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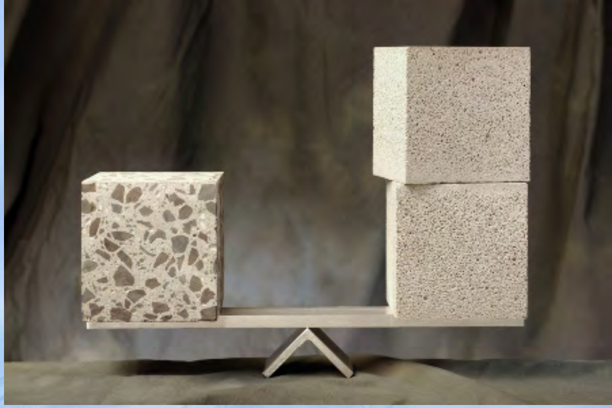

High strength open cell geopolymer foams with variable macro-porous structure

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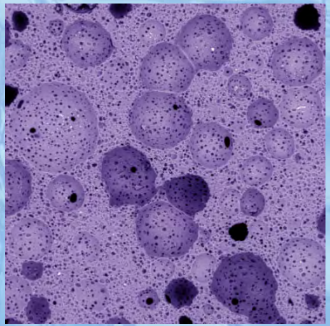
Background

Recently, various porous geopolymers have been produced for several industrial applications such as hot gas filters, solid/liquid separation process, catalyst support and thermal insulators. But the pores generated by common foaming technique are typically closed, thereby limiting the range of applications for the components.

The aim of our research

Fabrication of open cell geopolymer foams to enlarge the application (wastewater treatment, membrane supports,filter,.etc.)



Adsorbents

NH_4^+ CO_2

Pb Cu Co Zn Ni

Cd As Sb

Contents

Part 1

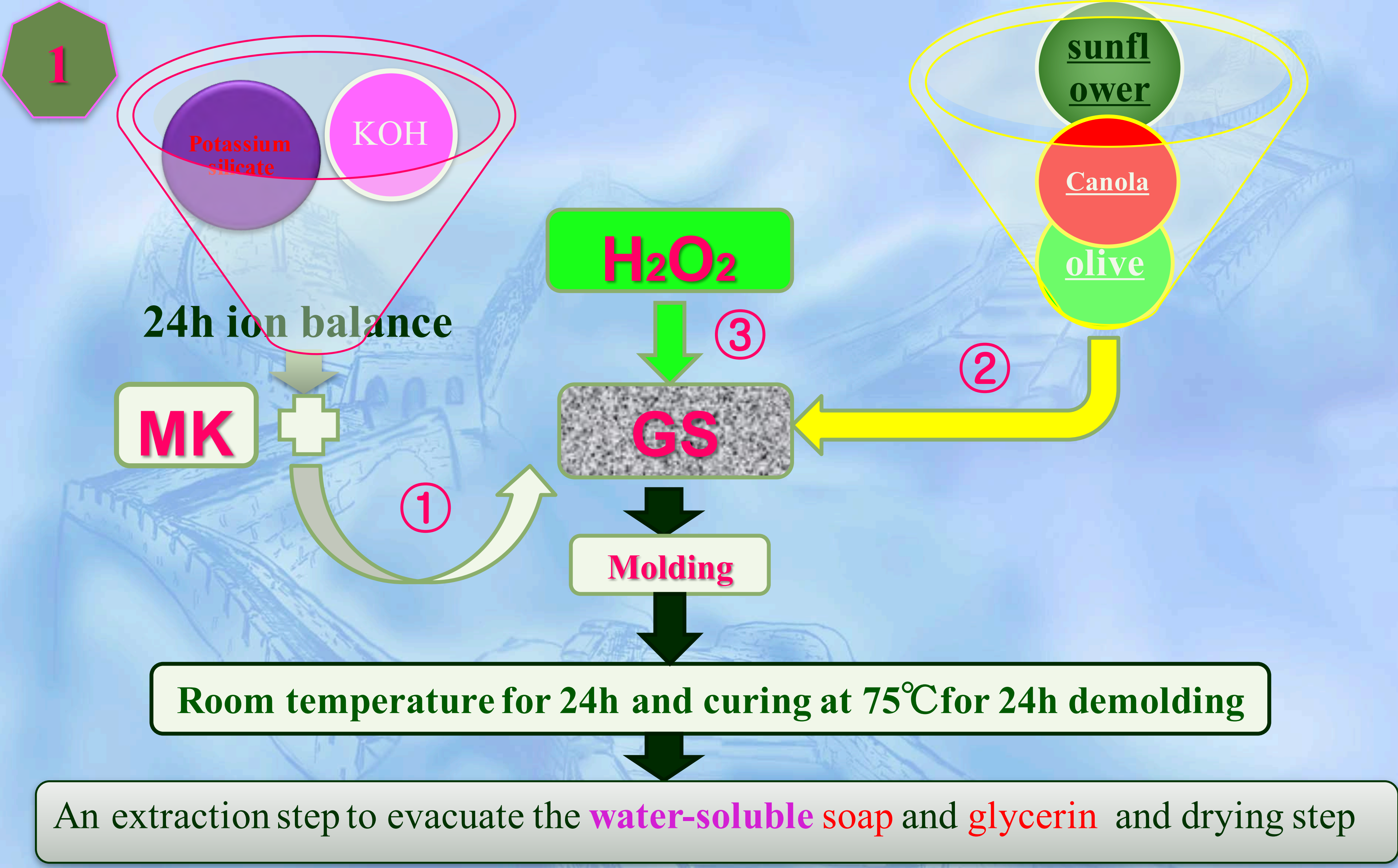
- **Preparation and mechanism of geopolymer foams by saponifaciton and peroxide combined route**

