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SINTERING OF SODIUM AND POTASSIUM TCP BASED CERAMIC FOR BONE GRAFTING APPLICATION

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Biomaterials for bone replacement and grafting should possess sufficient strength, be bioresorbable and demonstrate osteoconductive and osteoinductive properties. However, resorption of modern materials for bone grafting(hydroxyapatite (HA) and tricalcium phosphate (TCP)) is reported, in some cases, to be not enough, this is why the search for more soluble compounds compared to HA and TCP looks very perspective. A possible way to increase ceramics solubility leads to partial substitution of Ca2+ -ions in Ca3(PO4)2 by alkali cations, like Na+ or/and K+. Improvement of solubility stems from decreasing lattice energy of a substituted phase, as well as the increase in hydration energy of the ions releasing from the phase to ambient solution. From this viewpoint, bioceramics based on compositions from Ca3(PO4)2 - CaKPO4 - CaNaPO4 ternary system seems to be prospective for bone replacement and grafting in the sense of resorption properties. At the same time, one should bear in mind that solubility level (resorbability) is governed not only by reduction of lattice energy but also by microstructure features. Grain sizes and porosity contribute much to dissolution rate making the study of sintering of the ceramics mentioned above highly important.
To control Ca3(PO4)2 - CaKPO4 - CaNaPO4 based ceramic microstructure it is necessary to know possible phase transformations in the system and the way to manage microstructure by sintering schedule or sintering process.
In this work, an isothermal section for phase diagram of Ca3(PO4)2 - CaKPO4 - CaNaPO4 ternary system is studied with several techniques. According to the XRD of quenched samples, this phase triangle has four single-phase areas at 1200°C (Figure 1). It was shown that single-phase CaK0.6Na0.4PO4 cannot be sintered to full-dense ceramics by conventional sintering regardless time-temperature schedule. Two-step sintering technique, beneficial in the case of HA-ceramics, was unsuccessful in all cases of calcium-alkali phosphate compositions. However, field-assisted sintering techniques like e.g. Spark Plasma Sintering (SPS), can overcome this problem due to significant impact on grain boundary diffusion. In connection with this fact, grains grow much slower retaining sintering process in a pore control regime. In this work CaK0.6Na0.4PO4 low-porous ceramics was also fabricated by FAST-methods of sintering. Moreover, other alternative sintering techniques, such as reaction sintering, may be useful in accelerating ions diffusion but stopping excessive grain growth.
Strength properties of ceramics were evaluated by B3B-testing, micro- and nanoindentation techniques. Fracture toughness also becomes higher with potassium content increase, guiding porosity level.
Resorption properties of sintered ceramics were studied in different solutions with pH=5 and 7.4.

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