

# The Effect of BMP-2 Loaded PDO Nanospheres and Nano Hydroxyapatite in PCL Scaffolds for Bone Regeneration

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## Introduction

Biomaterial scaffolds have been used to create a three-dimensional structure support to induce directed cell behavior and support tissue growth. Since natural tissue are nanometer in dimension [1], incorporation of biomimetic nanomaterials within three-dimensional scaffolds can mimic surface properties of natural tissues, increase protein adsorption and increase the scaffolds' bioactivity. In this study, we will design novel nanostructured scaffolds for bone and osteochondral tissue engineering applications. For this purpose, we will fabricate novel poly(dioxanone) (PDO) spheres with BMP-2 growth factors via an electro spraying method and synthesize biomimetic nanocrystalline hydroxyapatites (nHA) for directing MSC functions and improving bone growth.

## Materials and Methods

Novel PDO spheres with encapsulated BMP-2 and bovine serum albumin (BSA) were prepared via a novel electro spraying method, (Figure 1) and nHA was synthesized via a wet chemistry method with a hydrothermal treatment. The hydrothermally-treated nHA and PDO spheres with encapsulated BMP-2 were incorporated into the porous PCL scaffold and human bone marrow derived mesenchymal stem cells (MSCs) adhesion on the scaffolds was evaluated.

The nanoscale bone scaffolds were made of a base polymer material and two co-porogens that were leached away to leave a highly porous scaffold made only of the base polymer material. In this case, the base material is poly(caprolactone) (PCL), and the co-porogens are NaCl and poly(ethylene glycol) (PEG) in a 38:38:24 weight ratio of PCL: PEG: NaCl. Furthermore, we cast a cartilage layer on the top of the bone scaffold in order to form a biphasic osteochondral scaffold as illustrated in Figure 2.

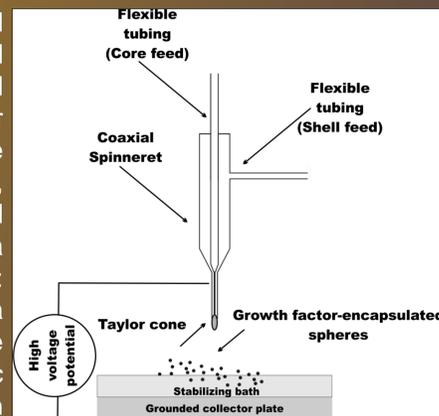


Figure 1: Diagram of novel nanosphere fabrication method involving coaxial electro spraying into a stabilizing, surfactant containing bath.

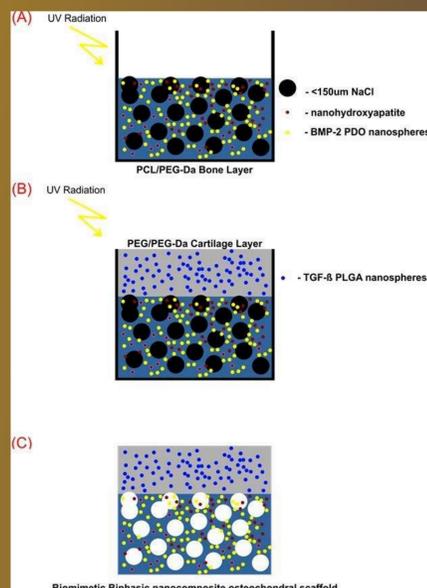


Figure 2: Biphasic scaffold created through modified porogen leaching.