Part 2

- **Effect of different types of oil**

Part 3

- **Effect of different amounts of olive oil and hydrogen peroxide**



Flow diagram of the process of geopolymer foams

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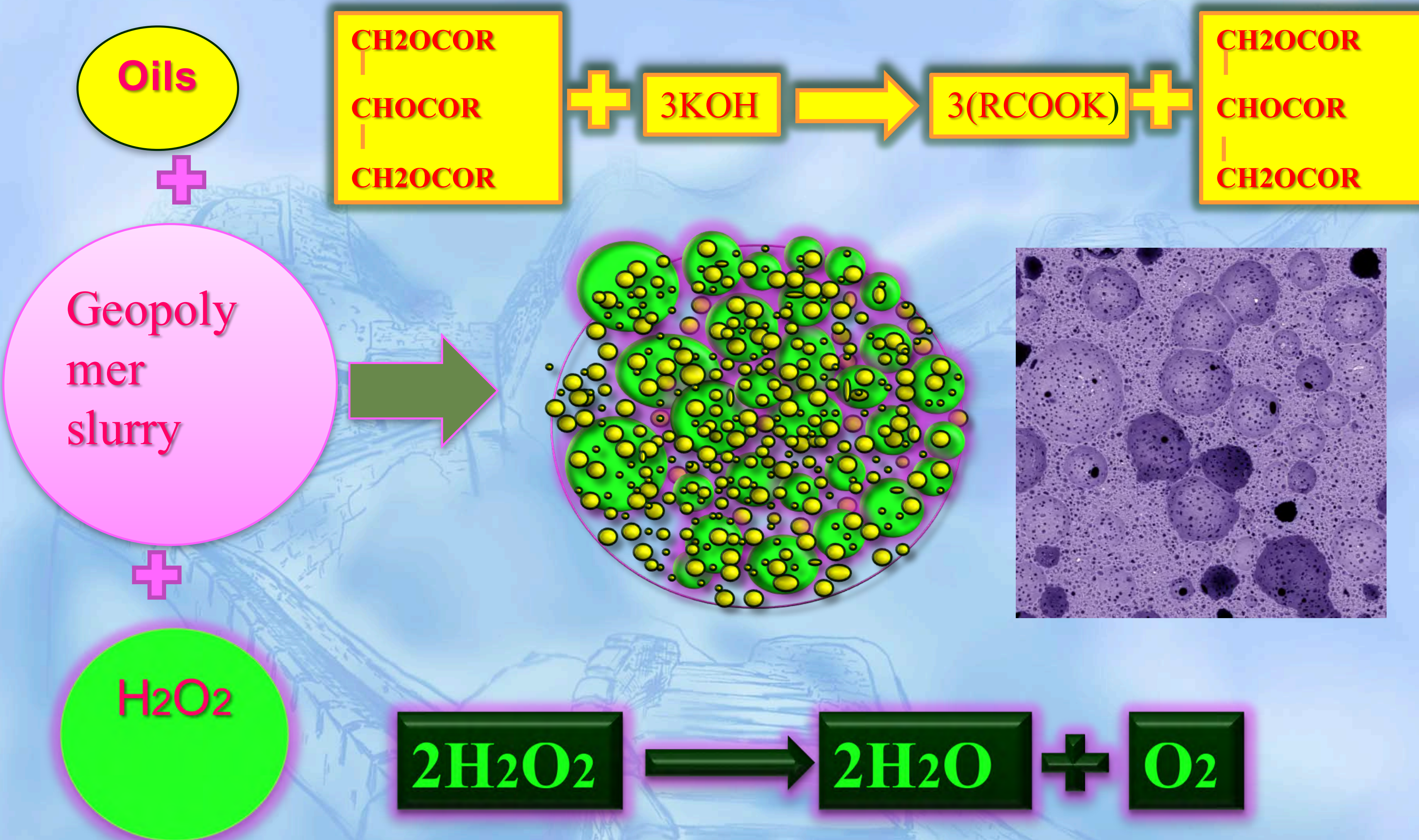

