Dissolvable Borophosphate Glasses: Unravelling Changes in Short- and Medium-Range Structure with Solid-state NMR Spectroscopy

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Abstract

The structural integrity, yet dynamic flexibility of regenerative inorganic tissues within living organisms involves a delicate balance that is difficult to reproduce from a materials science perspective. Take for instance the complex rearrangement at the atomic-level for sea urchin teeth, whereby a balance between Mg and Ca calcite is essential to maintain their unique "Rock-Chewing" ability whether for food or for eluding predators. Likewise, the formation of apatite within the body to repair, replace and strengthen mammalian skeletal features is a natural biomineralization process. In the search for new or improved biocompatible materials for dental and medical applications, we will discuss our current research in glass and glass-ceramic materials with targeted applications in ion releasing glasses. A series of borophosphate glasses modified with Ca (or Sr) will be presented revealing distinct local structures and dissolution effects upon exposure to simulated body fluid (SBF). Changes in the boron and phosphate chemical structural (both local- and medium-range structure) will be highlighted pre- and post- SBF treatment using Ca and Sr modifying cations. We will also discuss our recent developments looking at improving commercial dental ceramic veneers and the impact to atomic-level structure due to exposure of variable temperature treatment, highlighting the transition from ceramic to glassy materials through ex-situ variable temperature and multinuclear magnetic resonance spectroscopy. The major challenge in describing disordered structures is their inherent lack of long-range periodic order inhibiting traditional inorganic techniques such as X-ray or neutron diffraction. Solid-state NMR spectroscopy elegantly reveals atomic-level information providing a direct probe into the coordination of boron, phosphate speciation and boron-phosphorous neighbours using one and two-dimensional MAS NMR methods.

Keywords: NMR, Borophosphate, Feldspar, Medium range structure, Dissolution

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