

EFFECTS OF ALKALI TREATMENT TIME ON NANO-HYDROXYAPATITE COATING OF 3D PRINTED POLY (LACTIC-CO-GLYCOLIC ACID) SCAFFOLDS

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ABSTRACT

Poly (lactic-co-glycolic acid) (PLGA) as a biodegradable polymer is advantageous for 3D printing into complicated structures with large volume, providing a solution to overcome the shape and volume limitations of autograft bone for regeneration of large bone defects. To mimic the surface chemistry and morphology of native bone, surface modifications of PLGA are needed. Alkali treatment is an effective wet chemical method that modifies polymer surfaces via the introduction of negative charges, priming them for deposition of hydroxyapatite mineral. Nonetheless, the alkali treatment (AT) time necessary for successful nano-hydroxyapatite (nHA) coating on 3D printed PLGA scaffolds remains unknown. The *objective* of this work was to determine the appropriate alkali treatment time of PLGA surfaces that promotes efficient nHA coating. Our *hypothesis* was that 2-hour alkali treatment would enhance nHA coating of PLGA scaffolds and result in increased hydrophilicity of the material. Prior to 3D printing, the thermal properties of PLGA were investigated. The as-printed PLGA scaffolds were alkali treated in ammonia solution for 1 hour or 2 hours and coated with nHA via solution deposition. Comparisons were performed qualitatively through scanning electron microscopy (SEM) imaging with energy dispersive x-ray spectroscopy (EDX) element mapping, and quantitatively using water contact angle analysis. The printing temperature (145℃) fell in the range of the glass transition temperature (T_g, 42.9 to 47.2℃) and the thermal decomposition temperature (T_d, 244.5℃,) of PLGA. A higher density of nHA was observed on 2-hour AT surfaces compared to both 1-hour AT surfaces and non-treated surfaces. Two-hour AT significantly enhanced the hydrophilicity of PLGA scaffolds. In conclusion, the applied printing temperature successfully printed PLGA porous structures below 244.5℃, the temperature at which material breakdown would be expected to occur. Two-hour AT effectively promoted nHA coating and hydrophilicity of PLGA surfaces, with the goal of improving cell adhesion and osteoconductivity of PLGA scaffolds for bone regeneration applications.

Keywords: 3D printing, biodegradable polymers, poly (lactic-co-glycolic acid) (PLGA), nano-hydroxyapatite (nHA), thermal properties, hydrophilicity, alkali treatment, surface modification, bone regeneration, scaffolds

INTRODUCTION

It estimated that by 2023, around four million bone graft surgeries will be performed globally every year at a cost of 3.4 billion dollars, with over a million of those procedures in the US alone.[1] The global medical costs of these procedures have reached $15 billion each year, and are expected to increase at an annual rate of 13%.[2] Currently, the gold standard for treating bone defects is the use of autograft bone from a non-load-bearing site, normally the iliac crest. Autologous bone largely avoids the limitations associated with allografts, including undesired immune response, infection, and minimal osteoconductivity.[3][4][5][6] Nonetheless, the drawbacks of autografts including limited volume of bone and donor site pain and morbidity still limit their clinical efficacy. Therefore, the development of customized biodegradable scaffolds that mimic the surface properties of native bone is an urgent need.