The mechanism of producing pores by saponification and peroxide combined routes

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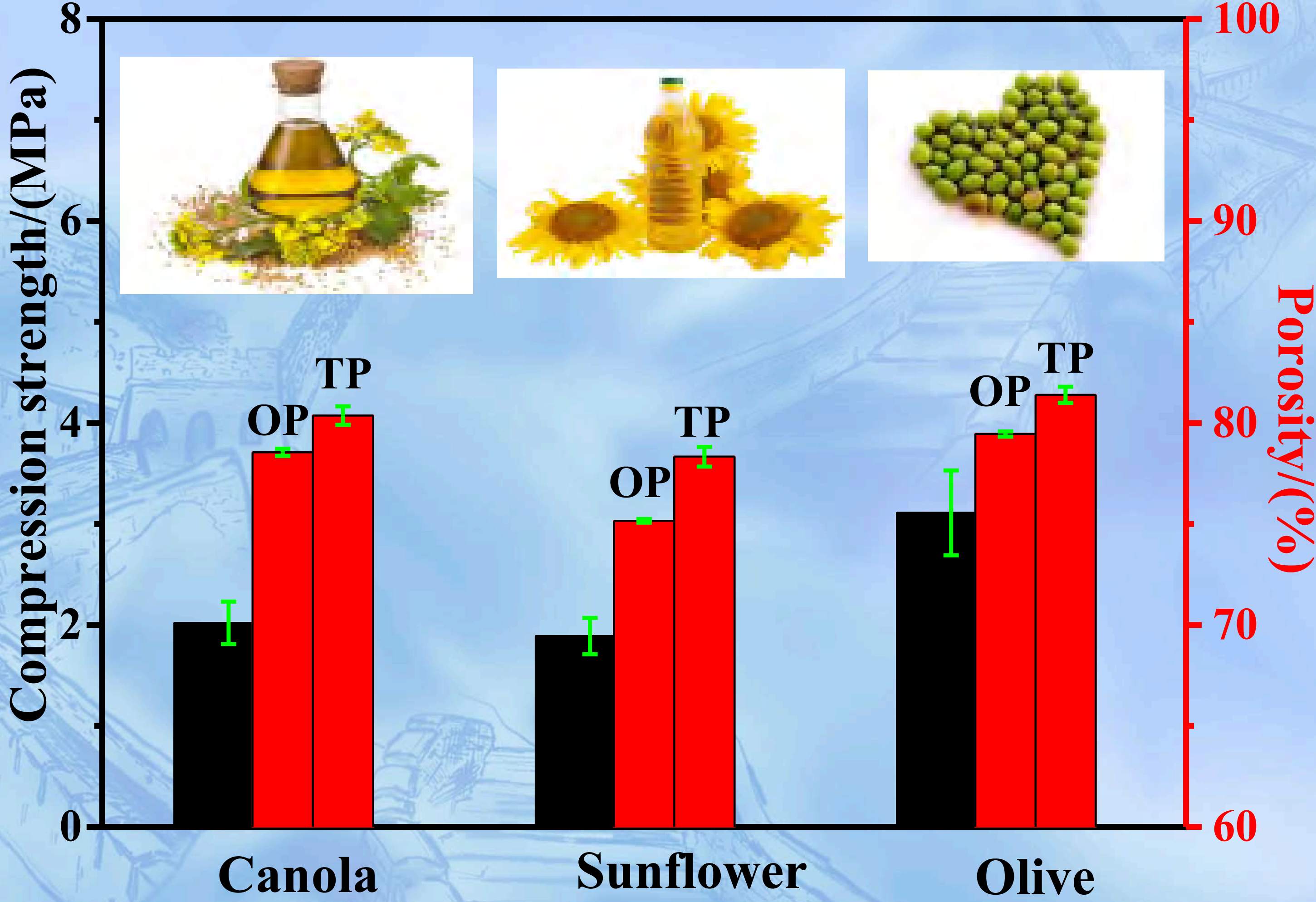
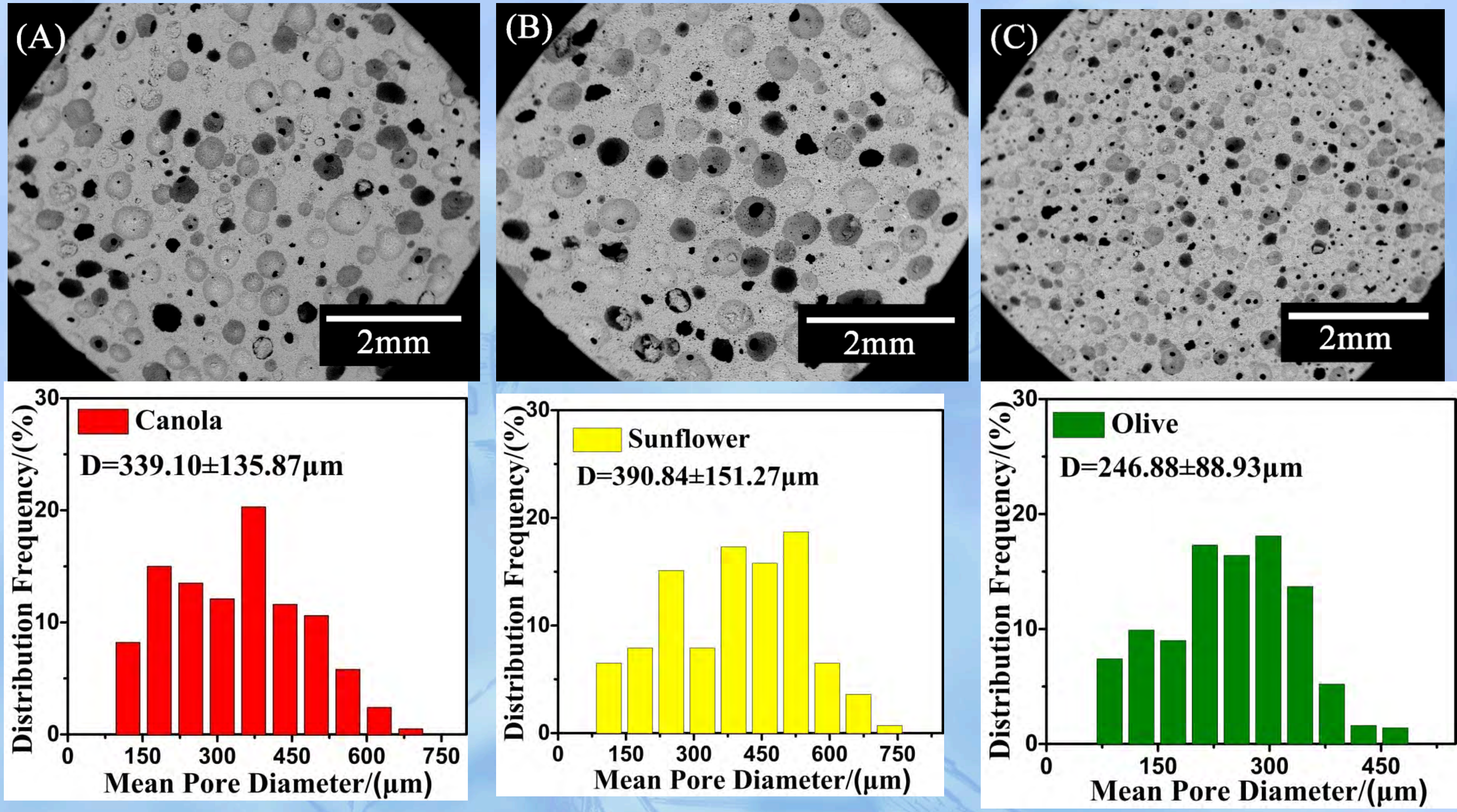
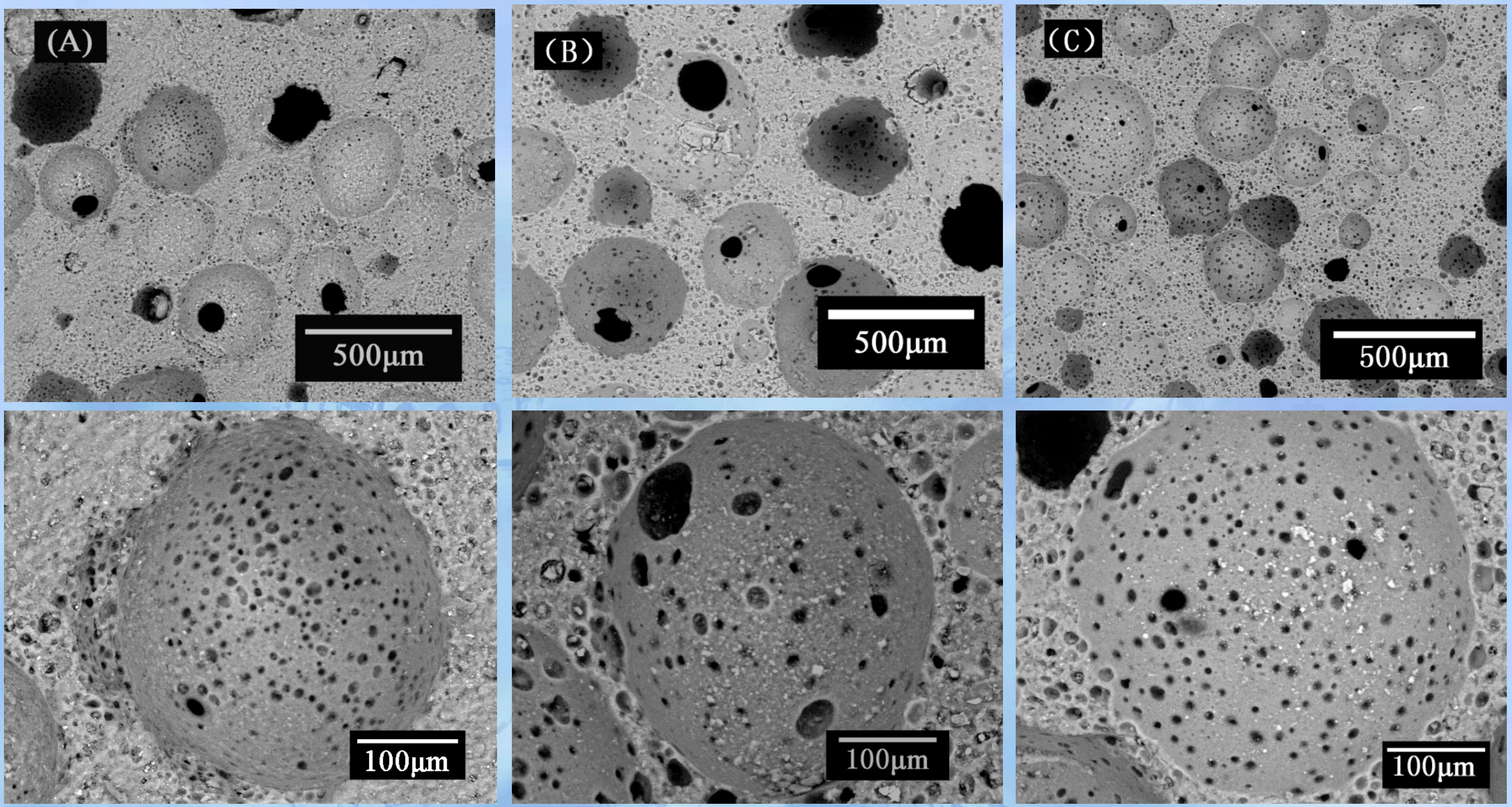


