IOCBE 2024 Conference
The 1st International Online Conference on Bioengineering
16–18 October 2024 | Online
MDPI

Granulated wollastonite – hardystonite bioceramics

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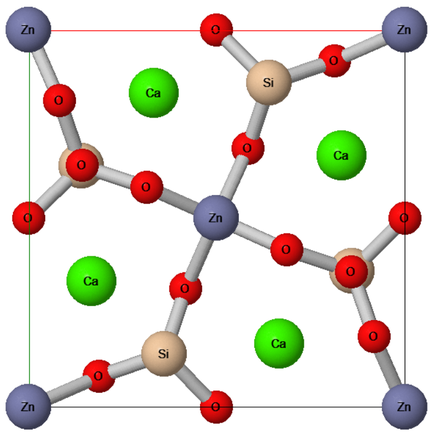
INTRODUCTION & AIM



Hardystonite (HS, $Ca_2ZnSi_2O_7$) is one of the promising compounds for bone tissue restoration due to its biocompability and good mechanical properties. However, it has too low rate of dissolution in (prototypes of) biological fluids, according to literature data. As a way of increasing HS **biomaterials** dissolution, the method of production of composites based on $Ca_2ZnSi_2O_7$ and **wollastonite** (W, $CaSiO_3$) mixtures has been proposed in this work.

METHODS

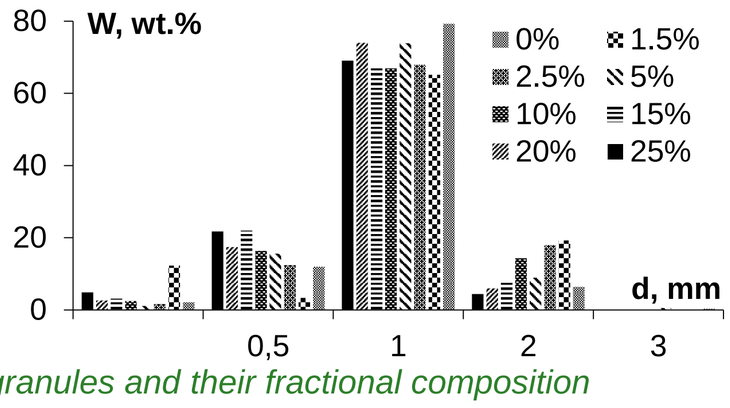
The granules were synthesized by the emulsion method using mechanical mixtures of powdered β-$CaSiO_3$ and ZnO (0, 0.5, 1.5, 2.5, 5, 10, 12.5, 15, 20, 25 wt.%), and gelatin as a binder. All synthesizes were carried out in 10 parallels.

Scheme for granules synthesis:
a - preparation of a powders mixture, b - gelatin addition, c - powder and gelatin mixing, d - suspension addition to oil under stirring, e - granules cooling, f - washing granules from oil and drying in air

The granules were heat treated in air at 1250°C. Materials were analyzed using XRD, FTIR, TGA, SEM. The fractional composition, true and average density, open porosity and solubility in Tris-HCl-buffer were also determined.

RESULTS & DISCUSSION

Spherical granules with a diameter 0.1 ÷ 3 mm were synthesized.

