Cork-containing alkali activated composites: a multifunctional ultra-light building material

Rui M. Novais[1], J. Carvalheiras [1], L. Senff [2], M.P. Seabra [1], R.C. Pullar [1], **J.A. Labrincha** [1,*]

[1] Materials and Ceramic Engineering Department / CICECO – Aveiro Institute of Materials, University of Aveiro, Campus Universitário de Santiago, 3810-193 Aveiro, Portugal

[2] Department of Mobility Engineering, Federal University of Santa Catarina (UFSC), 89.219-600 Joinville, SC, Brazil

jal@ua.pt

universidade de aveiro 1973 . 2018

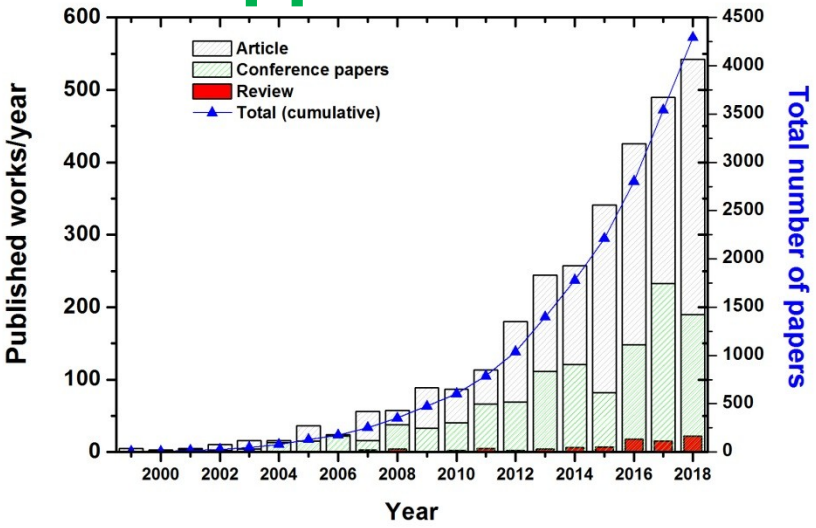
universidade de aveiro theoria poiesis praxis

ciceco instituto de materiais de aveiro

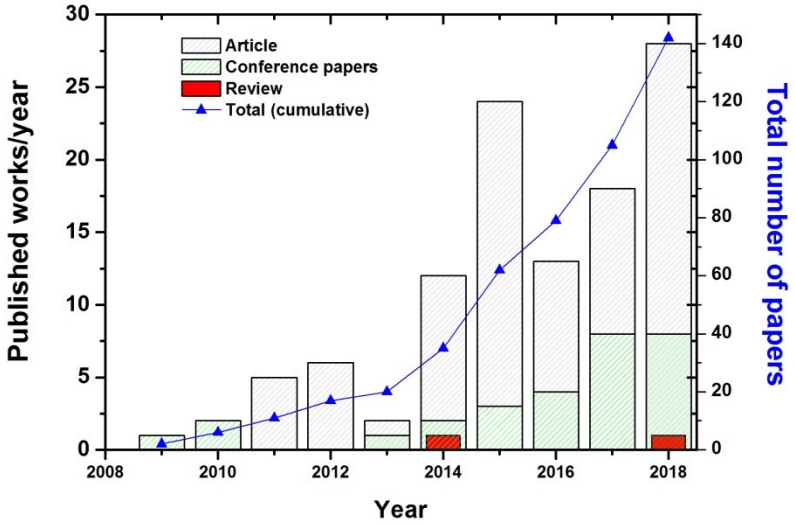
Geopolymers – current and future trends

Context

Common applications



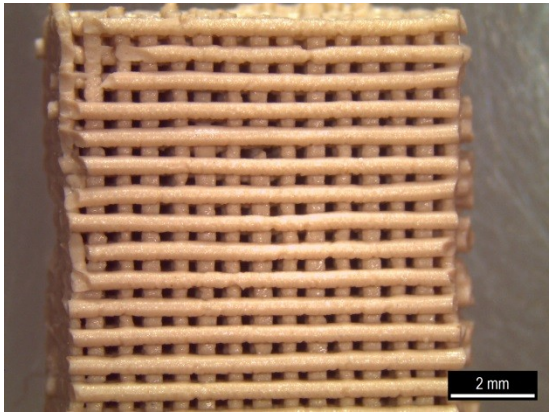
Novel uses ?



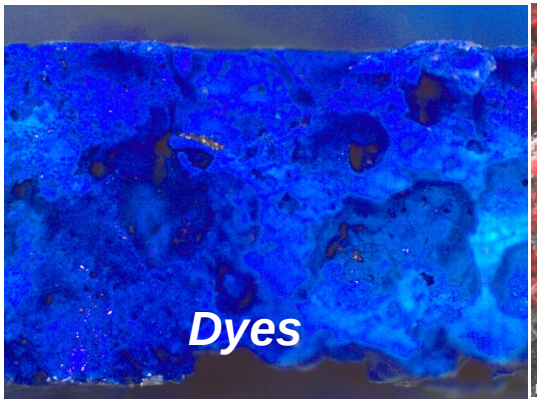
Porous geopolymers for innovative applications

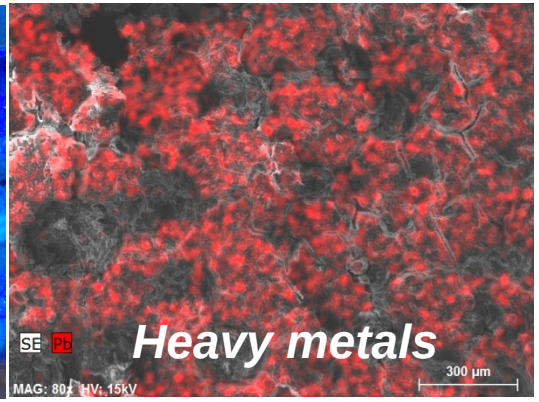
Ongoing work...

