Óbuda University

Doctoral School of Materials Sciences and Technologies

ELKH, Centre for Energy Research,
Institute of Technical Physics and Materials Science

Development and structural characterization of calcium silicates porous ceramics

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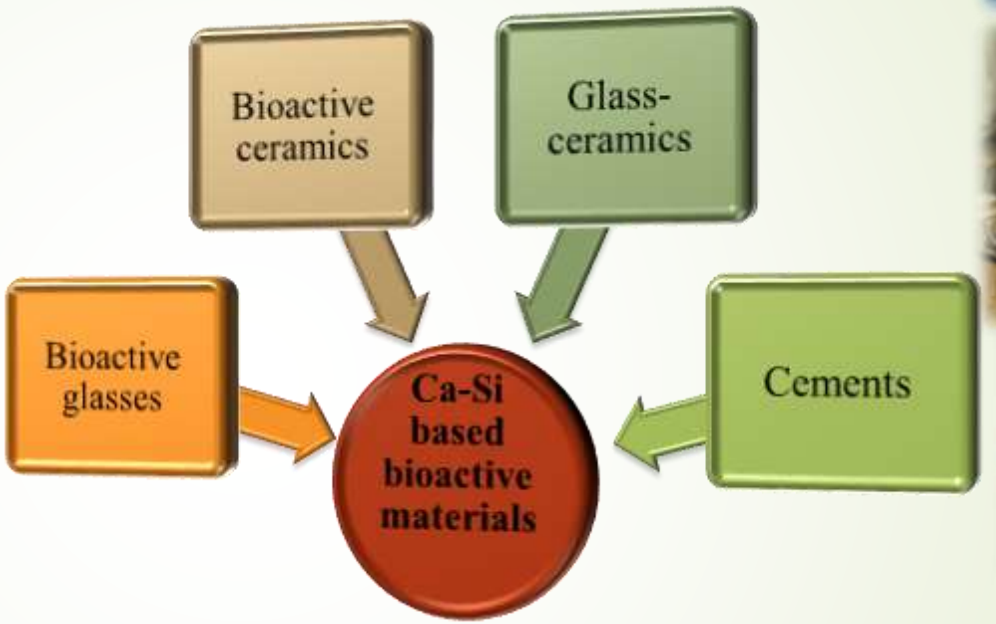
Calcium Silicates (CaO-SiO_2)

Different types of bioactive glasses have been developed and some have been already used in the clinic

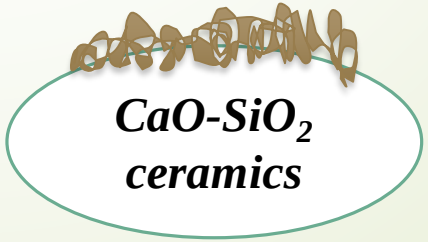
Glasses with this composition were able to bond to soft and hard tissues

Glass system of SiO_2 -CaO-Na_2O-P_2O_5

The beneficial effects of materials based on Ca-Si on inducing bone formation



Formation of an apatite layer



Calcium Silicates (CaO-SiO_2)

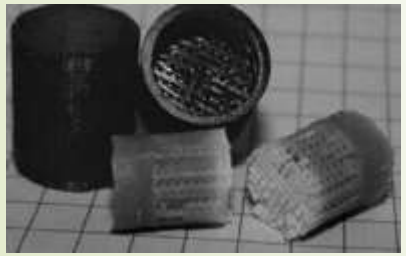
Different parameters can affect and control the biological behaviors

Fabrication method

Composition

Precursors

Sintering temperatures



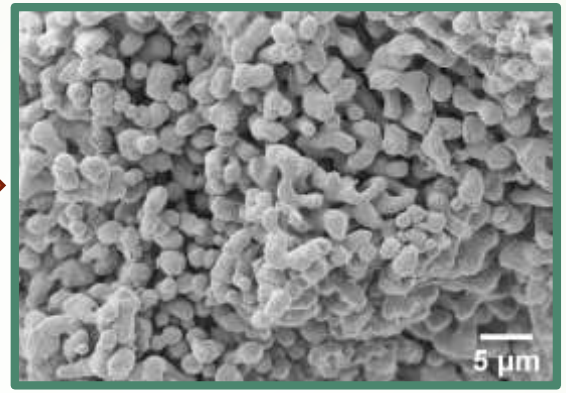
☺ Green environment synthetic routes

RESULTS 1. preparation of starting materials: milling, heat treatment

Chicken Eggshells

Heat Treatment (12h, 900 °C)

