Fabrication and histological evaluation of porous carbonate apatite blocks using disodium hydrogen phosphate crystals as a porogen and phosphatization accelerator

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The porous architecture of artificial bones plays a pivotal role in bone ingrowth. Although salt leaching methods produce predictable porous architectures, their application in the low-temperature fabrication of ceramics remains a challenge. Carbonate apatite (CO$_3$Ap) blocks with three ranges of pore sizes: 100–200, 200–400, and 400–600 μm, were fabricated from CaCO$_3$ blocks with embedded Na$_2$HPO$_4$ crystals as a porogen and accelerator for CaCO$_3$-to-CO$_3$Ap conversion. CaCO$_3$ blocks were obtained from Ca(OH)$_2$ compacts with Na$_2$HPO$_4$ by CO$_2$ flow at 100% humidity. When carbonated under 100% water humidity, the dissolution of Na$_2$HPO$_4$ and the formation of hydroxyapatite were observed. Using 90% methanol and 10% water were beneficial in avoiding the Na$_2$HPO$_4$ consumption and generating the metastable CaCO$_3$ vaterite, which was rapidly converted into CO$_3$Ap in a Na$_2$HPO$_4$ solution in 7 days. For the histological evaluation, the CO$_3$Ap blocks were implanted in rabbit femur defects. Four weeks after implantation, new bone was formed at the edges of the blocks. After 12 weeks, new bone was observed in the central areas of the material. Notably, CO$_3$Ap blocks with pore sizes of 100–200 μm were the most effective, exhibiting approximately 23% new bone area. This study sheds new light on the fabrication of tailored porous blocks and provides a useful guide for designing artificial bones.