

DOPAMINE-ASSISTED NANO-HYDROXYAPATITE COATING ON 3D PRINTED POLY(LACTIC-CO-GLYCOLIC ACID) SCAFFOLDS

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ABSTRACT

Background: Poly(lactic-co-glycolic acid) (PLGA) as a FDA approved material possesses advantages including tunable degradation rate and wettability. The polydopamine (PDA) assisted nano-hydroxyapatite (PDA-nHA) coating on 3D printed PLGA scaffolds may serve as a means to enhance the surface chemistry and morphology of these scaffolds. However, the traditional PDA treatment is time consuming and the thickness of the PDA coating has been limited to the nanoscale.
Objective: The as-printed PLGA scaffolds were treated in 4 mg/mL dopamine solution (pH=9.5) containing 0.5 wt% nHA at 60ºC. nHA- and PDA-only coatings served as controls, along with the as-printed PLGA scaffolds.
Methods: Comparisons were performed to investigate the surface properties using SEM imaging, EDX elemental quantification, FTIR spectra, and water contact angle analysis.
Results: The PDA and PDA-nHA coatings fully covered the PLGA surface and had consistent thickness with a porous, roughened morphology. The thickest coating (22.11 ± 2.91 μm, coating speed 1842 nm/h) was obtained for PLGA/PDA-nHA, an order of magnitude higher than previously reported. Hydrophilicity as a functional measure of coating efficacy was greatly enhanced on PLGA/PDA-nHA.
Conclusions: This modified coating method promoted effective PDA and PDA-nHA deposition on 3D printed PLGA scaffolds, with improved surface properties that may ultimately enhance cell-material interactions for regenerative applications.
Keywords: 3D printing, Biodegradable, Poly(lactic-co-glycolic acid), Polydopamine, Nano-hydroxyapatite, Coating thickness, Hydrophilicity

Introduction

Treating bone defects following trauma and disease continues to be a challenge for orthopedic surgeons.[1] Autologous bone from a non-load-bearing site, normally the iliac crest, is the gold standard of care but is limited by donor site pain/morbidity and volume of tissue that can be harvested.[2] An alternative strategy is the use of biodegradable thermoplastic polymers, which can be fabricated into unique geometries via 3D printing. However, since the polymer surface is smooth and hydrophobic, cells do not readily interact with the material.[3] Therefore, the development of customized biodegradable scaffolds with improved surface properties and cell-material interactions that mimic native bone is an urgent need.

Poly(lactic-co-glycolic acid) (PLGA), as one of the FDA approved biodegradable polymers,[4] has been extensively studied. The potential of biodegradation and hydrophilicity for PLGA is relatively superior to other polymers in the same family, such as polylactic acid (PLA) and polycaprolactone (PCL), due to more hydroxyl groups on the carbon chain of PLGA. The intrinsic molecular advantages notwithstanding, surface modifications are required to further improve the hydrophilicity and osteoconductivity of PLGA. As an osteoconductive bioceramic material, hydroxyapatite (HA) has comparable structral and chemical properties to those of the mineral phase of the native bone.[5,6,7] However, the brittle nature, poor ductility, and slow degradation rate of pure HA limit its use for bone tissue engineering. Consequently, the PLGA substrate augmented with HA coating is an effective approach to enhance the surface properties of PLGA.