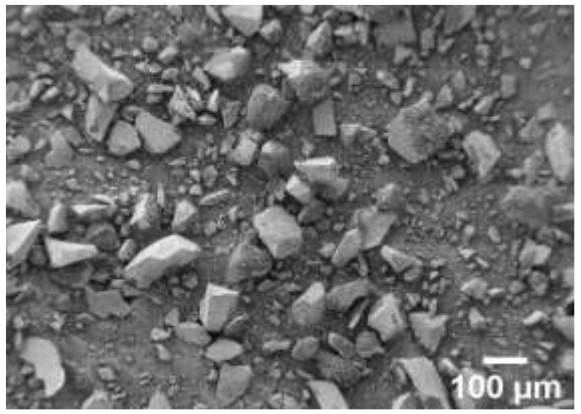
Calcium oxide

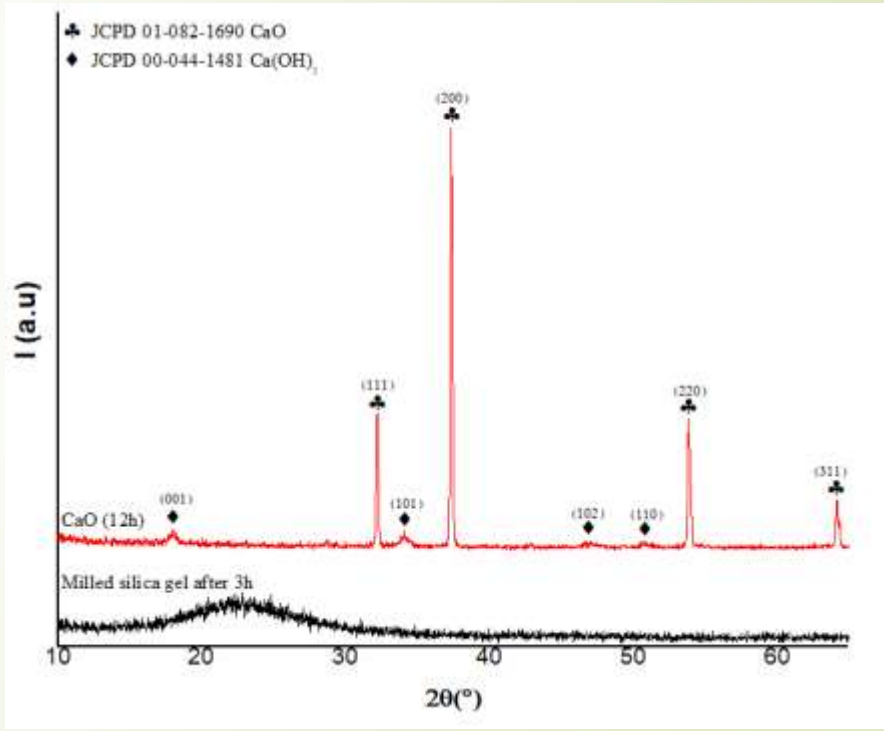


Silica gel

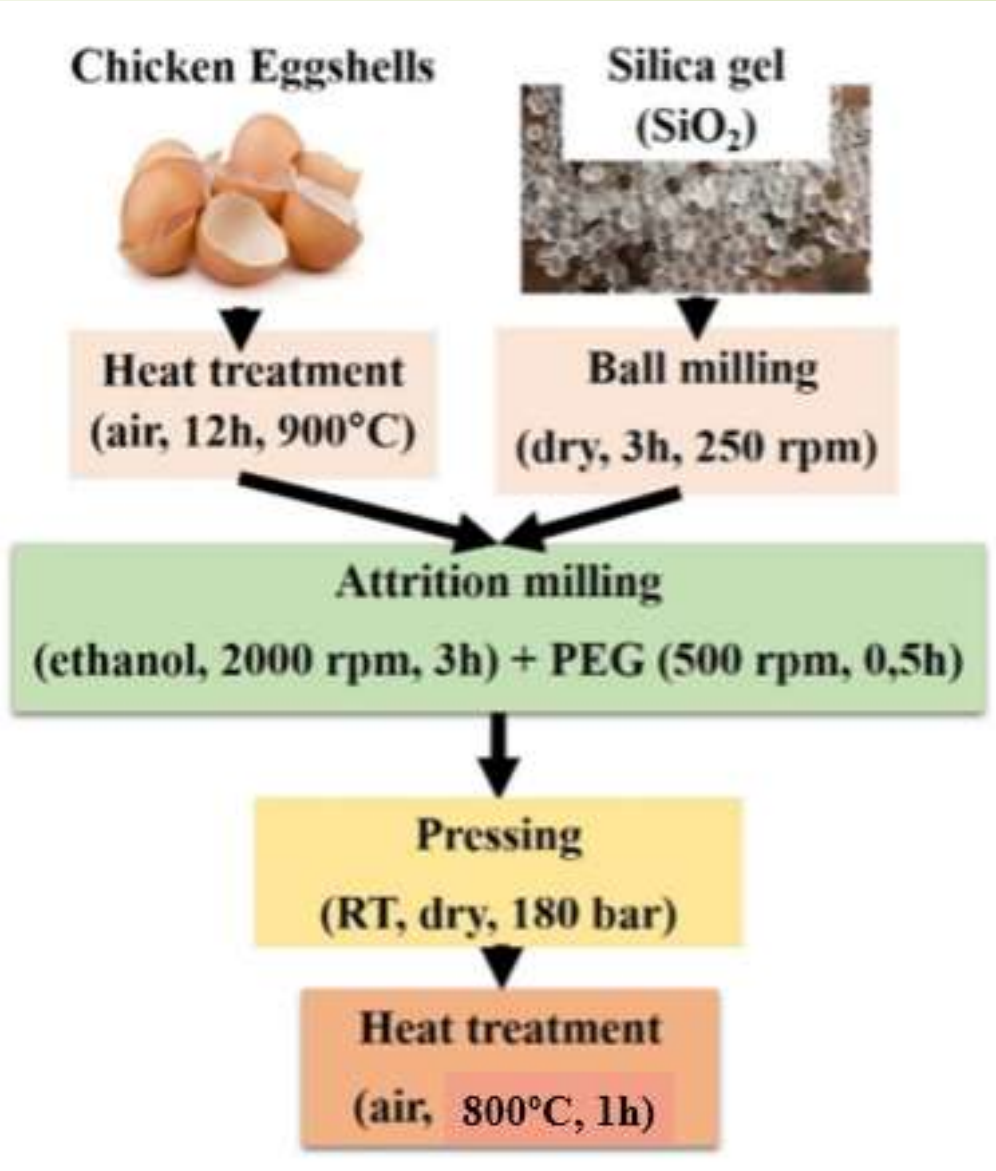
Ball Milling (3h, 10 balls of alumina)

Silica powder





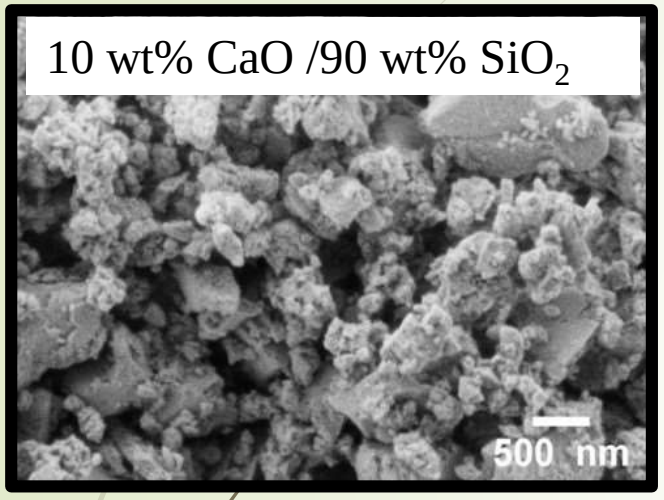
Composition name	Powder mixtures	CaO (g)	SiO_2 (g)
40C(7h)60S	40% wt. CaO (7h) + 60% wt. SiO_2	40	60
10C90S	10% wt. CaO (12h) + 90% wt. SiO_2	10	90
20C80S	20% wt. CaO (12h) + 80% wt. SiO_2	20	80
30C70S	30% wt. CaO (12h) + 70% wt. SiO_2	30	70
40C60S	40% wt. CaO (12h) + 60% wt. SiO_2	40	60
50C50S	50% wt. CaO (12h) + 50% wt. SiO_2	50	50
60C40S	60% wt. CaO (12h) + 40% wt. SiO_2	60	40
70C30S	70% wt. CaO (12h) + 30% wt. SiO_2	70	30
80C20S	80% wt. CaO (12h) + 20% wt. SiO_2	80	20
90C10S	90% wt. CaO (12h) + 10% wt. SiO_2	90	10