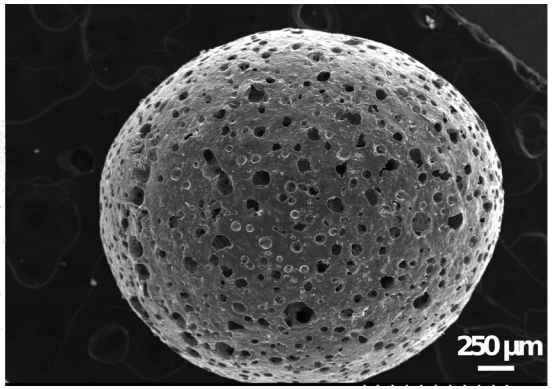
Adsorbents



3D printing



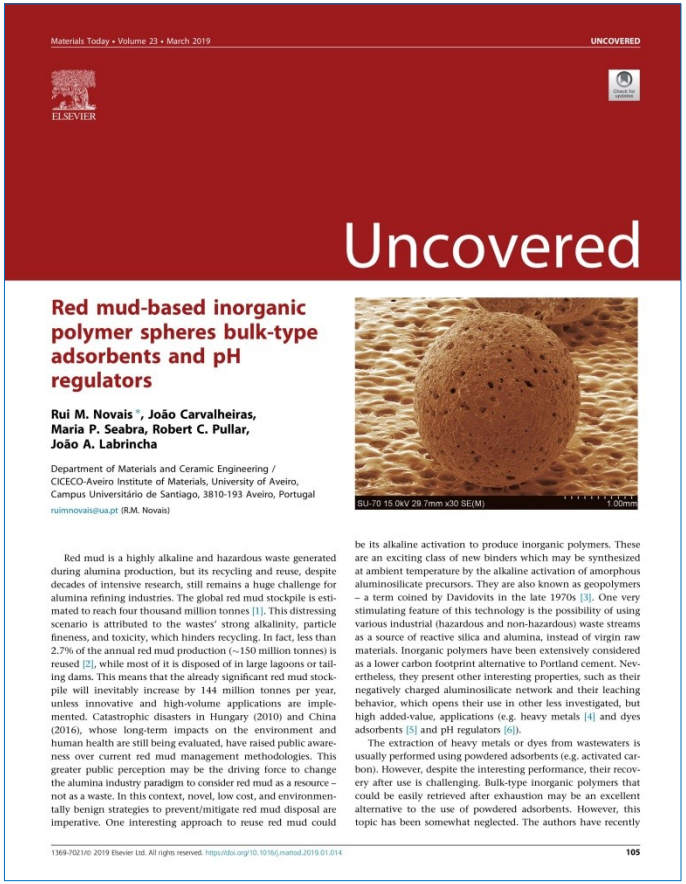




pH buffering material

Magnetic geopolymers

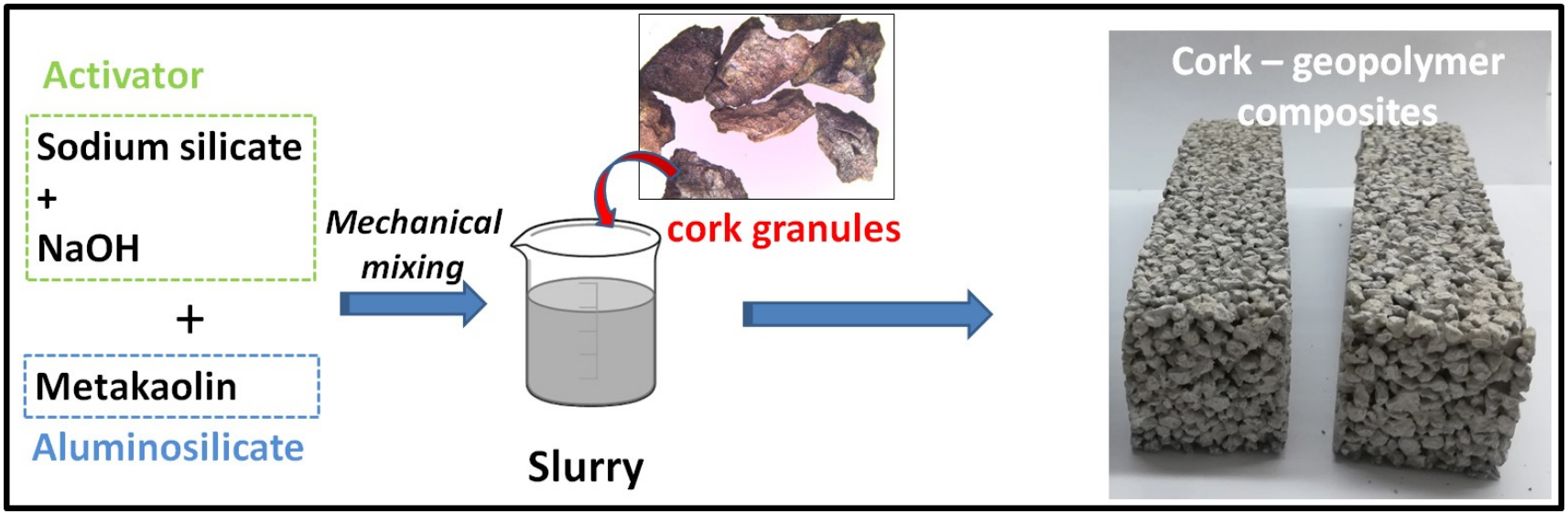
Our geopolymers are on the Cover of **Materials Today** (Vol **23**, March 2019, p. 105-106)



DOI: doi.org/10.1016/j.mattod.2019.01.014

Objectives

Production of multifunctional cork-geopolymer composites



Recent papers from Novais *et al.*:

***Cement and Concrete Composites*, 97, 107-117, 2019.**

Materials Today 23, 105-106 (2019).

Journal of Cleaner Production 220C, 630-641 (2019).

Journal of Cleaner Production 227, 877-889 (2019).

Cement and Concrete Composites 97, 143-153 (2019).

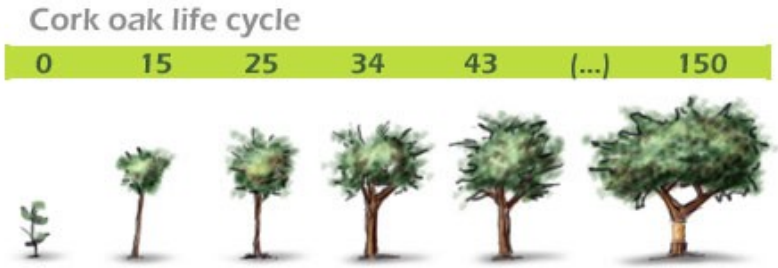
Applied Clay Science 179, 105147 (2019).

Journal of Cleaner Production 207C, 350-362 (2019).

Materials Letters 236, 644-648 (2019).