Porosity and compression strength of MGFs produced using different types of oils (OP = open porosity (vol%); TP = total porosity (vol%)). Samples produced using x=0.2, y=0.1.(Same content of oils and H_2O_2)



SEM images of MGFs produced using: canola oil (A); sunflower oil (B); olive oil (C). The below of figures (A)-(C) report the cell size distribution data.



SEM images of MGFs produced using: canola oil (A); sunflower oil (B); olive oil (C). The below of figures (A)-(C) are a magnification of a cell to better visualize the cell windows.

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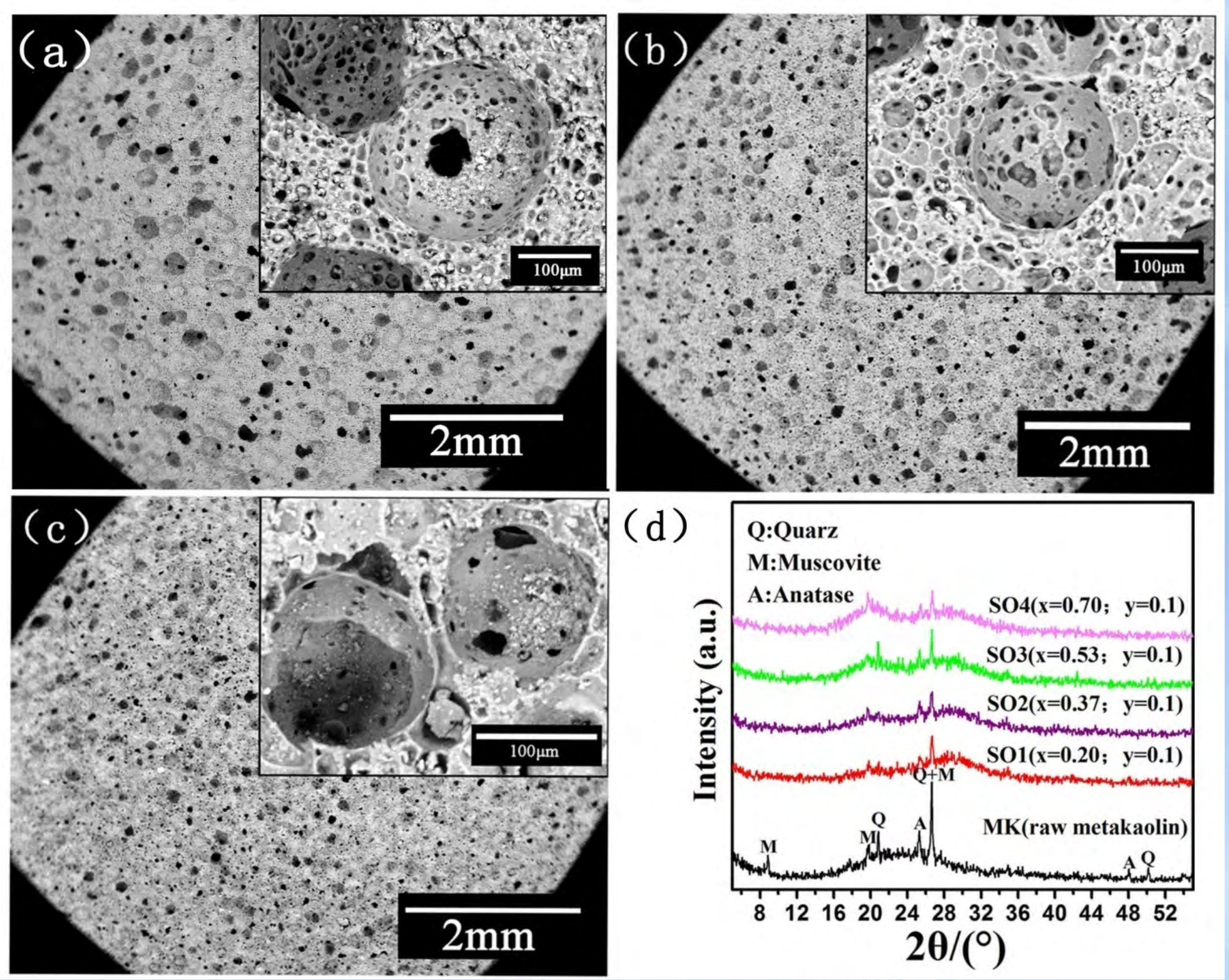
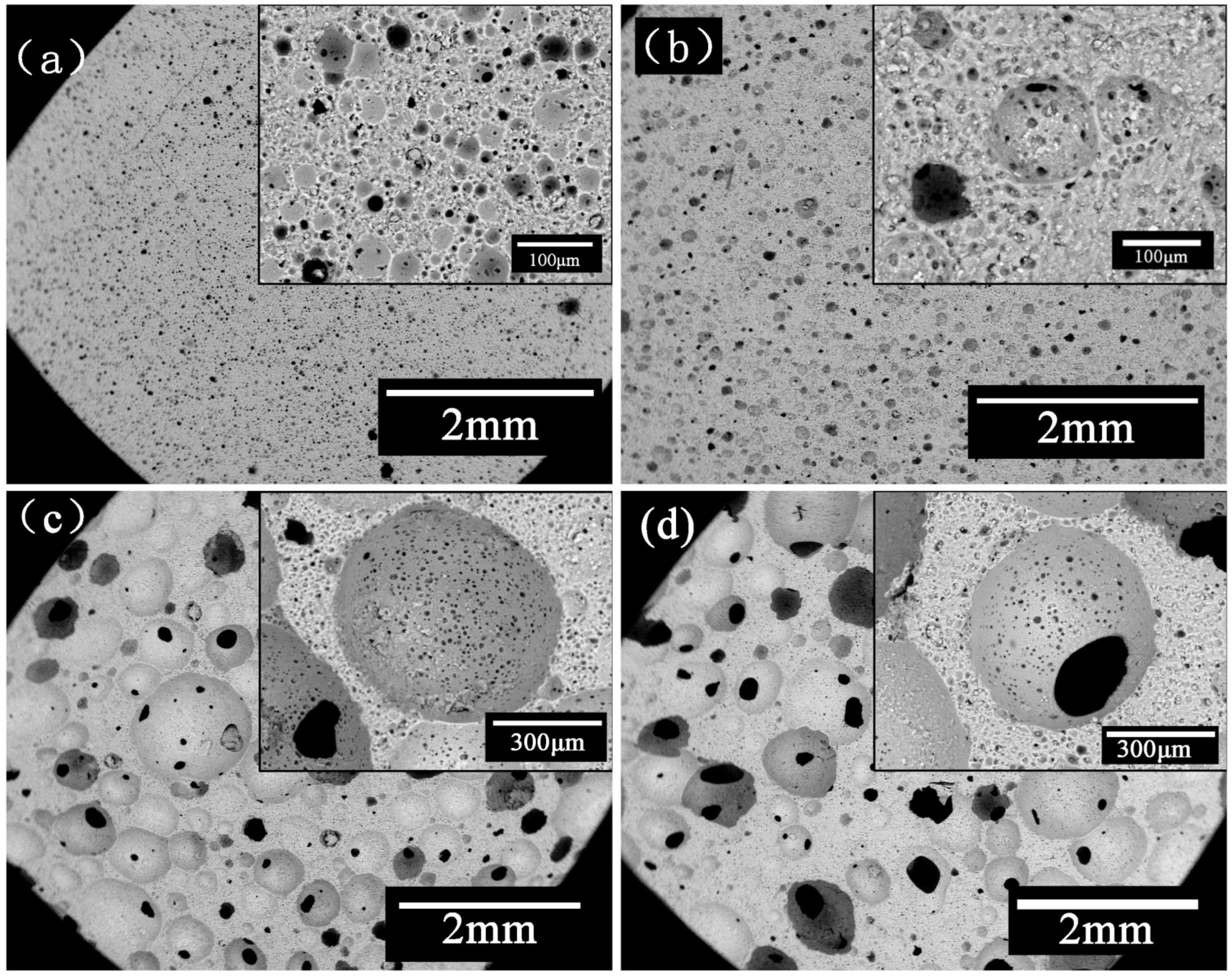


