FTIR and electron microscopy observed consequences of HCl and CO_2 interfacial interactions with synthetic and biological apatites: Influence of hydroxyapatite maturity

Abstract

HCl and CO_2 are active participant molecules in the re-modeling phase of bone materials of vertebrates, wherein old bone is dissolved (*resorbed*) by osteoclast cells (HCl acid and collagenase secreting cells) and new bone becomes deposited (*mineralized*) by osteoblast cells. The mineralization process results in the deposition of mature (i.e., non-carbonated) or immature (i.e., partially carbonated) hydroxyapatite (HAP), which may involve CO_2-carbonation, depending on the function of the perceived bone (e.g., non-dissolvable tooth enamel bone or dissolvable skeletal bone). The present investigation adopted a surface chemical approach to examine impacts of interfacial interactions of wet HCl vapor (at 673 K) and CO_2 gas molecules (at 298 K) on the chemical composition and particle morphology of synthetic and biological apatite (AP) materials of varied contents of mature HAP. Studies employing X-ray powder diffractometry, Fourier-transform infrared spectroscopy, scanning electron microscopy and energy dispersive X-ray micro-probing were carried out. Accordingly, high relative crystallinity, extent of hydroxylation and Ca/P atomic ratio were found to discern synthetic from biological APs. Furthermore, results obtained helped revealing that (i) compositional (atomic ratios, and extents of hydroxylation and carbonation) and morphological (particle shape and agglomeration) parameters are more diagnostic to the HAP maturity than the geometric structural (crystallization and crystallinity) parameters, (ii) the higher the maturity of the contained HAP, the higher is the resistance of chemical integrity and morphology of the AP material particles to the HCl-acidification, and (iii) a preceding CO_2-carbonation lessens HAP-maturity of the AP materials thus rendering them more vulnerable to retrogressive chemical and morphological consequences of the acidification.