Cork is the Bark of a Slow Growing Oak (*Quercus Suber*) from the Mediterranean

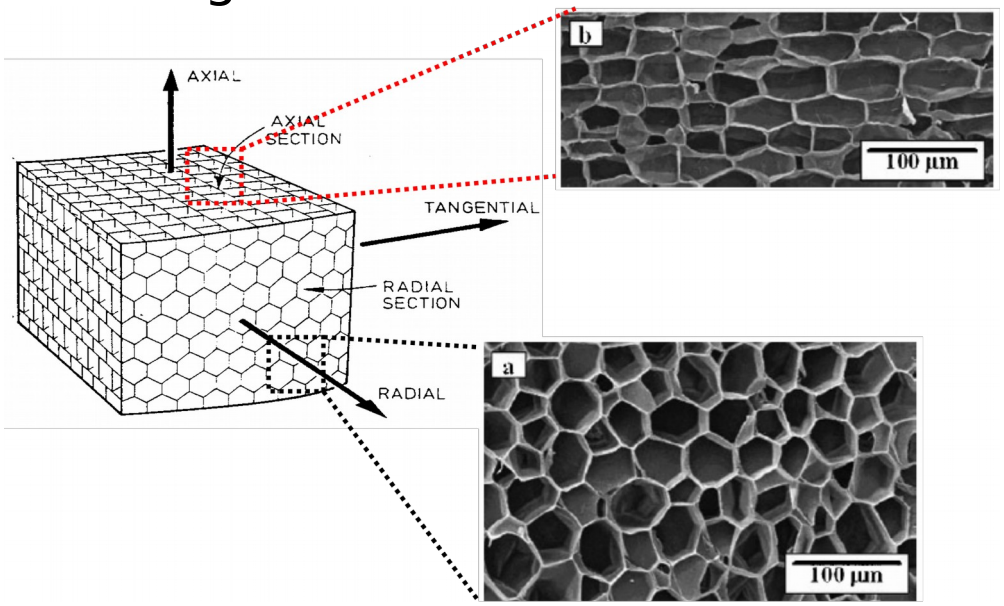
50% of all cork comes from **Portugal**

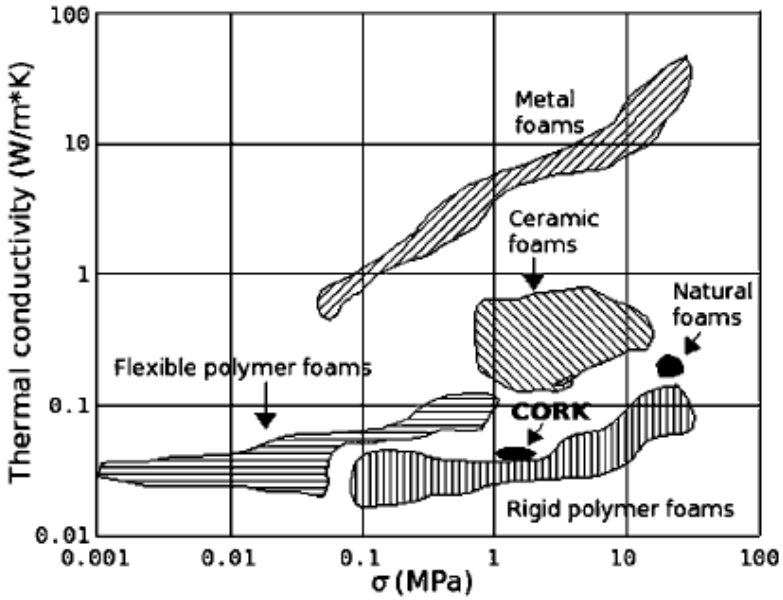


Bark is harvested every 9-13 years, but tree lives on unharmed as carbon sink for >200 years

Cork is a Renewable Portuguese Resource

Cork has a natural 3 **Dimensionally Ordered Macroporous structure** (3-DOM), hexagonal in radial direction and rectangular in others





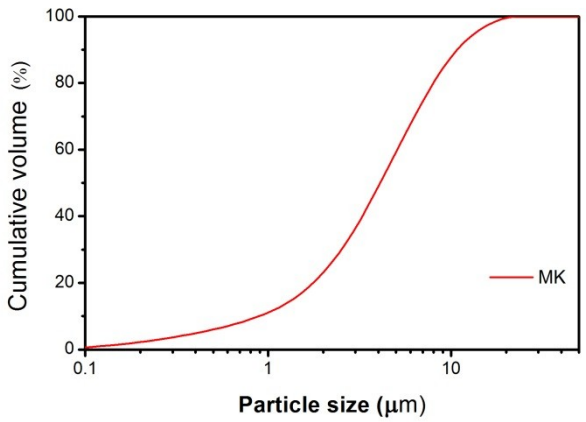
Silva *et al.*, *Int. Mater. Rev.* 53, 345-365, 2008.

Cork is also **very light** (up to 0.120 g/cm³), presents **low thermal conductivity** and **high sound absorption.**

Metakaolin and cork characterizati

Metakaolin

(Argical M1200S, Univar)

