

Experimental fluoridation of nanocrystalline apatite

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ABSTRACT

Biological apatite, i.e., the major component of teeth and bones, is a widely available source of nanocrystalline apatite. More information is needed about its chemical reactivity in the environment. In the present study, wafers of cross-sectioned dentin and enamel from a modern horse tooth were soaked in phosphate-buffered solutions with NaF concentrations ranging from 0.01 to 2 molar for periods of up to 14 days at about 19.5 °C. The samples were removed at intervals and analyzed by Raman microprobe spectroscopy. Additional, real-time, in-situ Raman spectroscopic analyses were made on some samples during their fluoridation reaction, using an immersible probe. All spectra were deconvolved and their spectral components analyzed for band position, width, and area. Spectral modeling indicates that fluoridation occurred by a kinetically controlled dissolution-reprecipitation process—bioapatite grains partially dissolved and released Ca and P to the F-bearing solution, which caused essentially end-member fluorapatite to nucleate and precipitate, gradually replacing some of the original bioapatite. The replacement process, i.e., fluoridation of the sample, progresses due to the difference in solubility between bioapatite and (highly insoluble) fluorapatite. The bioapatite in (more soluble) dentin reacted much faster and to a much greater extent than that in (less soluble) enamel. These results have implications for paleoenvironmental reconstruction based on the geochemistry of fossil teeth, heavy-metal remediation in soils and water through addition of phosphate phases, and the recommended methods for dental fluoridation in humans.

Keywords: Fluoridation, medical mineralogy, Raman spectroscopy, apatite, fossilization