The role of phosphate in bioactive silicate glasses

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Abstract

Bioactive glasses typically are phospho-silicate glasses, and they are used as temporary implants to regenerate bone. They degrade in the body, release ions and enhance bone formation. Phosphate was originally incorporated into bioactive silicate glasses to facilitate bone bonding through the formation of a biomimetic apatite surface layer during contact with body fluids. It has been shown since that, while phosphate does offer various advantages, it is not technically needed to make silicate glasses biocompatible and bioactive. So what exactly is the role of phosphate in these glasses? And how does it affect properties such as thermal behaviour, crystallisation and reactions with aqueous solutions?
Crystallisation in particular is an interesting aspect of these glasses to study. Owing to their highly disrupted silicate network, they devitrify readily when exposed to temperatures above glass transition. This crystallisation, in turn, may affect numerous properties such as sintering, ion release or ultimately bioactivity. While the most well-known bioactive glasses tend to form silicate phases during crystallisation, variation in phosphate content allows for the formation of phosphate phases, such as apatites, instead.
This talk presents the results of a combination of analytical methods, including solid-state NMR, transmission electron microscopy with energy-dispersive X-ray spectroscopy and 3D X-ray nano-computed tomography to visualise structural changes with heat treatment and during reactions with aqueous solutions. Taken together, our data illustrate how compositional changes in the glass, and the phosphate-to-silicate ratio in particular, affect the microstructure at a sub-micrometre to nanometre level during both crystallisation and reactions with physiological solutions.

Keywords: Bioactive glass, phosphate, crystallisation, bioactivity

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