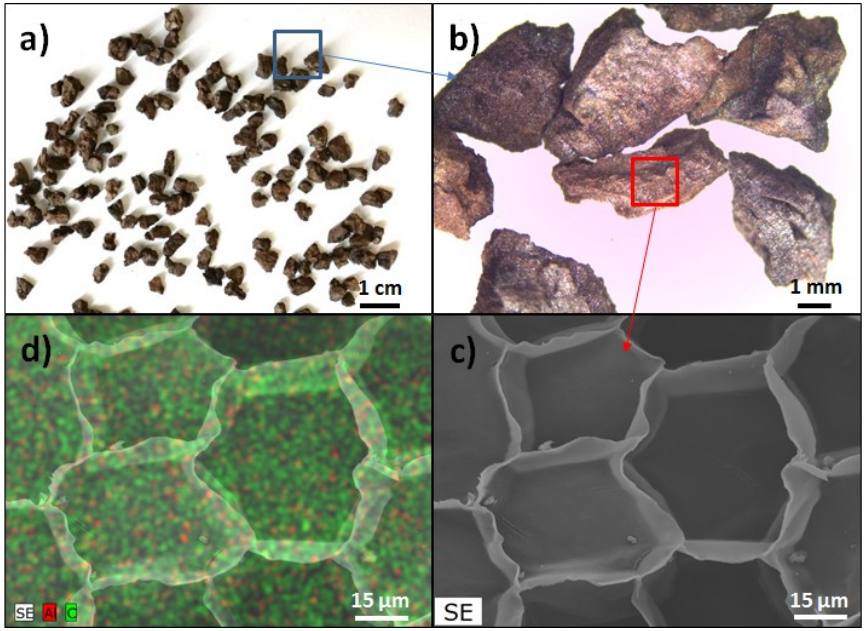


- Mean particle size: ~5 µm
- BET SSA (BET): ~25 m²/g

Oxides (wt.%)	MK
SiO_2	54.40
Al_2O_3	39.40

Black expanded cork granules

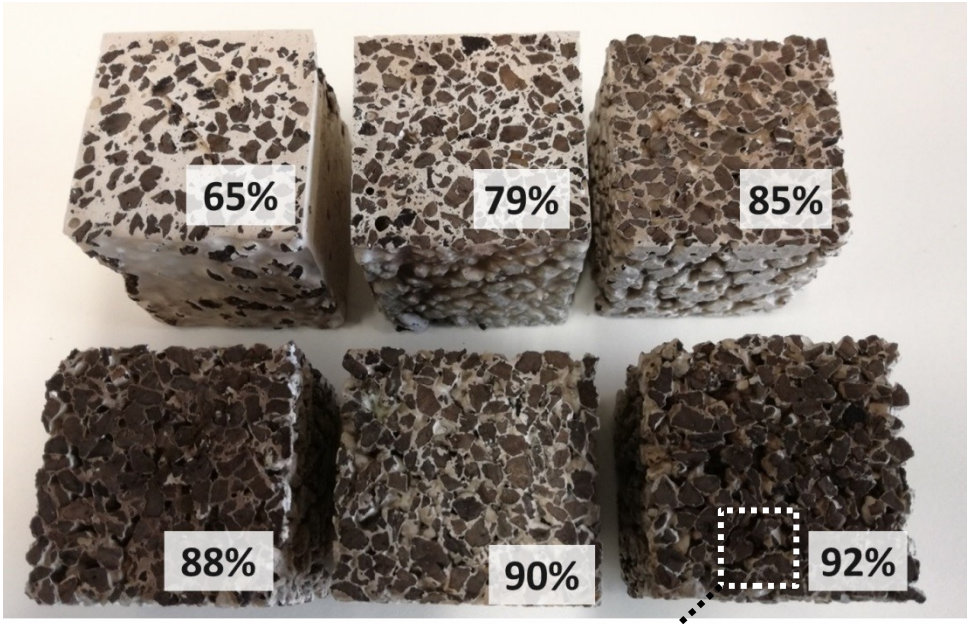
SEM/EDS

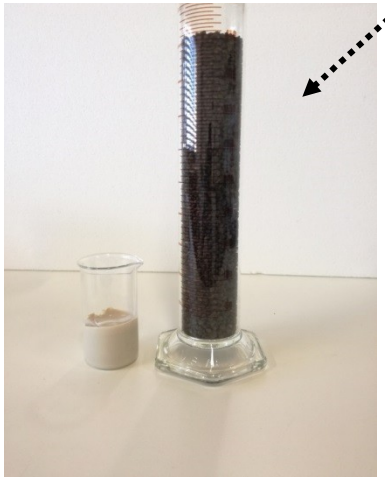


- **Apparent density**: 70 kg/m³
- **Average size**: 5.7± 1.1 mm

Cork-geopolymer composit characterization

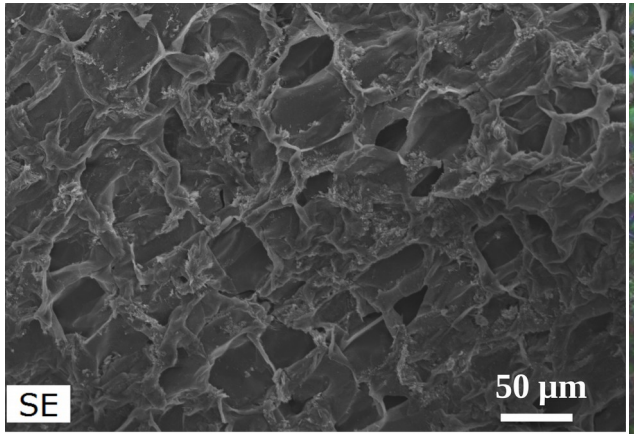
Microstructural analysis

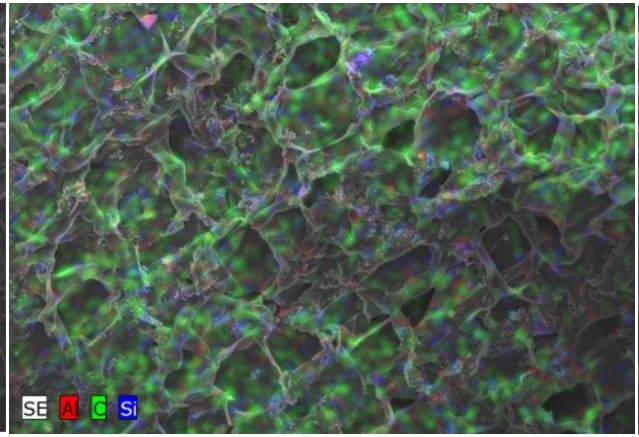


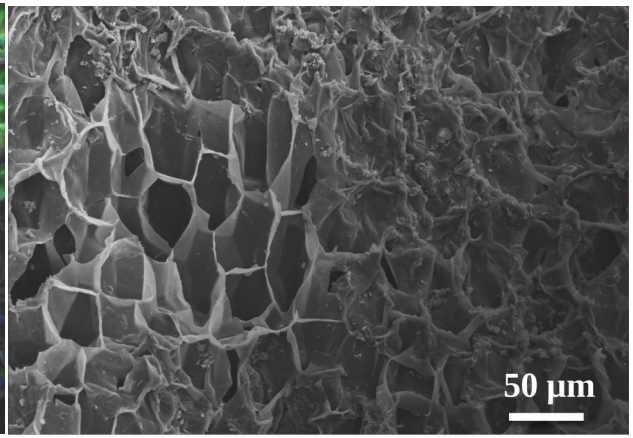


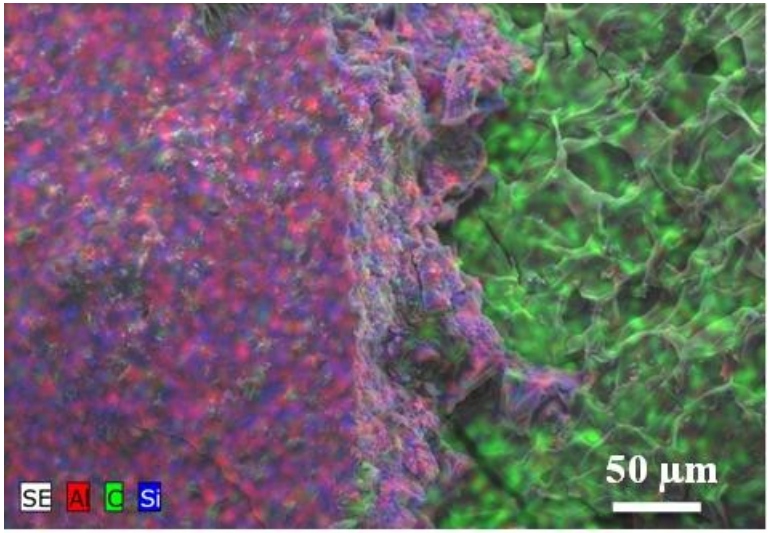
Cork-geopolymer composit characterization

