A Co-Polymer of Chitosan and Dextran Coating on Ti6Al4V for Orthopedic Applications

Lisa Actis, Anand Srinivasan, Anand K. Ramasumaramian, Joo L. Ong.
Department of Biomedical Engineering, The University of Texas at San Antonio.

Statement of Purpose: It has been reported that 10% of orthopedic implant failure occur due to aseptic loosening leading to increased occurance of hip arthroplasty [1]. Loosening can be attributed to mechanical or biological reasons that results in particulate-debris from the coating on the implant, triggering bone resorption mediated by cell stimulation. Hence it is quintessential to find a suitable coating, predisposing the aforementioned phenomenon. Previous studies have reported the feasibility of using chistosan and dextran with osteoblasts for its mitogenic activity and phenotypic stability.. However, very little is known about their use as co-polymers and their role in addressing these issues. In this project we have developed a chitosan-dextran co-polymer coating on Ti6Al4V. We studied the degradation kinetics of the polymer coated onto smooth and rough Ti6Al4V discs and their susceptibility to serve as a substrate for microbial colonization. Finally, we also studied the effect of coating on the proliferation and engraftment of Human Fetal Osteoblasts (hFOBs) on chitosan-detran coated Ti6Al4V discs.

Methods: Degradation kinetics of the co-polymer was studied by measuring their release from Ti6Al4V discs. Briefly, FITC-labeled deacetylated chitosan (1% w/v in water) was mixed together with Texas red-labeled oxidized dextran (15% w/v in water) at different ratios of chitosan to dextran (1:0, 3:1, 1:1, 1:3, 0:1). The co-polymer was spin-coated onto Ti6Al4V disks (15mm diameter). The disks were then sterilized by ethylene oxide (ETO) for 12 hours. The disks coated were submerged in 1ml of FBS-supplemented DMEM media and incubated at 37^{o}C for 12, 24, and 48 hours. Fluorescence of the eluents were measured using a fluorescence plate reader. The effect of the co-polymer on human fetal osteoblasts (hFOB), was measured in a rather indirect fashion. Polished and roughened disks of Ti6Al4V were coated as described above. The disks were submerged in FBS-supplemented DMEM media for 12, 24, and 48 hours. The supernatant collected was used as growth medium for hFOBs and their viability was determined using an MTT assay. The effect of these discs on serving as substrates for microbial colonization was also studied in a similar fashion.

Results: As shown in Figure 1 and 2, we observed an exponential degradation of chitosan at lower co-polymer ratio of dextran and vice versa. However, the rate of chitosan degrading from the disc is reduced by the presence of dextran in the co-polymeric mix. The roughness of the Ti6Al4V discs had very little role in the degradation kinetics of the polymers. The proliferation of hFOB seem to be unaffected by the ratio of the co-polymers on the Ti6Al4V discs but higher concentration of chitosan in the co-polymeric mix inhibited microbial colonization.

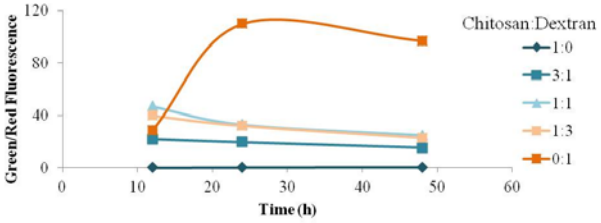

Figure 1. Degradation profile of chitosan and dextran from polished Ti6Al4V disks

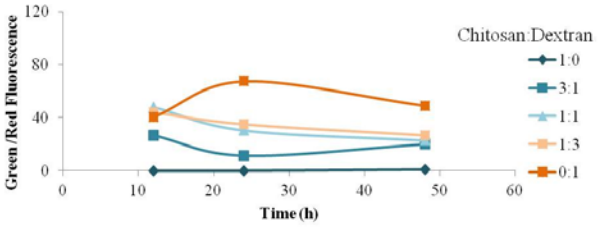

Figure 2. Degradation profile of chitosan and dextran from roughened Ti6Al4V disks

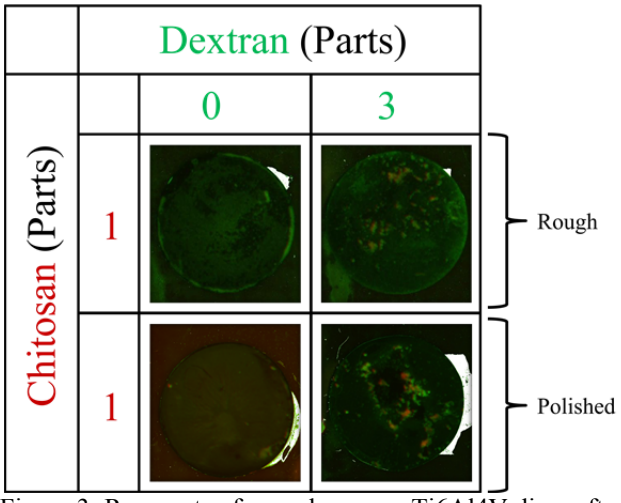

Figure 3: Remnants of co-polymer on Ti6Al4V discs after 48 h degradation.

Conclusions: Based on these results we conclude that the degradation of chitosan is dependent on the amount of dextran present in the co-polymer ratio. In essence, we believe that the dextran acts as a tie-layer in holding the chitosan on to the Ti6Al4V discs. As a favorable surface for hFOB growth and with appreciable antimicrobial property, this copolymer may serve as a suitable coating for Ti6Al4V implants.

References:

[1] Geetha M., *et al*. Progress in Materials Science. 2009; 54: 397-425.