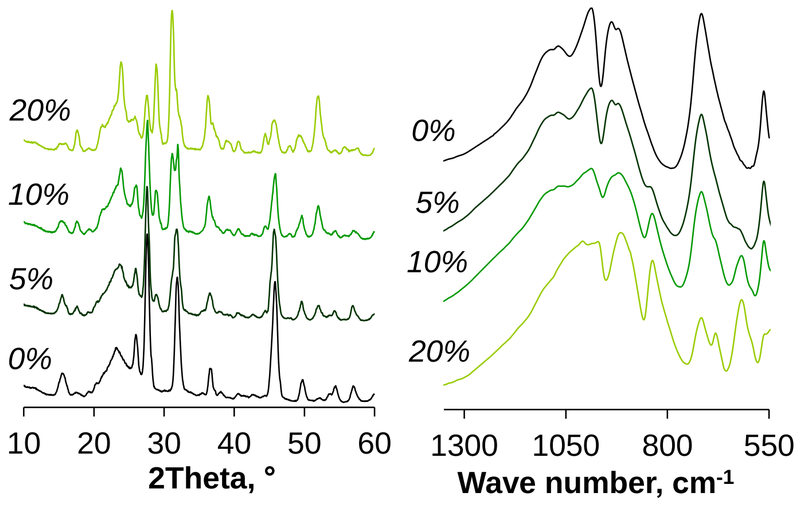


General view of the granules and their fractional composition

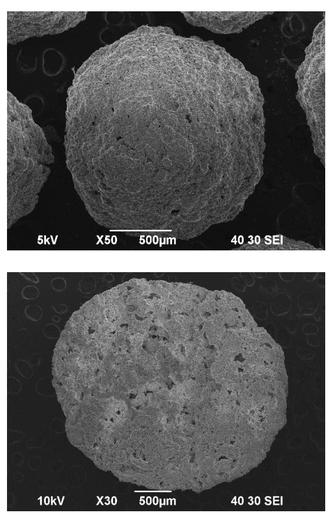
During heat treatment the binder burns out (at 200 ÷ 500 °C) and hardystonite is formed as a result of solid-state interaction between ZnO and $CaSiO_3$:

$$2\ CaSiO_3 + ZnO \xrightarrow{t > 750\ ^\circ C} Ca_2ZnSi_2O_7$$

XRD and FTIR showed that variation of ZnO content in the initial powder leads to formation of α-$CaSiO_3$ mixed with up to 96 wt.% $Ca_2ZnSi_2O_7$ (at 25 wt.% ZnO).



XRD and FTIR data for granules with different initial ZnO content

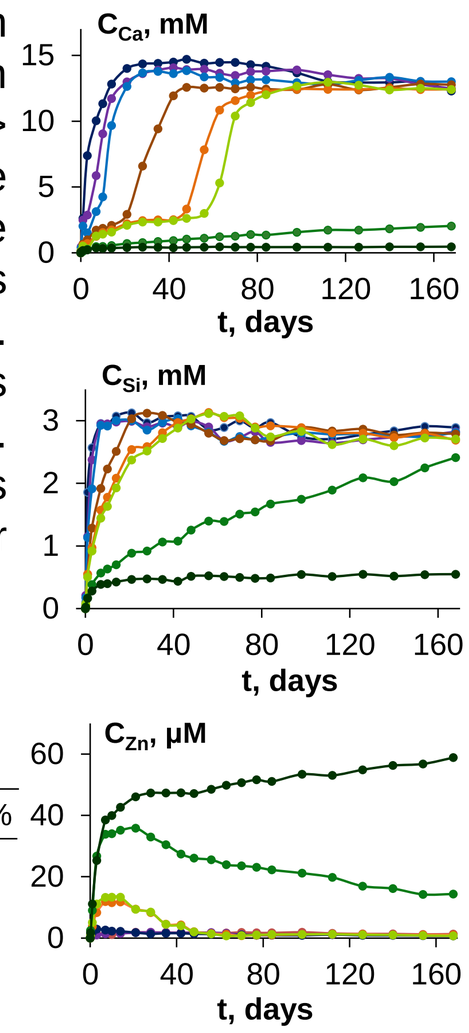


Surface and internal structure of the granules

Materials can gradually dissolve in Tris-HCl-buffer. Ions concentrations in solutions decrease in order Ca^{2+} > SiO_3^{2-} > Zn^{2+} at all time points. The less HS content in granules, the more Ca^{2+} and SiO_3^{2-} quantities and less Zn^{2+} in the surrounding media. Granules with 96 wt.% HS lost less than 0.5 wt.% for 6 months. Decreasing of its content in 2 times leads to increasing of weight loss for 25 times.

Dependence of the granules composition, open porosity (OP), average density (ρ) and mass loss (Δm) on initial ZnO content (W_{ZnO})

W_{ZnO}, wt.%	W_{HS}, wt.%	OP, %	ρ, g/cm^3	Δm, wt.%
0	0	55.7	1.146	7.6
1.5%	5.8	58.6	1.239	20.7
2.5%	9.7	56.7	1.252	23.0
5%	19.3	58.3	1.233	20.5
10%	38.6	60.4	1.238	14.6
15%	58.0	60.4	1.245	13.8
20%	77.3	57.5	1.380	1.3
25%	96.6	61.6	1.410	0.3



Dependences of ions concentrations on time of granules soaking in Tris-HCl-buffer

CONCLUSION

- ✓ Composites with varying content of $Ca_2ZnSi_2O_7$ and $CaSiO_3$ was produced.
- ✓ Mixing with wollastonite allow to significantly increase dissolution rate of hardystonite containing materials.