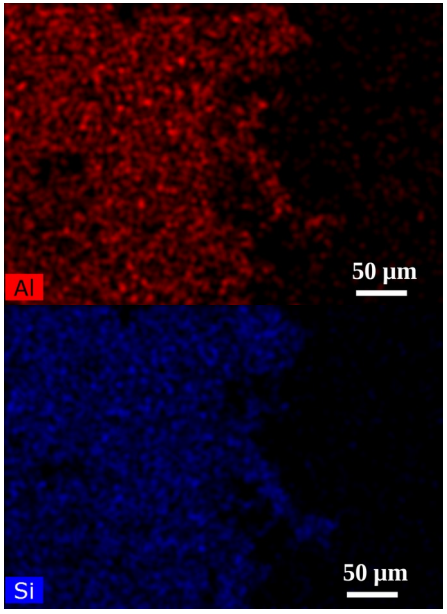
Microstructural analysis

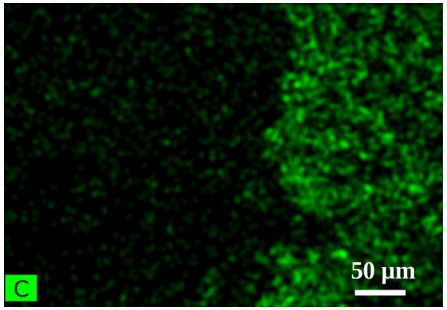




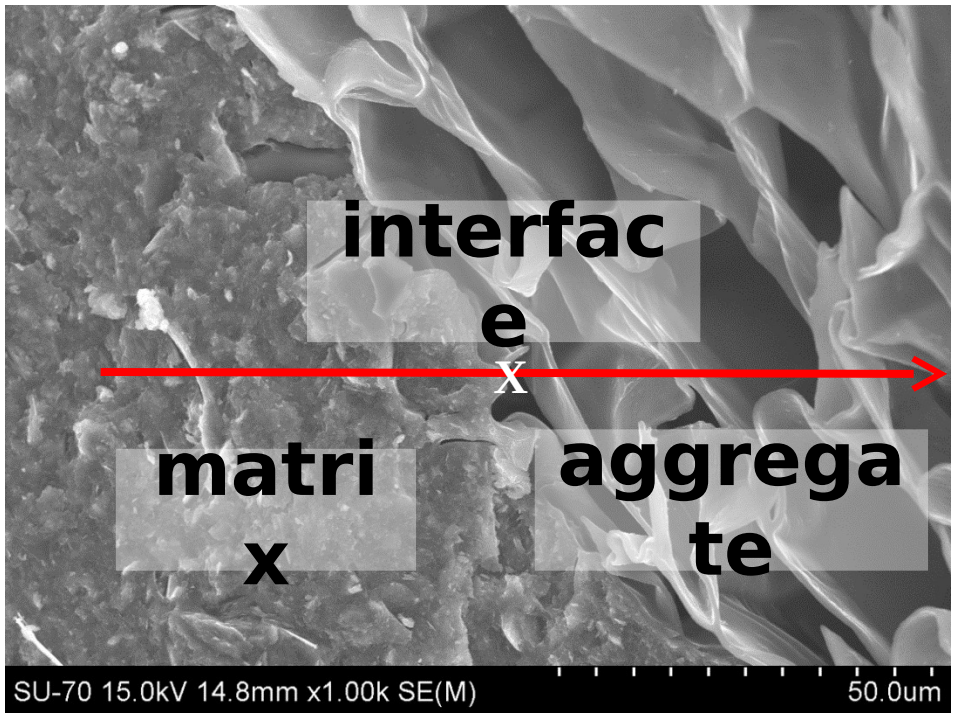


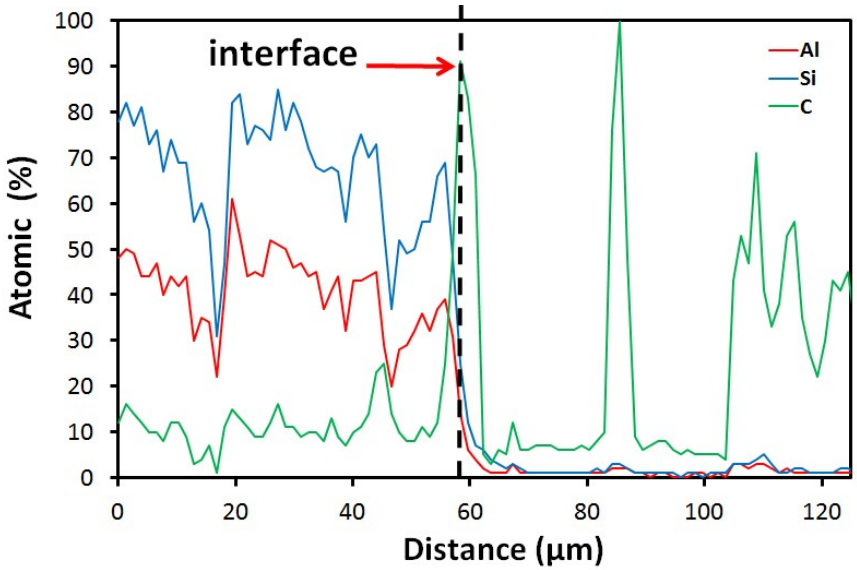






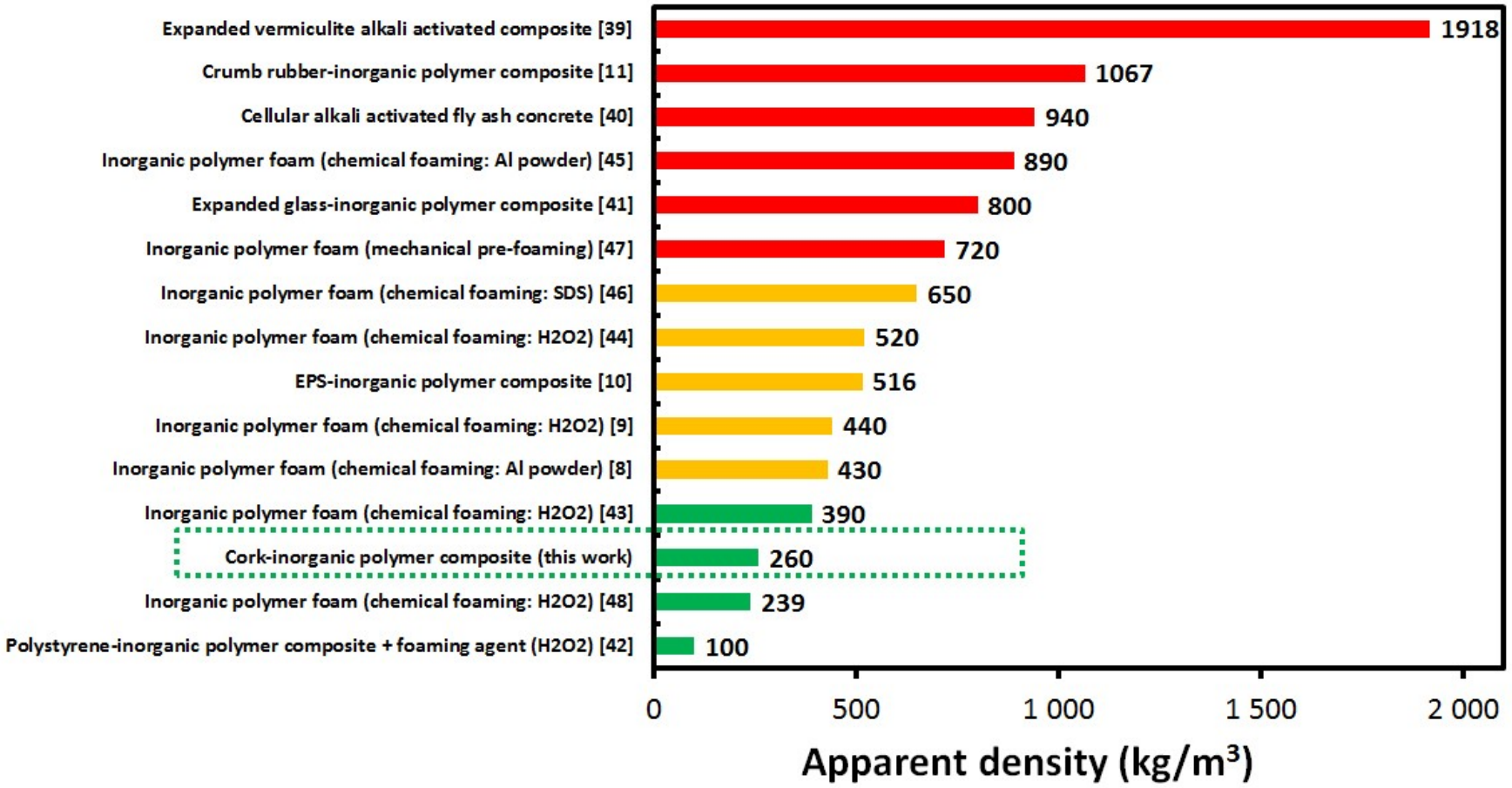
Microstructural analysis