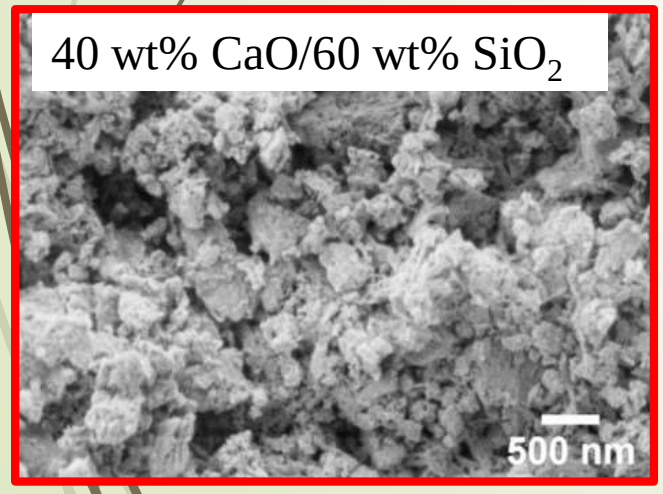
***M. H. Kaou**, Zs E., Horváth ; K, Balázsi ; C, Balázsi, Int. J. Ceram Technol, 2022, in press, 1-11.*

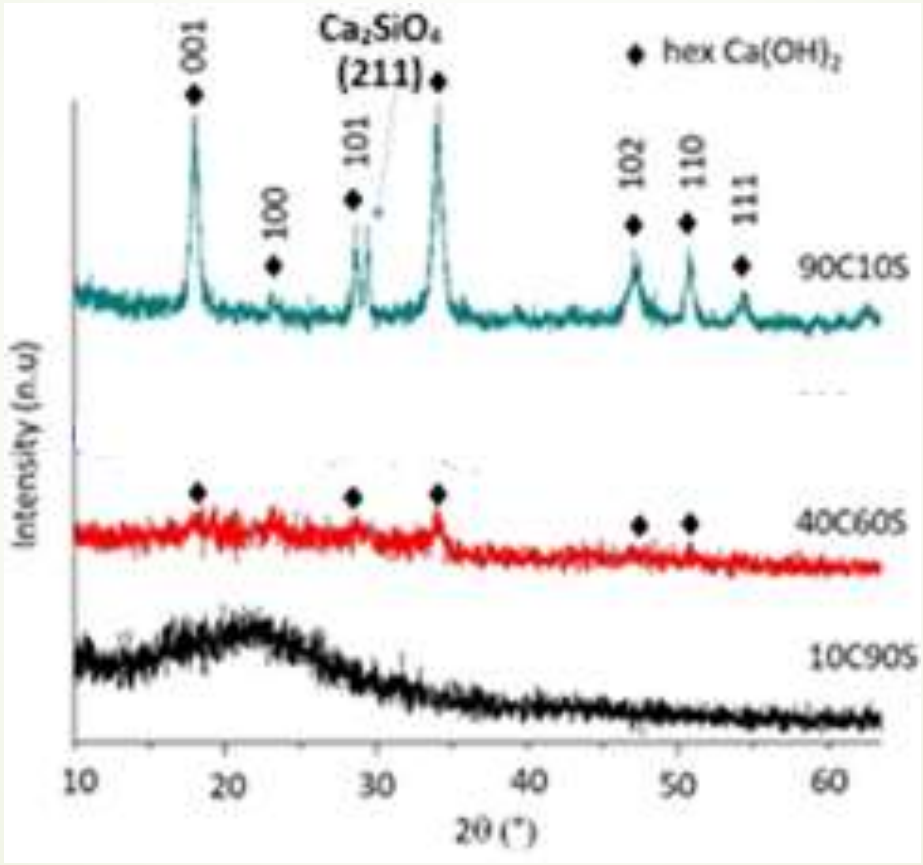
2. Morphological investigations of milled powder mixtures

