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Mechanochemical Synthesis of Magnesium Substituted Hydroxyapatite

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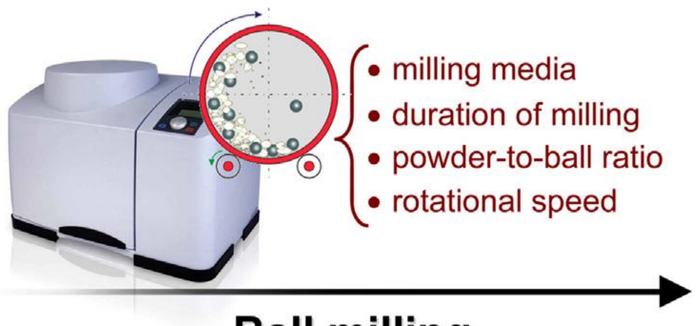
Concept and actuality of work

Mechanochemical synthesis

Ca-reagent + **PO_4-reagent** + **Substituent**



Ball milling during few hours

HA product

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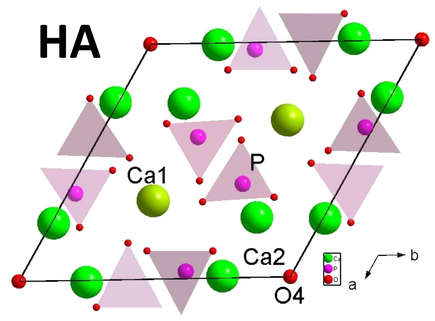
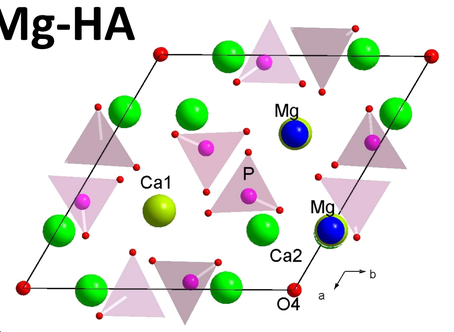
HA



Unsubstituted hydroxyapatite
- Biocompatible
- No antibacterial properties

Object of study

Mg-HA



Mg-substituted hydroxyapatite
- Biocompatible
- Antibacterial properties
- Enhances osteoconductivity
- Improved adhesion
- Stimulates the proliferation and differentiation of osteoblasts

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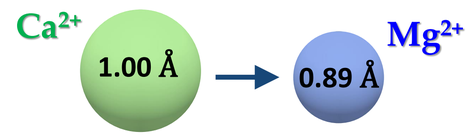
Mechanochemical reactions



(1) $$6CaHPO_4 + (4-x)CaO + xMgO \rightarrow Ca_{10-x}Mg_x(PO_4)_6(OH)_2 + 2H_2O$$

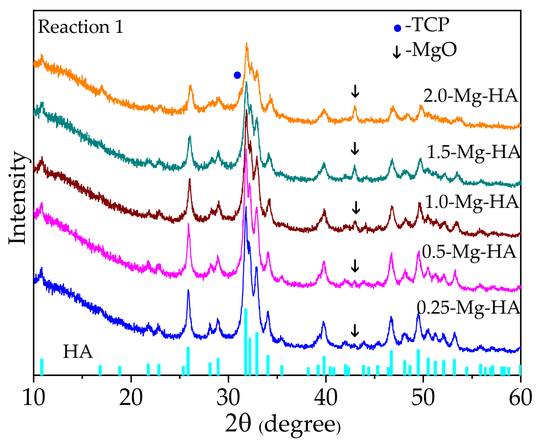
(2) $$(6-2x)CaHPO_4 + (4+x)CaO + xMg(H_2PO_4)_2 \cdot 2H_2O \rightarrow Ca_{10-x}Mg_x(PO_4)_6(OH)_2 + (2+3x)H_2O,$$

