Nano Architecture Formation from Novel Poly(L-lactic acid)-based Biomaterials

Liu X., and Ma PX.
Department of Biologic and Materials Sciences, School of Dentistry
University of Michigan, Ann Arbor, MI 48109, USA

Introduction

The development of novel synthetic matrix materials as well as suitable scaffolding architecture for tissue engineering applications has long been a challenge. A good scaffolding material should be capable of mimicking certain critical features (including physical architecture and chemical compositions) of natural extracellular matrix (ECM). In this study, we aim at designing and synthesizing a series of novel poly(L-lactic acid)-based (PLLA-based) biomaterials. Besides maintaining the advantageous properties of PLLA, these PLLA-based biomaterials have controllable hydrophilicity-hydrophobicity balance and possess functional groups on the polymer chains which can be further utilized to couple with bioactive molecules. These PLLA-based biomaterials can be used to mimic both the nano-fibrous architecture and chemical compositions of natural ECM, and thus have the potential to be tailored into ideal scaffolds for various tissue engineering applications.

Methods

PLLA-based macromonomers were first prepared by using functional hydroxyalkyl methacrylates or acrylagtes (HAA) as initiators. The PLLA-based copolymers were synthesized by free radical copolymerization of PLLA-based macromonomers and HAA. Nano-fibrous PLLA-based matrices were fabricated by using the thermally induced phase separation technique. The PLLA-based macromolecules and copolymers were characterized by NMR, FTIR, and GPC. The nano-fibrous architecture was observed by scanning electron microscopy (SEM) and transmission electron microscopy (TEM).

Results and Discussion

PLLA-based macromonomers were synthesized by ring-opening polymerization of L-lactide in the presence of HAA as initiators (Figure 1). The molecular weight of the macromonomer was controlled by varying the initiator-to-monomer molar ratio. The macromonomers were further copolymerized with HAA to yield graft copolymers via free radical polymerization (Figure 1). The molecular weights of the graft copolymers ranged from 10 kD to 40 kD, and did not show significant difference with the ratios of macromonomer/monomer.

Nano-fibrous porous matrices were created from the novel PLLA-based copolymers by using a thermally induced phase separation technique (Figure 2). These synthetic nano-fibrous matrices mimicked the physical architecture of natural collagen. The diameter of the fibers ranged from 50 to 500 nm, which was the same diameter range of natural collagen fibers.

The nano-fibrous architecture was controlled by macromonomer composition, copolymer composition, and solvent composition. The surface wettability of the nanofibers was controlled by copolymer compositions. Nano spheres from the PLLA-based graft copolymers were also prepared by using a simple coacervation and dialysis method.

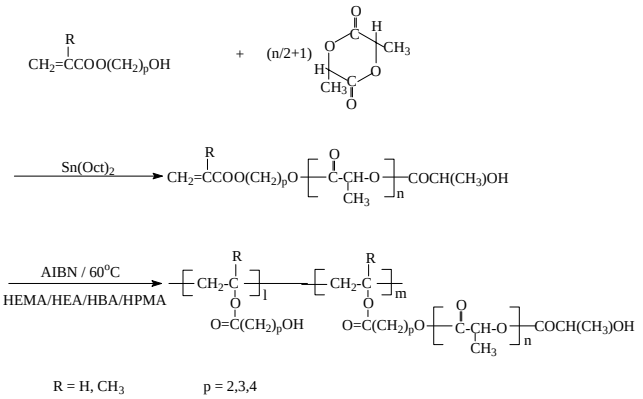

Figure 1. Synthesis of PLLA-based macromonomers and copolymers

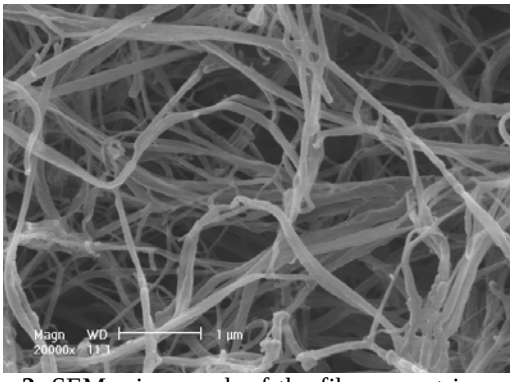

Figure 2. SEM micrograph of the fibrous matrix prepared from PLLA-based copolymer, scale bar=1 μm.

Conclusions

A series of novel PLLA-based functional copolymers have been synthesized and characterized. These PLLA-based copolymers can be fabricated into biomimetic nano-fibrous matrices as well as other nano and micro structures. The novel PLLA-based copolymers have the potential to be tailored into ideal scaffolds for tissue engineering applications.

Acknowledgements

The authors gratefully acknowledge the support from the NIH (DE014755, DE015384, DE017689).

References

[1] Liu X. et.al. *Ann Biomed Eng. 3*2:277-286, (2004)
[2] Ma PX. et.al. *J Biomed Mater Res. 46*:60-72, (1999)