SOLUTION COMPOSITION AFFECTS DISSOLUTION-RECRYSTALLIZATION MECHANISMS OF BIOMIMETIC APATITES

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INTRODUCTION

Aging affects bone health and blood chemistry but it is unknown how these are related. As we age, kidney function diminishes, which decreases blood bicarbonate and pH leading to aging-induced metabolic acidosis[1]. In addition, other blood components, such as ionic strength and phosphate levels, change with aging-induced metabolic acidosis[2]. To aid the body in reaching homeostasis, bone mineral dissolution occurs to attempt to increase bicarbonate and pH levels[2]. While it is generally known that acidic pH's can increase bone mineral dissolution[3], it is unknown how these other factors affect bone mineral dissolution. Therefore, the objective of this study is to identify the mechanisms of pH, ionic strength, and phosphate content on the dissolution of biomimetic bone mineral.

METHODS

Biomimetic carbonated apatite (CAP) with either 2, 6, or 12 wt% carbonate was synthesized by an aqueous precipitation. These were exposed to various solutions for 72 hours in order to determine the effects of pH, ionic strength, and phosphate (PO_4^{3-}) content. To evaluate the effect of initial solution pH (pH_i), 6 wt% CAP was exposed to either 0.1M potassium chloride (KCl), water, or 1x phosphate-buffered saline (PBS) all at pH_i 5.5, 7.4, and 8.0. To isolate ionic strength effects, water and 0.1M KCl at pH_i 5.5 was used for 2, 6, and 12 wt% CAP. For PO_4^{3-} content, 0.1M KCl and 0.7x PBS both at pH_i 3.0 was used for 6% CAP in order to have identical ionic strength, pH, and buffering capacity while varying PO_4^{3-} content. After exposure, the powders were weighed, filtered, and dried in a 60°C oven overnight. Then, the powders were analyzed by Raman spectroscopy to identify the change in carbonate to phosphate ratio (ΔCO3/PO4) and X-ray Diffraction (XRD) to analyze the lattice and microstructure. The change in pH (ΔpH) of each solution was measured at 72 hours to obtain buffering information. In addition, calcium (Ca), sodium (Na), phosphorus (P), and potassium (K) levels in the solutions were measured by Inductively Coupled Plasma - Optical Emission Spectroscopy (ICPOES).

RESULTS

pH Effects: In all cases, the ΔpH positively increased as pH_i decreased. Mass loss occurred for all conditions and was not well correlated to pH_i. Generally, PBS and KCl showed a greater loss of carbonate (-ΔCO3/PO4) with decreasing pH_i (Fig. 1). Conversely, water gained carbonate (+ΔCO3/PO4) irrespective of pH_i (Fig. 1). For CAP in PBS, the c-axis decreased and a-axis generally increased as pH_i decreased, however, no trend in pH was observed for the lattice of CAP in KCl and water. Ca in the solution increased for all solutions after exposure with no clear correlation to pH_i. P was increased in water and KCl but decreased in PBS with no relationship to pH_i. Na generally increased as pH_i decreased in water and KCl while PBS exhibited no correlation to pH_i.

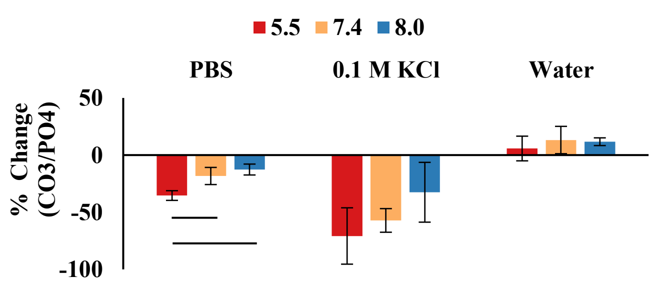

Figure 1: Carbonate decreased in CAP as pH_i decreased after exposure to PBS and KCl.