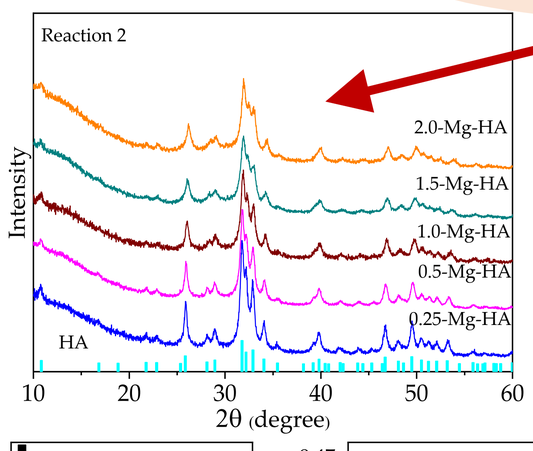
where $x = 0 - 2.0$

Synthesis in planetary ball mill AGO-2 during 30 min

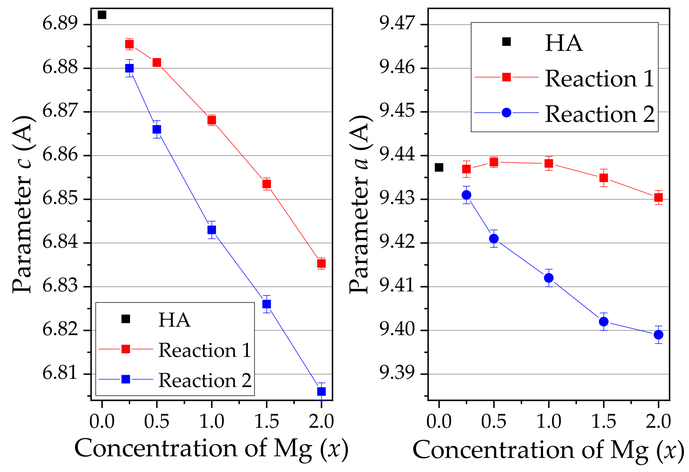
$Mg(H_2PO_4)_2$ is the best source of Mg-ions!

Characterization of as-synthesized materials





Reaction 1			
x	HA, wt.%	CaO, wt.%	TCP, wt.%
0	100	0	0
0.25	99	1	0
0.5	98	2	0
1.0	97	3	0
1.5	93	7	0
2.0	81	8	11

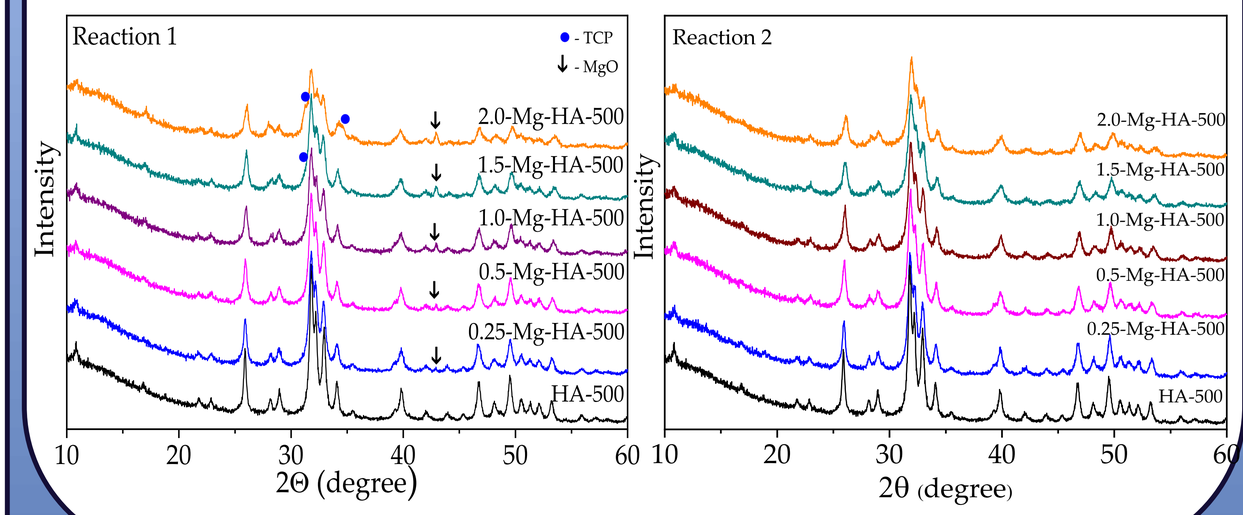


It has been established that, starting from the concentration x = 0.25, the samples synthesized with the introduction of magnesium oxide (reaction 1) contain the phase of the unreacted MgO reagent. However, the lattice parameters of the HA phase in these samples decrease with an increase in the concentration of introduced magnesium. This indicates only a partial incorporation of magnesium ions into the HA structure.

In the case of using magnesium hydrogen phosphate (reaction 2) as the initial dopant reagent, single-phase synthesis products were obtained, where only HA phase is present. Moreover, the lattice parameters of this sample deviate significantly from the values of the unsubstituted HA. The more magnesium introduced, the smaller the lattice parameters, which is consistent with the change in ionic radii when calcium is replaced by magnesium.Å

Characterization of annealed materials

The products of mechanochemical synthesis were annealed at 500°C to remove water released during the synthesis (see reactions). It is shown that the annealing of the products of reaction 1 leads to an increase in the concentration of magnesium oxide, and tricalcium phosphate appears already at x = 1.5. Products of reaction 2 are more stable and remain single-phase at all magnesium concentrations.



Conclusions

The local environment of the substituent cation in the initial reagent plays an important role in the formation of the structure of substituted HA during the mechanochemical synthesis. It was found that the synthesis of magnesium-substituted HA using magnesium phosphate as a substituent carrier proceeds better than from magnesium oxide. Unlike other synthesis methods, this method makes it possible to obtain hydroxyapatite with magnesium concentration up to x=2.

Acknowledgement

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