10 wt% CaO /90 wt% SiO_2

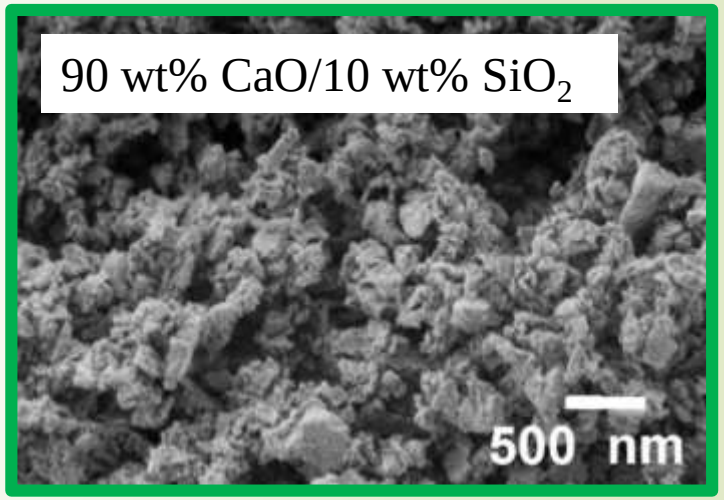


40 wt% CaO/60 wt% SiO_2





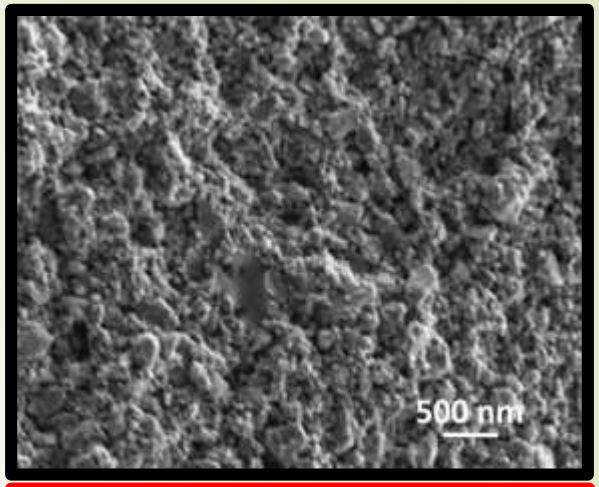
90 wt% CaO/10 wt% SiO_2

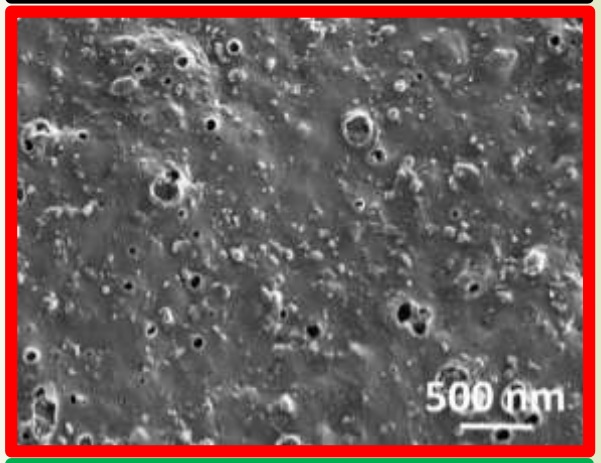


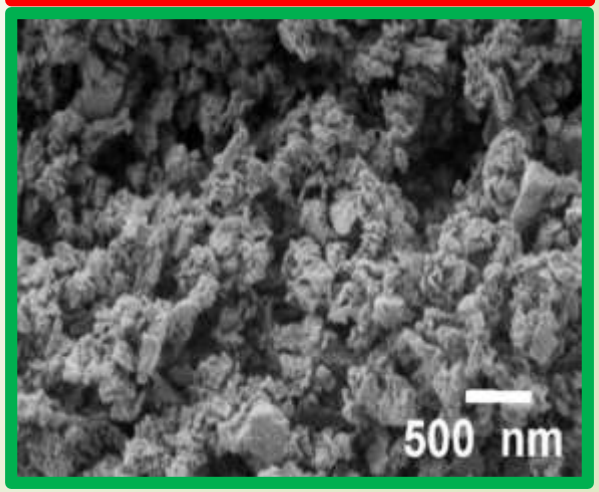
3. Preparation of ceramic discs

Heat treatment (Air, 800° C, 1h)

