A Comparison of Calcium Sulfate Polymer Composites for the Reconstruction of Bone

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Statement of Purpose: Various bone grafting materials have been used in the medical industry, but none have been utilized as long as calcium sulfate (CS). CS is both osteoconductive and osteointegratable. The main problem associated with CS is its rapid degradation, which prevents regeneration of bone in a large defective area. The purpose of this *in vitro* study is to evaluate the degradation rate of novel CS based composites and compare them to pure CS. The goal is to find a composite with a slower degradation rate based on granule size and CS ratio. This slower rate would act as a scaffold support network throughout the healing process of bone. These 5 CS based composites have varying ratios of polymer: 2 and 4% of poly(DTE)-carbonate (p(DTE-C), 4 and 8% salicylate-based poly(anhydride-esters) (PA) and 4% poly(L-lactic) acid (PLLA). P(DTE-C) is a biocompatible and biodegradable material that has a higher tensile strength than pure CS. PA releases salicylate and is an anti-inflammatory polymer that could locally reduce inflammation and pain at site of implantation. As well as being anti-inflammatory, PA can potentially also reduce bone resorption. PLLA, a common material biomaterial, should also regulate the degradation of CS. With potentially longer degradation profiles, anti-inflammatory properties, and ability to heal and reduce bone resorption these composites could be used in areas with larger bony defects, when normal CS can not be used. When forming CS composite pellets, granule size of the composites need to be taken into account. Smaller particle sizes degrade faster relative to larger particles. By separating the granules into different particle sizes, degradations profiles can be determined. With a suite of composites each could be tailored to unique applications.

Methods: All materials were made by agglomeration and provided by Orthogen, LLC (Springfield, NJ). All materials, CS, 2 and 4% p(DTE-C), 4 and 8% PA and 4% PLLA were sieved into different granule sizes: 1000, 850, 600, 425, 212 µm. *In vitro* testing was done per Mamidwar *et al*; composite granules were placed in individual meshes and submerged in simulated body fluid (SBF) at 37 ºC. SBF was prepared according to Kokobu *et al*'s formula minus the *tris*(hydroxymethyl)-aminomethane. SBF was changed every 3-4 days and imitates the body's natural ability to carry precipitates and ions away. An initial weighing was done at day 4, which serves as the baseline. Weighing during each change provided data to support a degradation curve, which is used to determine each composite's and granule size's degradation profile.

Results: Preliminary 14 day data (Figures 1 and 2) shows that all materials have degraded over time. For 425 µm values CS has degraded to approximately 15%, while 4% PLLA has degraded the least at approximately 5%. Only 8% PA degraded more than any other material. When comparing the 425 and 600 µm pure CS, the latter degraded at a slower rate, as expected.

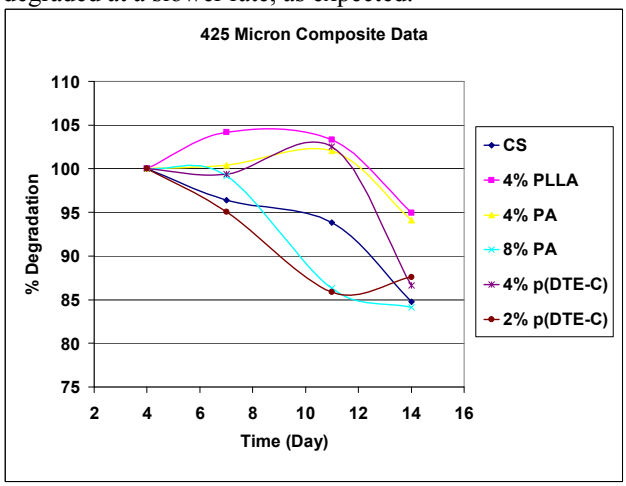

Figure 1: Degradation profiles of 425 µm composites at 14 days.

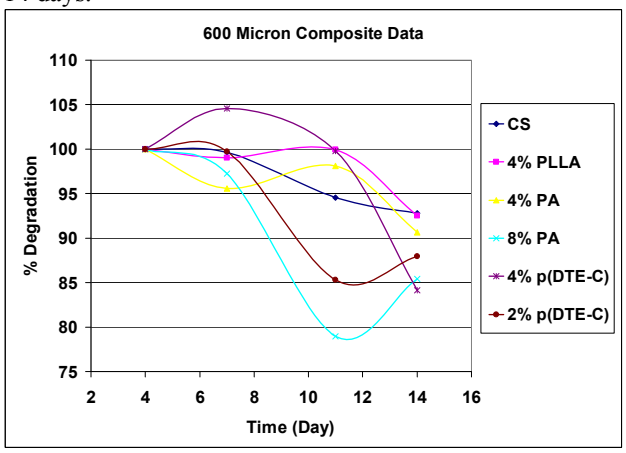

Figure 2: Degradation profiles of 600 µm composites at 14 days.

Conclusions: From these preliminary results, it can be seen that all 425 µm composites had a slower degradation rate than pure CS, except for 8% PA. Granule size also seems to affect the degradation rate of CS with the 600 µm granules degrading at a slower rate. Granule size does not seem to affect our CS composite degradation as much as seen with pure CS. These composites may represent a set of controlled degradation rate, osteoconductive, fully resorbable bone repair materials, some of which have anti-inflammatory properties.

References:

Kokubo T., Kushitani H., Sakka S., Kitsugi T. and Yamamuro T. Journal of Biomedical Materials Research 24(6):721-734, 1990.

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