## Results

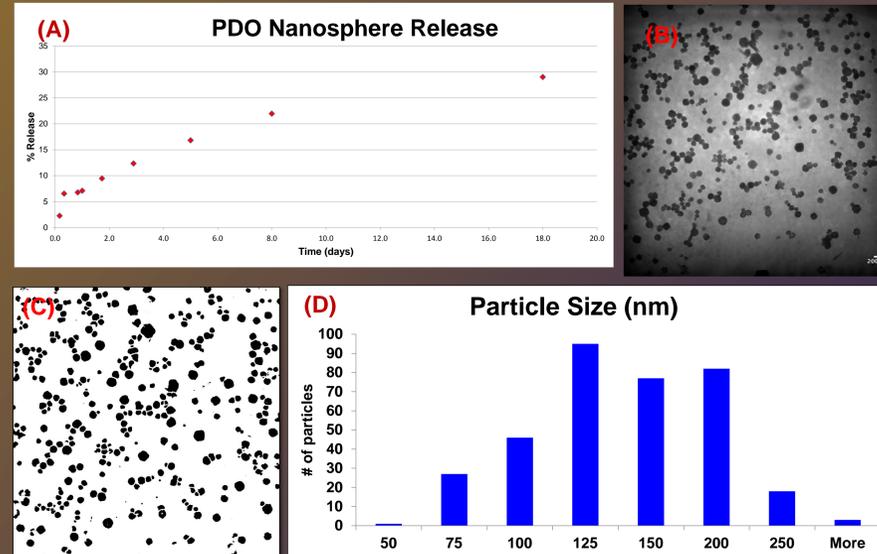


Figure 3: (A) A slow BSA release profile of PDO nanospheres with >70% encapsulation efficiency. (B) TEM image of PDO nanospheres. (C) Processed binary image of PDO nanospheres used to create (D) bar graph of distribution of radii of PDO nanospheres.

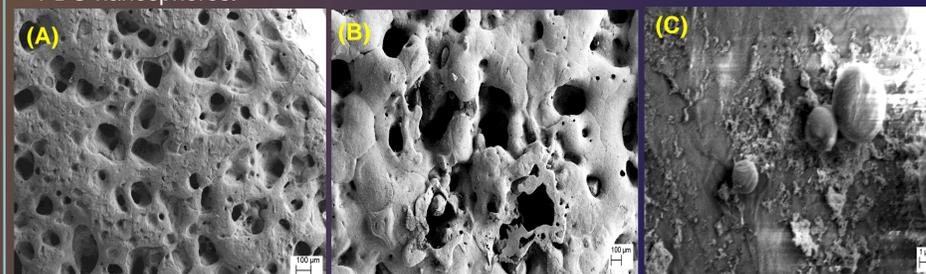


Figure 4: SEM images of (A) Porous PCL bone scaffold. (B) PCL scaffold with embedded PDO nanospheres and 20% nHA at low magnification and (C) at high magnification.

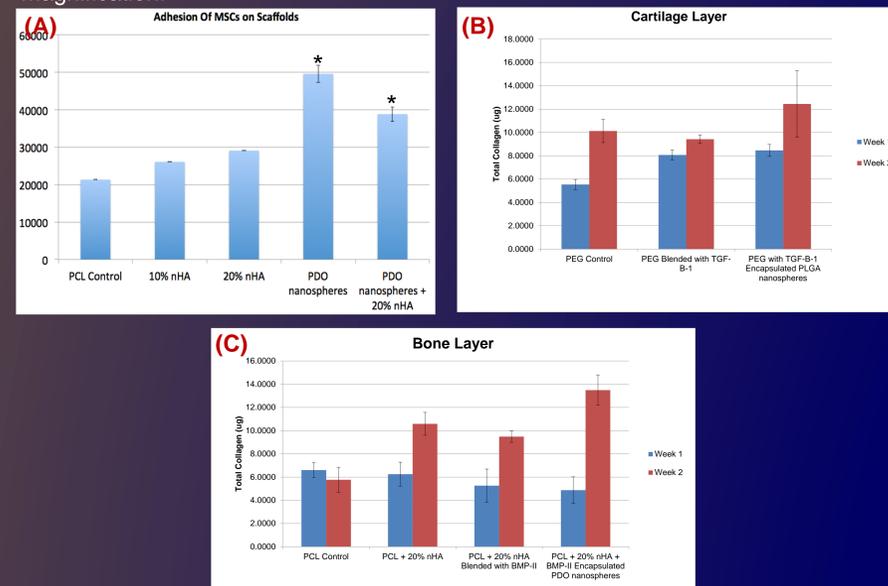


Figure 5: A. Enhanced human mesenchymal stem cell adhesion on PCL scaffold with PDO nanosphere and 20% nHA, Data are mean ± SEM, n=9; \*p<0.05 when compared to all other samples. B and C Total Collagen evaluated on Cartilage and bone scaffolds respectively during a 2 week differentiation study.