Composition name					
Real image of the heat-treated bioceramic	10C90S	20C80S	30C70S	40C60S	50C50S
					
	60C40S	70C30S	80C20S	90C10S	40C(7h)60S
					



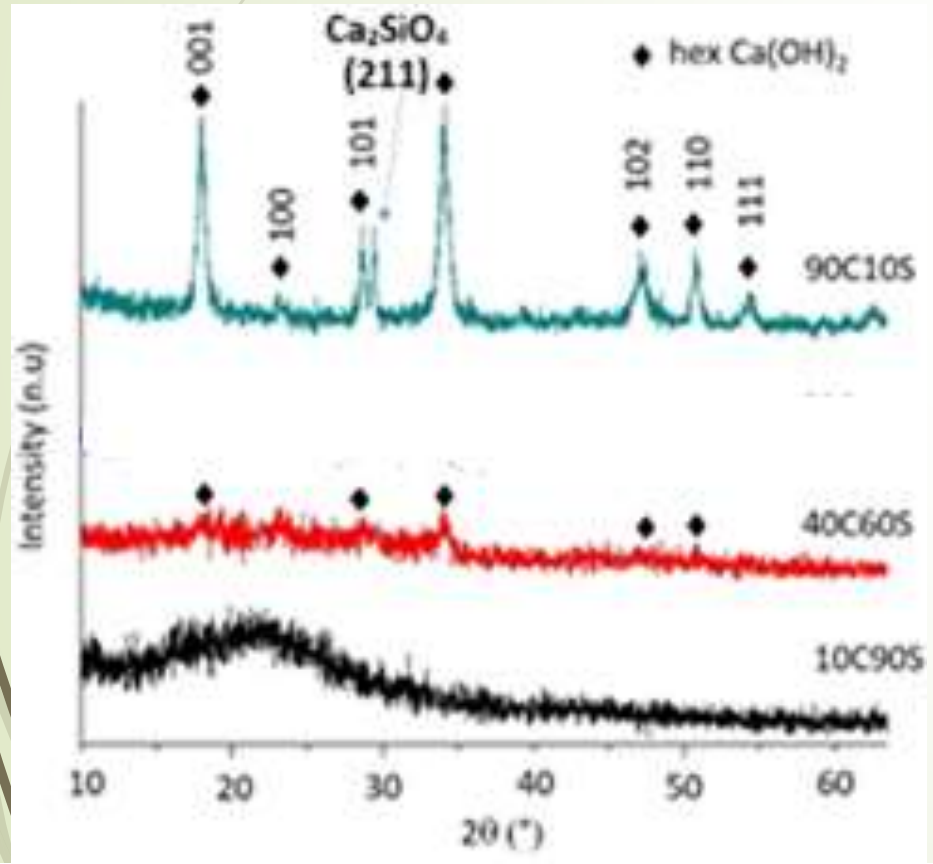




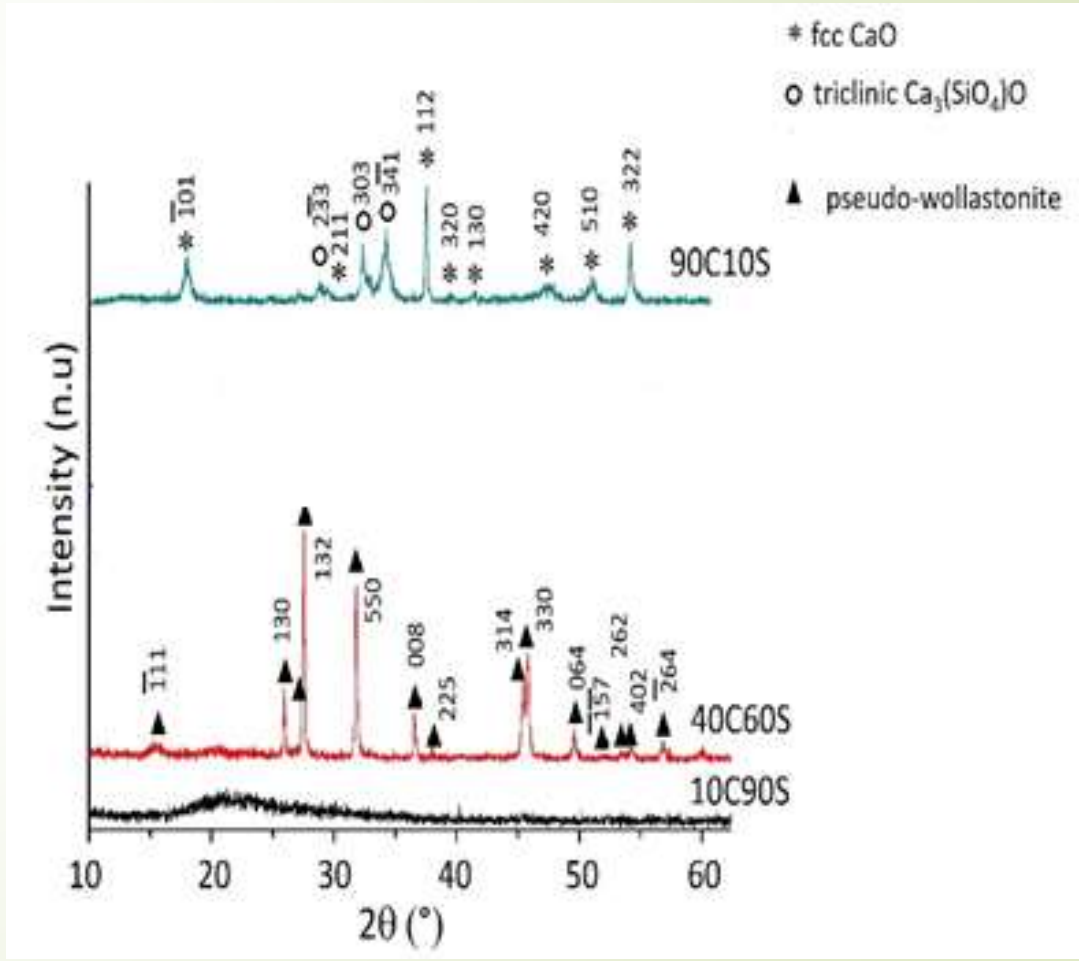
Effect of heat treatment and pressing on powder mixtures