a-c) Morphology of MGFs produced with various amounts of olive oil (a) x=0.37; b) x=0.53; d) x=0.70); insets show a magnified view of a cell and surrounding struts. d) XRD patterns of pure MK and of different samples.



SEM images of MGFs produced using different amounts of hydrogen peroxide (a): y=0.0; b) y=0.05; c) y=0.10; d) y=0.15. x=0.20); the insets are a magnified view of a cell and surrounding struts.

Sample	x	y	K_2O/SiO_2	Bulk density (g/cm^3)	Average size (μm)		Open porosity (vol%)	Total porosity (vol%)	Compression strength (MPa)
					Cell	Strut and cell wall pores			
SO1	0.20	0.1	0.29	0.40±0.01	247±89	17.3±5.3	79.5±0.1	81.4	3.11±0.82
SO2	0.37	0.1	0.23	0.42±0.01	210±73	20.9±6.0	75.2±0.3	75.4	2.57±0.52
SO3	0.53	0.1	0.17	0.48±0.02	169±51	28.3±9.6	68.4±0.3	70.3	2.38±0.47
SO4	0.70	0.1	0.12	0.51±0.02	130±52	37.8±13.6	62.9±0.2	67.4	2.19±0.21
SH0	0.20	0	0.29	0.84±0.01	40±15	—	—	62.0	25.96±5.12
SH2	0.20	0.05	0.29	0.59±0.02	125±46	16.5±5.4	67.0±0.1	72.6	8.83±2.38
SH6	0.20	0.15	0.29	0.30±0.01	383±265	17.2±5.9	84.0±0.1	86.3	0.78±0.12
SH8	0.20	0.20	0.29	0.26±0.01	490±335	20.9±8.6	85.8±0.3	89.2	0.38±0.08