## Results

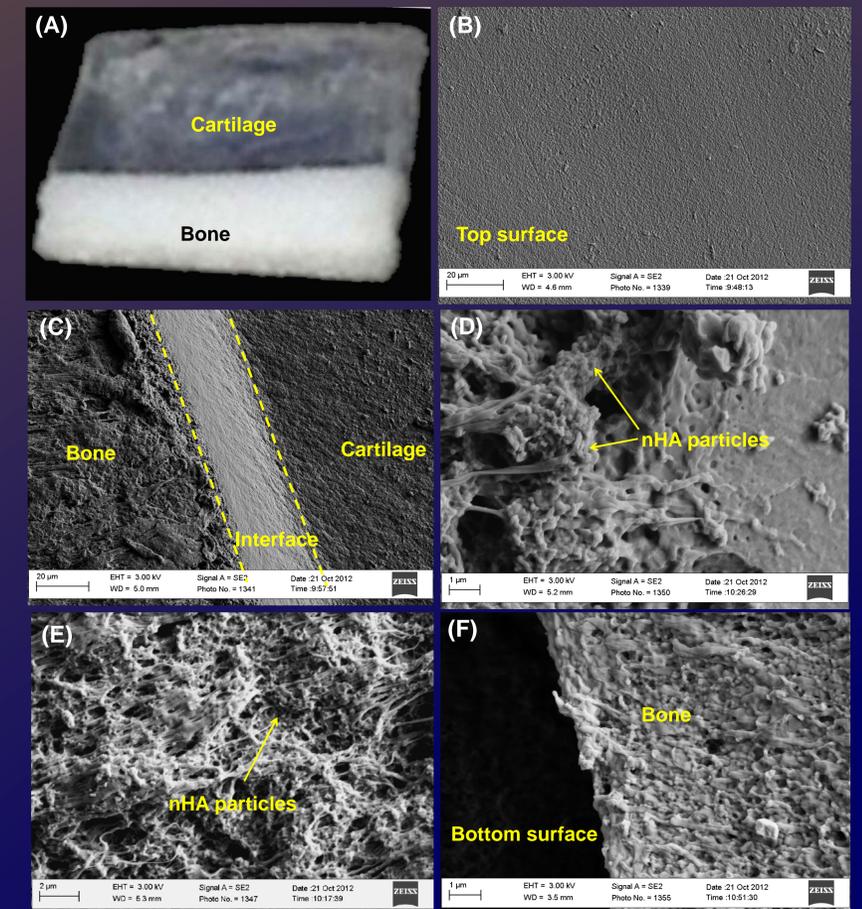


Figure 6: (A) Photo image of the biphasic PCL-PEG-DA osteochondral scaffold. (B-F) SEM images of osteochondral scaffold, from cartilage layer to bone layer.

## Conclusion

Our novel PDO nanosphere design allows for a sustained release of bioactive factors which make it promising to overcome the initial burst release of traditional delivery systems. We also observed a highly interconnected pore structure revealed by SEM imaging in our co-porogen leached scaffolds. The MSC adhesion result shows that combining porous PCL scaffolds with biomimetic nHA and novel electro sprayed PDO nanospheres with sustained BMP-2 release can significantly improve the scaffold cytocompatibility, thus warrant further exploration for bone regeneration. Finally, our preliminary result in a novel osteochondral scaffold design shows a well integrated biphasic scaffold with biomimetic bone layer and cartilage layer.

## Acknowledgements

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## References

[1] Zhang, L., et al. *Nanotoday*, 2009; 4(1):66-80.