XRD patterns of calcium silica ceramics pressed and heat-treated ceramics

powders with different compositions



Heat treatment



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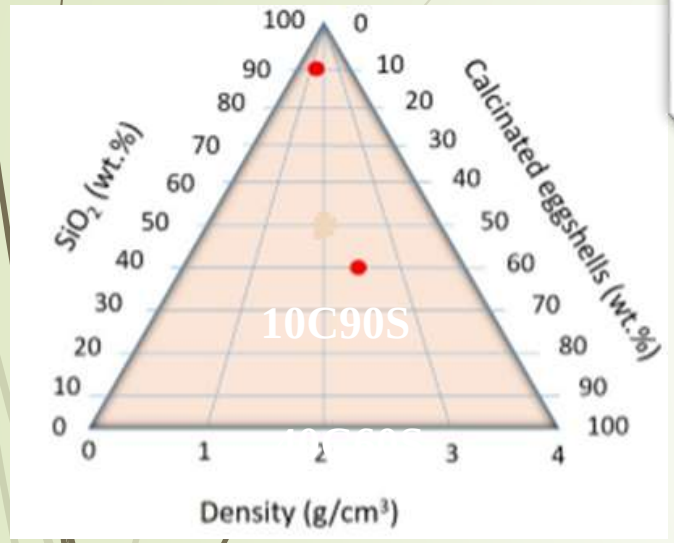
Density and roughness measurements for different compositions

