Melt-electrowriting of Electrically Conductive Composite Biomaterial for Bone Tissue Engineering

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INTRODUCTION:

Bone-related injuries continue to be a growing concern within the healthcare community. These issues are exacerbated in elderly populations since the incidence of bone-related issues increases along with decreased healing capacity. To resolve this problem, we propose fabricating three-dimensional (3D) scaffolds made by electroconductive polymers to promote bone regeneration. Electrical stimulation has been shown to upregulate growth factor expression, and accelerates tissue repair[1]. As such, we aim to synthesize an “electroconductive polymer ink” by combining polycaprolactone (PCL) with Poly(3,4-ethylenedioxythiophene) (PEDOT) to create 3D scaffolds using melt-electrowriting. Melt-electrowriting is a novel high-resolution technology for creating predefined micrometric fibers where geometries can be customizable [2]. Osteoblast cell lines will be used to determine if effective bone cell proliferation is possible on the scaffold.

[1] Clark D. et al. (2017), Curr Osteoporos Rep.
[2] Aleem IS. et al. (2021), Scientific Reports.

METHODS: PEDOT nanoparticles were synthesized by oxidative polymerization of the 3, 4-ethylenedioxythiophene monomer (EDOT) in the presence of ferric. The morphology and chemical composition of resulting PEDOT was determined using SEM and XPS. PCL was mixed with PEDOT at 5, 10 and 20% weight ratio and melted in a microwave. Composites were loaded into the Axo-A3 3D bioprinter (Axolotl Bio) and melt-electrowriting was conducted using an electrical field of 5 kV. Human osteoblasts were used to test cell adhesion, proliferation, and osteogenic differentiation.

RESULTS: PEDOT nanoparticles were successfully synthesized using oxidative polymerization. A typical compact and globular morphology of PEDOT was observed under SEM. XPS analysis of the C(1s) core spectrum revealed the typical peaks from three distinct types of carbon present in the chemical structure of PEDOT. The 3D fabricated electroconductive scaffold is non-cytotoxic and effectively improved osteoblasts adhesion and proliferation.

DISCUSSION AND CONCLUSION:

Ultimately, prospective scaffolds will be installed within devices that permit electrical stimulation, which, when implanted into an animal or human model, may conceivably promote bone regeneration.