There <u>isn't any clear gradual transition</u> between the dense matrix and the porous aggregate.

Cork-geopolymer composit characterization

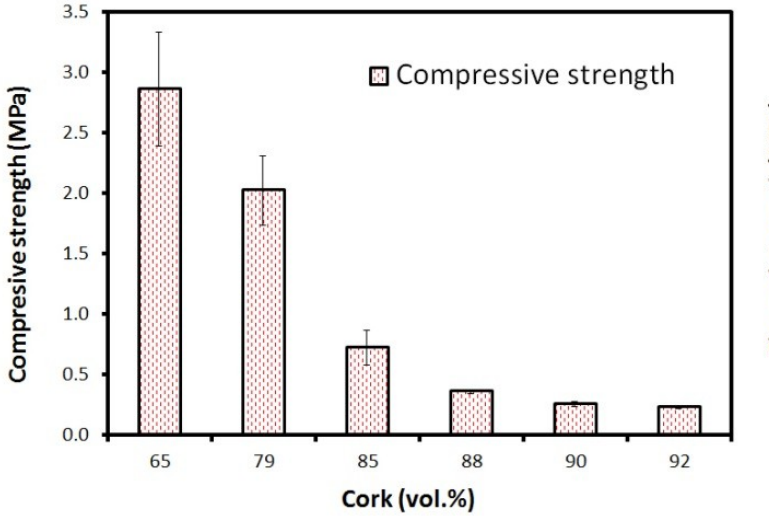


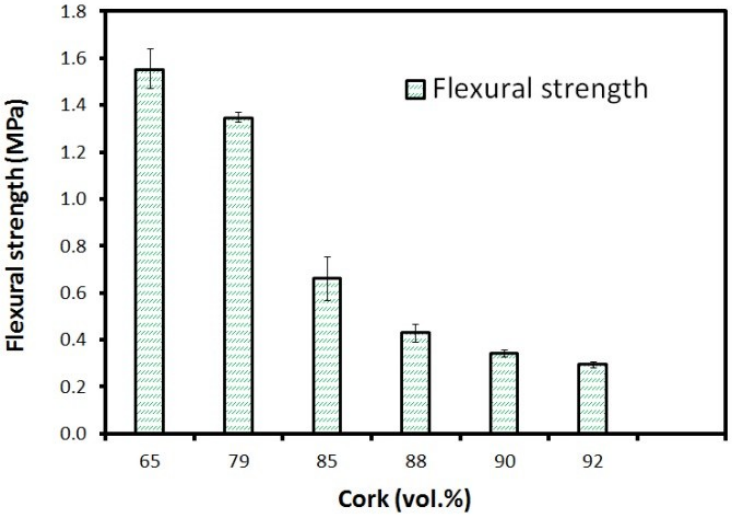
Novais *et al.*, *Cement and Concrete Composites*, 97, 107-117, 2019.

