Developing PLA/CDHA Bionanocomposite Coatings for Tissue Engineering Applications via Electrospraying

Huan Zhou[1], Sarit B. Bhaduri[2,3]
[1]Department of Bioengineering, [2]Department of Mechanical, Industrial & Manufacturing Engineering,
[3]Department of Surgery
The University of Toledo, Toledo, OH, 43606

Statement of Purpose: The main objective is to develop bionanocomposite coatings composed of carbonated calcium deficient hydroxyapatite (CDHA) and poly lactic acid (PLA). There are many interesting concepts combined in this new coating deposition procedure. First, the coating deposition process takes place at benign low-temperature, enabling the deposition of relevant phases such as carbonate and bio-molecules into coatings. Second, both CDHA and PLA are biocompatible and biodegradable. Additionally, osseointegration at substrate and coatings surface can be promoted by the biologically active property of nano-CDHA [1]. Third, the coating setup is simple and the whole coating process is controllable and can be finished in minutes. Fourth, the deposition process has the ability to produce varied surface topography by adjusting electrospraying parameters with enhanced cell attachment and proliferation. Finally, hybrid coatings produced can be bi-functional with incorporation of bio-molecules to PLA/CDHA bionanocomposite coatings.

Methods: Concentrated SBF (simulated body fluid) solutions previously developed by our group were used for the synthesis of CDHA precipitations [2]. CDHA precipitates were co-electrosprayed with PLA in chloroform to deposit coatings. One significant difference between this study and previous electrospraying is that the flowing rate jumped to over 25 ml/h [3]. Different electrospraying parameters were studied to investigate their effect on coating morphology. As fabricated hybrid coatings were characterized using XRD and SEM and tested *in vitro*.

Results: The characterization showed that PLA/CDHA coatings can be deposited on oxidized Ti6Al4V substrates via electrospraying (Fig. 1).

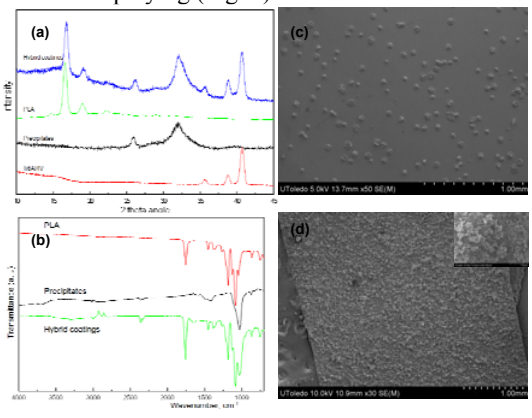

Figure 1. Characterization results: (a) XRD, (b) FTIR, (c) SEM of electrosprayed droplets on collector after 5s electrospraying, (d) SEM of as-deposited coatings

Fig. 2 showed that after 7 days biomimetic coating, apatite particles were observed to be randomly deposited on the surface Ti6Al4V substrate instead of uniform coating found on the surface of PLA/CDHA coating. Undercoat-like layer of apatite coatings with agglomerates of apatite randomly growing on top of it were observed.

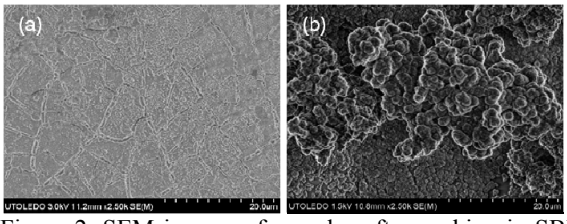

Figure 2. SEM images of samples after soaking in SBF: (a) oxidized Ti6Al4V substrates; (b) hybrid coatings

The *in vitro* osteoblast cells culture testing results are shown in Fig. 3. Incorporation of CDHA into PLA improved osteoblasts cells response in the first 4 days as compared to neat PLA coatings. The full confluence of cells after 7 days on oxidized Ti6Al4V, conventional PLA coatings and PLA/CDHA coatings demonstrates coatings produced by electrospraying are non-toxic and can support osteoblast cells proliferation. Based on these results, electrosprayed CDHA/PLA bionanocomposite coatings can be applied as alternative technique to currently practiced technology. Additionally, drug can be loaded to the PLA/CDHA coatings, where PLA works as barrier to prolong drug release, and CDHA works as loading site.

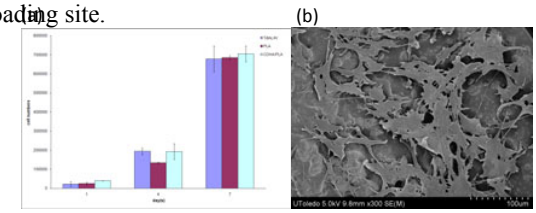

Figure 3. (a) Osteoblast cells numbers on oxidized Ti6Al4V, PLA coatings and PLA/CDHA coatings; (b) SEM of osteoblast cells on PLA/CDHA coatings

Conclusions: The aim of this study was to investigate the possibility of electrospraying novel PLA/CDHA bionanocomposite coatings on the surface of Ti6Al4V substrates as bi-functional implants for promoting osseointegration and assisting sustained bio-molecules release. Fabricated PLA/CDHA bionanocomposite coatings were biocompatible and favored by osteoblast cells. This approach is rapid, simple, and can be operated at normal room temperature. Based on our observations, this approach can be a promising coating technique in biomedical field.

References:

1. Sergey V.D. et al. Angew. Chem. Int. Ed. 2002;41: 3130-3146
2. Tas A.C. Biomater. 2000;21:1429-1438
3. Kumbar S.G. et al. J. Biomed. Mater. Res.: Appl. Biomater. 2007;81: 91-103