Mechanical and in vitro properties of PLA/bioactive glass composites

Mechanical and *in vitro* Properties of PLA/Bioactive Glass Composites

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INTRODUCTION

Composites of bioactive glass and biodegradable polymers are easily machined to different shapes (screws, plates, scaffolds) and promote bone regrowth.[1] Their dissolution rate can be easily tailored and they can be doped with ions for example enhancing vascularization or inhibiting inflammation.[1] However, the fast degradation and high water content of some bioactive glass leads to thermal degradation of the polymer during extrusion. New composite rods of bioactive silicate or phosphate glasses and polylactide (PLA) were processed and immersed in TRIS buffer for 40 weeks. The objectives were to assess the release of ions from the glasses and their potential for osteogenesis and the impact of the glasses on the PLA degradation.

EXPERIMENTAL METHODS

Medical grade PLDLA (L/DL ratio 70/30, Evonik Industries AG, Darmstadt, Germany) was co-extruded into 2mm diameter rods with silicate glass 13-93 (10, 30 and 50 wt-% loading) and phosphate glass Sr50 (10, 25 and 35 wt-% loading). The 7 cm rods were immersed in TRIS buffer for up to 40 weeks. The buffer solution was changed every two weeks. The pH, ion release (using ICP-OES), water uptake, mechanical properties (3-point bending) and the dispersion of the glass particles (125-250 µm) and CaP formation (EDX/SEM) were studied.

RESULTS AND DISCUSSION

pH results

The PLA alone did not lead to any change in pH indicating that the material is stable. PLA/13-93 composite, however, induce a rise in pH during the first two weeks of immersion before stabilizing. This can be attributed to leaching of ions from glass particles at the materials surface, initially and within the bulk (lower mobility) later on. PLA/Sr50 composites induce a decrease in pH for immersion up to 2 weeks which then leveled off. This can be attributed to the fast glass dissolution. Furthermore, the high release of phosphate is known to lead to a pH decrease. In both composites the pH changes were loading dependent. The higher the glass content the more pronounced was the pH change.

Water uptake

The water uptake was high for the PLA/Sr50 (20-65 %), compared to the PLA/13-93 composites (4-25 %). This can be attributed to the faster dissolution rate and congruent dissolution as well as the known tendency of phosphate glasses to be hydroscopic. The water uptake increased with increasing immersion time and glass content. The pure PLA did not seem to absorb any water up to 10 weeks.

Ion release

Upon PLA/13-93 immersion, all the ions present in the glass are released in the buffer solution in a non-congruent manner. The release of Na and K are lower than typically seen when immersing the glass alone. These ions seem to be trapped inside the polymer matrix. The PLA/Sr50 dissolves congruently, as expected. Overall, the phosphate glass released a higher amount of ions into the solution compared to silicate glasses. As for the pH and water uptake, the ion release is a function of the glass content.

Mechanical properties – three-point bending

Adding bioactive glass decreased the stress at maximum load. The decrease increased with increasing glass load and was independent of glass composition. The mechanical properties of the composites decreased with increasing immersion time. This is attributed to the pores formed upon glass dissolution. In pure PLA there was no change in mechanical properties for up to 10 weeks.

EDX/SEM

At 10 weeks there was some 13-93 left in the composites, but the Sr50 had been almost completely dissolved and formed a CaP reactive layer as shown in Fig. 1.

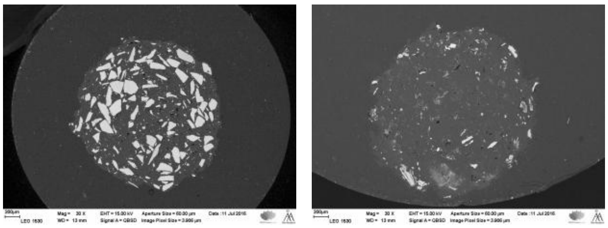

Fig. 1. SEM images of the composites cross section with (left) silicate and (right) phosphate glass particles, at 10 weeks in TRIS.

CONCLUSION

Composites of PLA and bioactive glasses can be co-extruded without altering either of the materials. Increasing glass content led to increased water uptake, ion release, and a decrease in mechanical properties. This study introduces new processable bioactive glass-polymer composites with tailored ion release and potential for inducing osteogenesis and antimicrobial properties to be used in bone tissue engineering.

REFERENCES

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