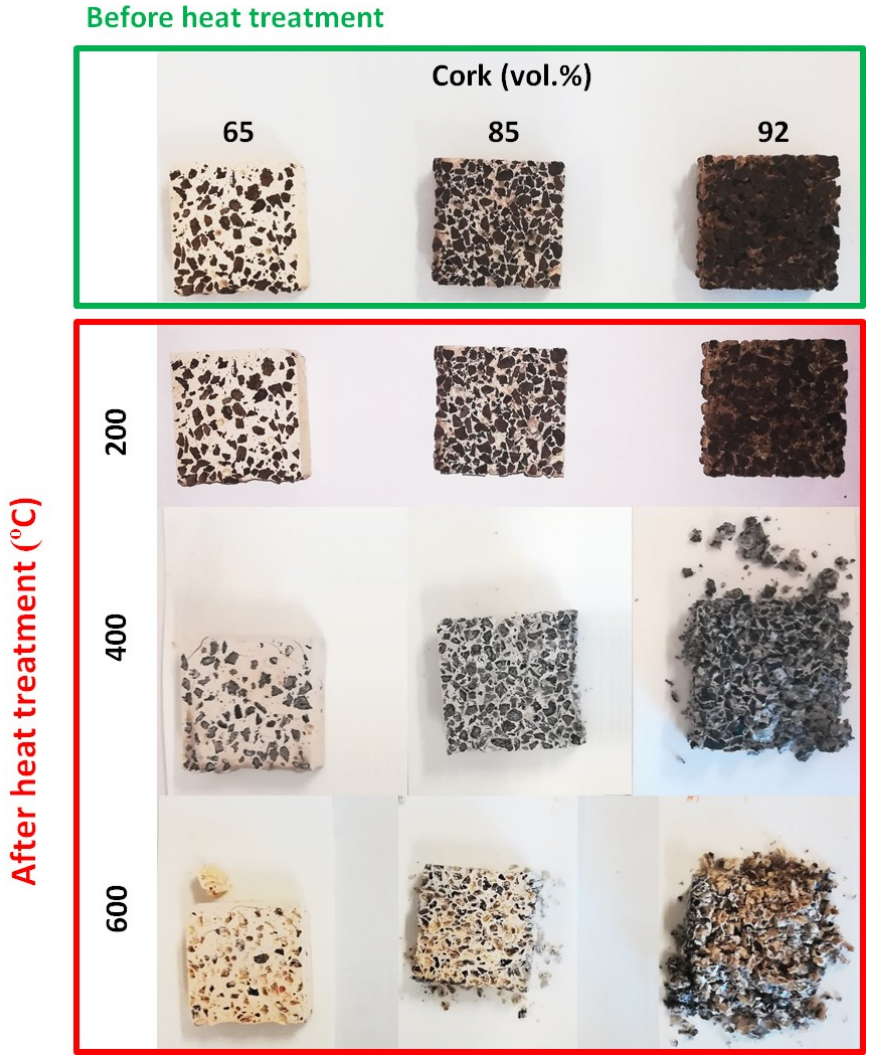
The cork-geopolymer composites apparent density is among the lightest ever reported for geopolymer composites!

