In situ Reactive Electrospinning of PLA-Monetite Nanocomposite Scaffolds for Dental Tissue Engineering

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Statement of Purpose: The objective of this paper is to develop a new scaffold for use as tissue regenerative periodontal membranes in dentistry by reactive electrospinning PLA based nanocomposite fibers.[1] It is well known that surface porosity and other features of scaffolds enhance tissue regeneration.[2] A literature search revealed that in fabricating nanocomposite scaffolds, calcium phosphate (Ca-P) particles are usually synthesized separately before adding them into a suitable biopolymer for electrospinning.[3-4] In this paper, an *in situ* reactive electrospinning route is described, wherein the appropriate calcium-phosphate phase (monetite) is formed during electrospinning. To the best of our knowledge, there has been no such attempt before. The reaction releases heat and water during monetite formation. This has interesting effect on the surface morphology of the fibers. In addition, the monetite particles get distributed homogeneously. Finally, the process is amenable to high loading of the monetite in the composite.

Methods: In this study, monetite particles were synthesized *in situ* during the electrospinning with PLA dissolved in chloroform/DMF (3:1). The monetite precursors used here were calcium hydroxide and phosphoric acid. Effects of electrospinning parameters such as spinning voltage, feed rate and monetite contents on the fiber morphology were investigated.

Results: Figure 1 shows that the monetite was successfully formed and dispersed on PLA fibers during electrospinning.

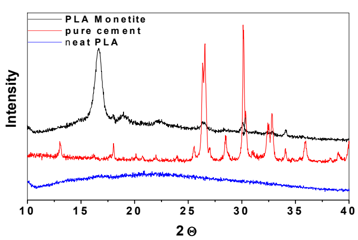

Fig.1 X-ray diffraction patterns for pure PLA, pure monetite and reactive electrospun PLA/monetite composite fibers.

Figure 2 shows the formation of moderately interconnected nano-porous features on the surface of the electrospun PLA/monetite fibers. These fibers have a round shape and aligned orientation

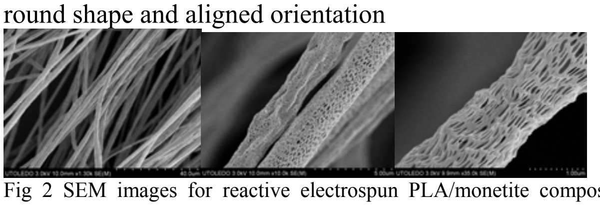

Fig 2 SEM images for reactive electrospun PLA/monetite composite fibers at different magnifications (from left to right)

The effect of electrospinning feed rate on the morphology of PLA/monetite fibers is seen in Figure 3. Briefly, the feed rate was varied mainly to determine its effect on the porous structure and the fiber size. All fibers with different rates showed nanoporous structure on their surfaces.

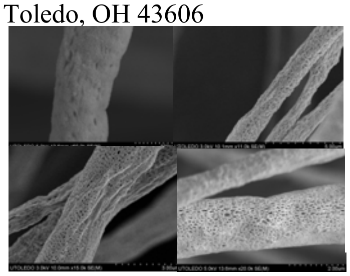

Fig 3 SEM images for reactively electrospun PLA/ monetite composite fibers at different rates. (top-left is 1.5 ml/h, top-right is 3ml/h, bottom-left is 6 ml/h and bottom- right is 8 ml/h).

To verify the effect of spinning voltage on the fiber morphology (porous structure and fiber size), reactive electrospinning of PLA/monetite were processed at different voltages as seen in Figure 4. With the increase in voltage, the surface topography of fibers was changed from containing isolated to highly interconnected ones.

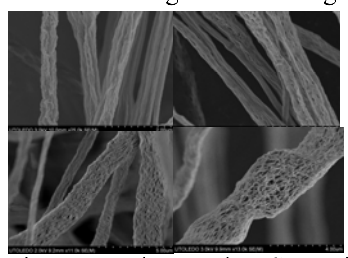

Fig 4 SEM images for reactively electrospun PLA/monetite composite fibers at different voltages. (top-left is 10 Kv, top-right is 15 Kv, bottom-left is 20 Kv and bottom- right is 26 Kv).

Figure 5 shows the SEM images of PLA/monetite composite fibers electrospun with different monetite contents. As the monetite content increased, the pores became elongated, while the average diameters of fibers decreasing slightly.

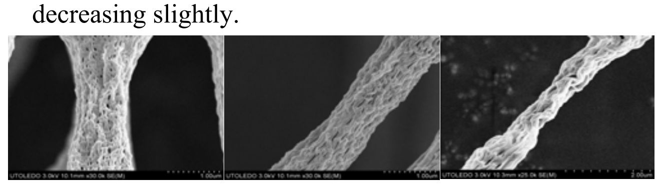

Fig 5 SEM images for reactively electrospun PLA/monetite composite fibers at different monetite contents. Left is 22 wt%, middle is 28 wt% right is 32 wt%)

Conclusions:

A unique *in situ* reactive electrospinning approach was developed to fabricate nanoporous PLA/monetite nanocomposite scaffolds for dental tissue engineering. The released heat and water during monetite formation played an important role on the morphological structure of the PLA/monetite nanocomposite fibers. As the rate and voltages increased, the fiber surfaces changed from having loosely packed pores to interconnected ones. On the other hand as the monetite content increased, the pores elongated and the average diameters of the fibers slightly decreased.

References:

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