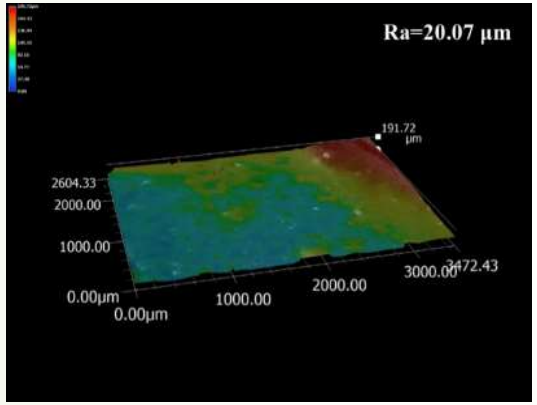
Density

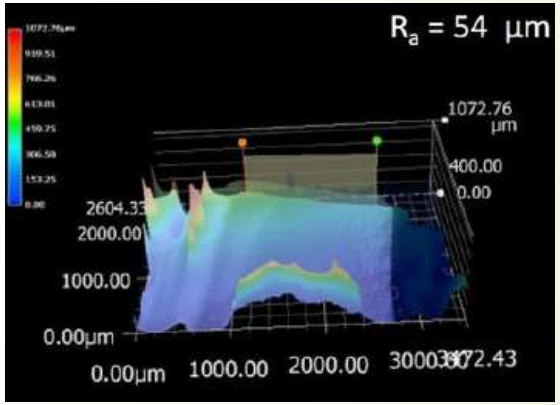


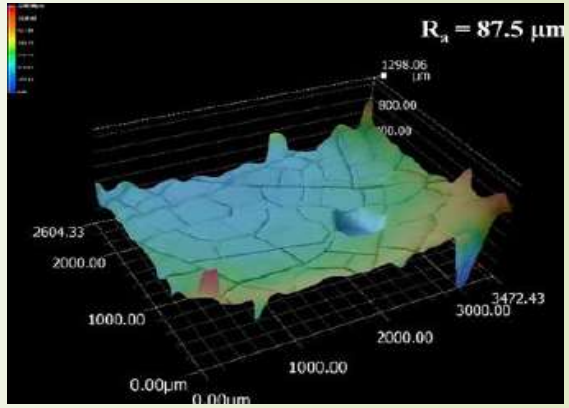
** The density of 90C10S was not measurable due to the porous behavior of the sample*

Aparent density
$$= \frac{\text{Weight of dry sample}}{\text{Weight of dry sample} - \text{weight of soaked sample}} \times \rho_{water}$$

Apparent porosity
$$= \frac{\text{wt. of soaked sample} - \text{wt. of dry sample}}{\text{wt. of soaked sample} - \text{wt. of the immersed sample}} . 100$$







Roughness (µm)

40C60S **10C90S** **90C10S**

Apparent porosity

2.936 1.509 n.m (not measured)

Results

1. Semester:

1) Powder technology (Dr. Balázsi C.)

2) Biomaterials for medical applications (Dr. Balázsi C.)

2. Semester:

1) Transmission electron microscopy for structural investigations of different materials (Dr. Balázsi K.)

2) Selected chapters of material testing methods I. (Dr. Takács E, Dr. Judit Telegdi)

3) Hungarian I (Dr. Szloboda József Sándorné K.)

3. Semester:

1) Fracture mechanics (Dr. Kovács T. A)

2) Composites (Dr. Klébert Sz.),

3) Hungarian II (Dr. Szloboda József Sándorné K.)

4. Semester:

1) Cellulose chemistry (Dr. Borsa Judit)

2) Synthetic fibres and technical textiles (Dr. Borsa Judit)

Complex Exam: **06/08/2022**

1) Selected chapters of material testing methods I. (Dr. Takács E, Dr. Judit Telegdi)
2) Cellulose chemistry (Dr. Borsa Judit)

Presentations and publications

Publications:

[1] Kaou M. H., Horváth Z. E., Balázsi K., Balázsi C. Eco-friendly preparation and structural characterization of calcium silicates derived from eggshell and silica gel. Int. J. Appl. Ceram. Technol. 2022; 1-11. https://doi.org/10.1111/ijac.14274

Conferences:

1) Participated in [Virtual] European Congress and Exhibition On Advanced Materials and Progress - (EUROMAT 2021), September 12-16 (Poster).

2) Participated in [Virtual] 46th international Conference and Exposition on Advanced Ceramics and Composites (ICACC 2022), January 23-28 (Poster).

3) Participated in Ceramics In Europe (ECerS 2022) conference, July 10-14 (Poster).

4) Participated in [Virtual] ACerS Pan American Ceramics Congress (PACC-FMAs 2022), July 24-28 (Poster).

Research Plan

Next steps for 2023:

- ✓ **Continuing the preparation and sintering of the samples using Spark Plasma Sintering (SPS).**
- ✓ **Conducting mechanical testing (hardness, tribology, bending tests)**
- ✓ **Testing the biological characteristics of all samples in SBF solution.**
- ✓ **2 manuscripts currently are in the process of writing.**

Köszönöm szépen a figyelmet!

Thank you for your attention!