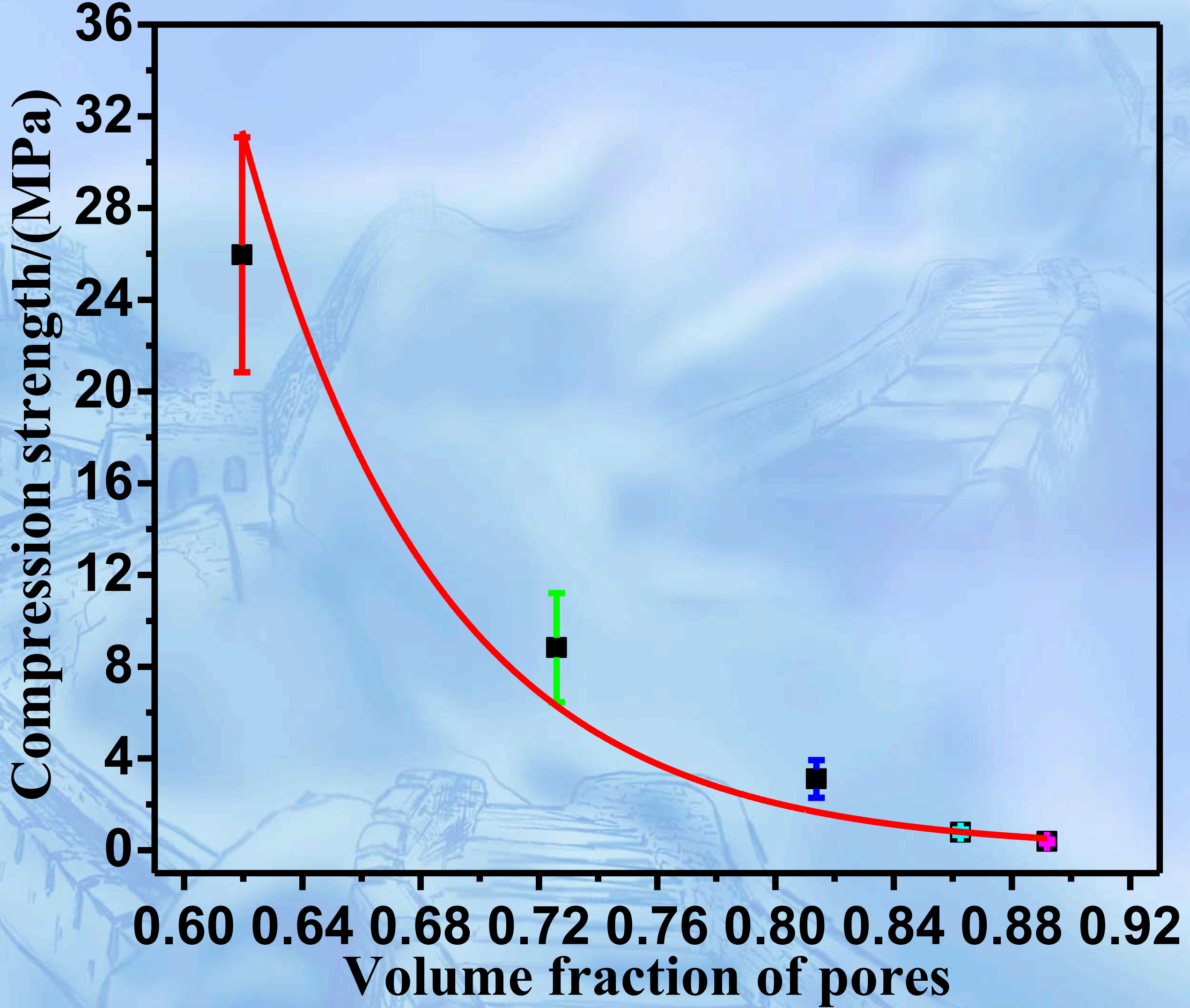
Porosity, relative density, average cell size and compressive strength data as a function of the amount of olive oil (x) and peroxide (y).

MSA models

According to the **minimum solid area** models(Minimum solid areas are the actual sintered or bond areas between particles and the minimum web cross-sections between pores; i.e., the flexural strength of the MGFs should be related to the whole cumulative area of all fracture points on the fracture surface.) proposed by Rice, when the other factors in a porous material that may affect the mechanical strength of cellular ceramics, such as the synthesis temperature or the pore characteristics, are not dominant, the strength-porosity dependence can be approximated by an exponential function:

$$\sigma = \sigma_0 \exp(-bp)$$

where σ is the strength at total porosity p, σ_0 is the value when p=0 for the same composition, and b is an empirical constant depending on the pore characteristics.



Plot of compression strength vs. total porosity for MGFs produced using different contents of H_2O_2 and the same amount of olive oil (x=0.20).

Conclusions

1)High strength and high porosity geopolymer foams with varied pore morphology were fabricated by a combined saponification/peroxide using H_2O_2 and three different oils (canola, sunflower and olive oil).

2) Increasing the amount of oil decreased the total porosity and cell size, because of the increase in viscosity , while the compression strength decreased because of the higher amount of pores (deriving from the oil droplets) in the struts. And with increasing oil content (lower K_2O/SiO_2 ratio) could also be a contributing factor to the variation in strength.

3) With increasing H_2O_2 content, the total porosity increased, while the compression strength decreased, because the minimum solid cross-sectional load bearing areas were reduced.

Acknowlegements

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This work is accepted in Journal of the European Society.

Any questions?

THANK YOU FOR YOUR ATTENTION!