scaffolds, they were initially FIB cut and then characterized.

It has been observed that carbon nanotubes are dispersed on the surface of the spheres more or less uniformly. Once in a while clusters of nanotubes are observed (Figure 2). In the FIB section homogeneous distribution of carbon nanotubes was not observed. In the scaffolds, it has been observed that the polymer spheres sinter together to form neck. Initial studies of cell growth behavior and the behavior of the scaffolds in simulated body fluid appear promising (figure1).

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References

[1] N. Syam et al., Biomaterials 29 (2008) 4100
[2] N. Syam et al., Biomacromolecules 9 (2008) 1818
[3] N. Syam et al., Biomedical Nanostructures, John Wiley & Sons Inc. (2007) 371
[4] The authors would like to acknowledge the University of Connecticut for support for this research.

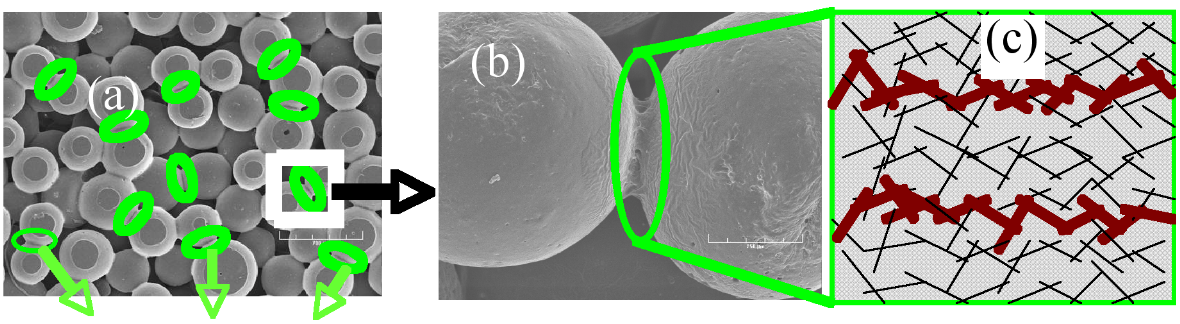

Figure 1: Microstructure of (a) sintered PLGA matrix. The arrows represent the mechanically weak regions and (b) microsphere to microsphere contact region in a PLGA-water soluble carbon nanotube composite matrix. (c) A schematic showing carbon nanotube dispersion and the microsphere-microsphere joint reinforcement. Proposed work is to fabricate biodegradable composite grafts with human cancellous bone matching mechanical properties for effective bone defect repair.

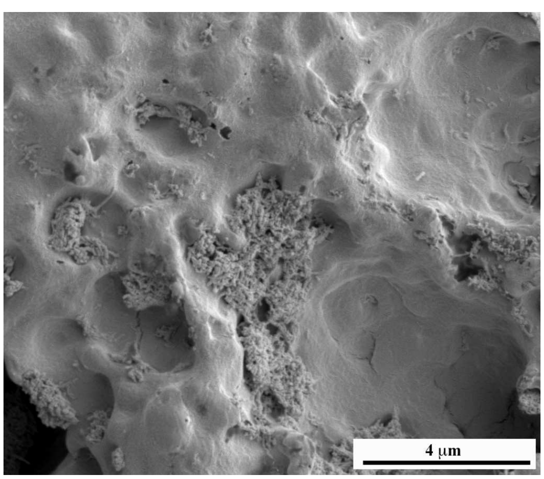

Figure 2: SEM image of carbon nanotube on PLGA spheres.