Cork-geopolymer composit characterization

Mechanical strength and thermal stability

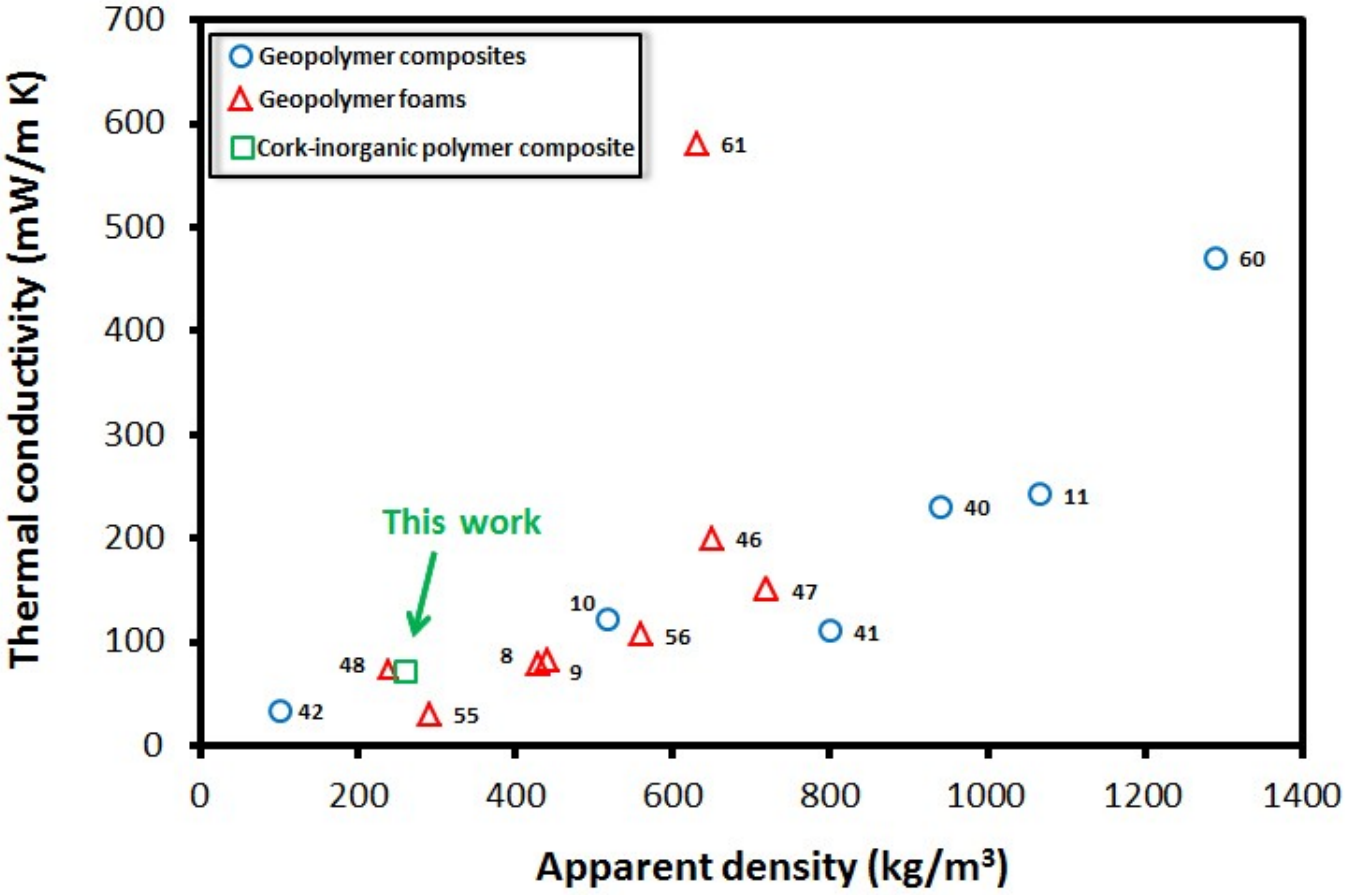






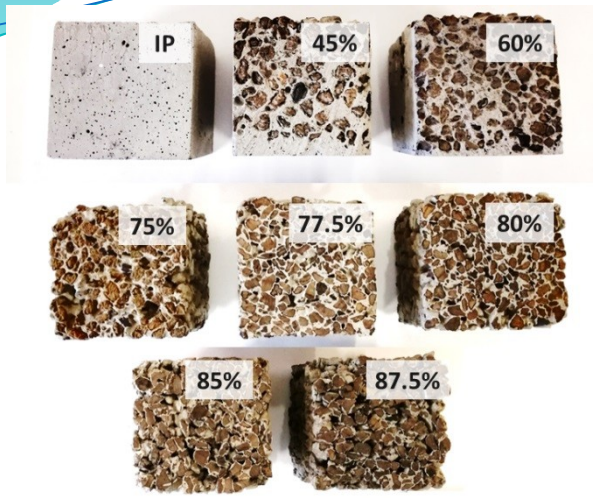
Cork-geopolymer composit characterization

Thermal conductivity



Low thermal conductivity composites: 72 mW/ m.K

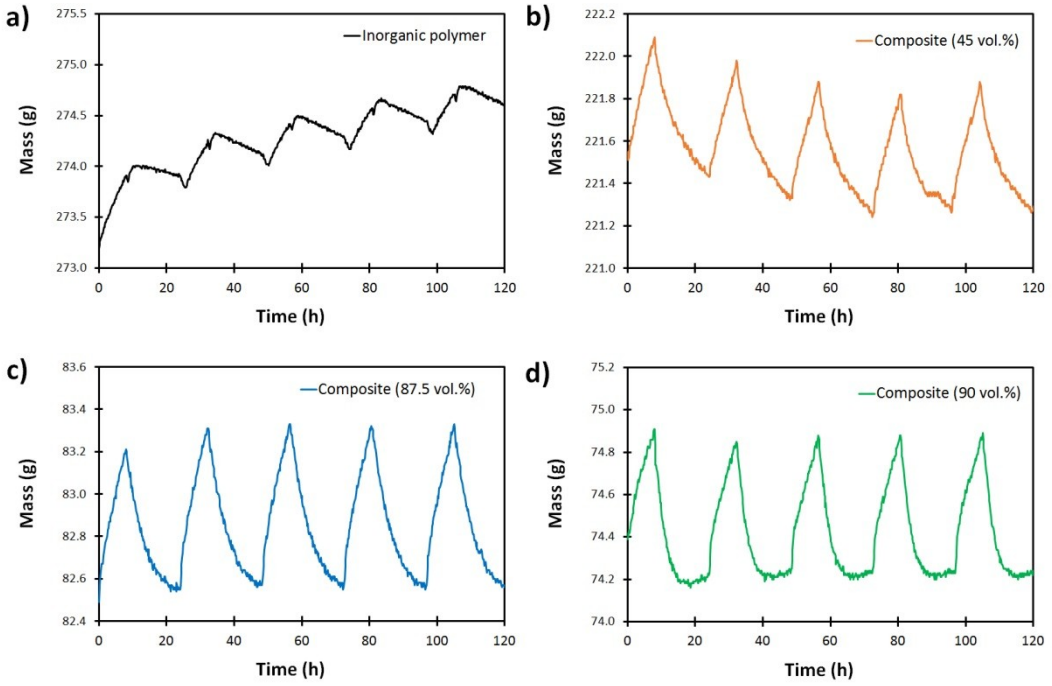
Cork-geopolymer composit characterization

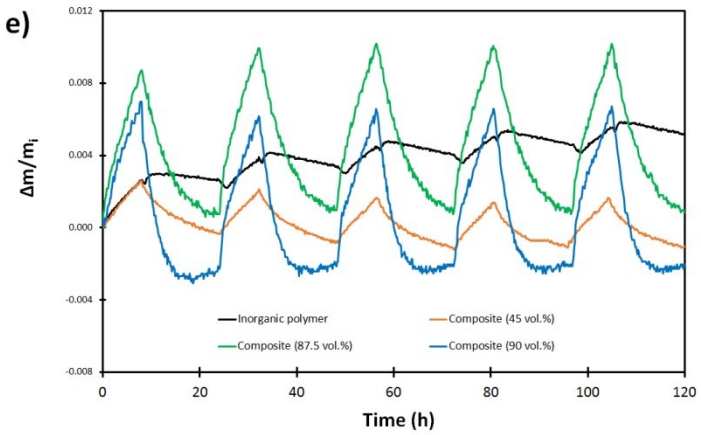


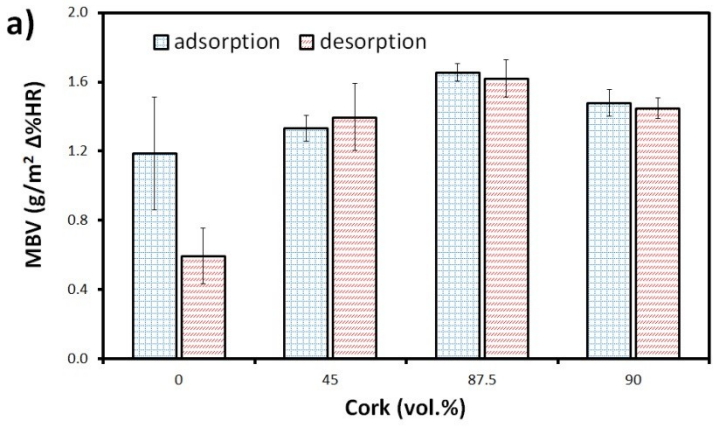
Novais *et al., Unpublished results.*

$$MBV = \frac{\Delta m}{A \times \Delta\%RH}$$

Moisture buffer value (MBV)

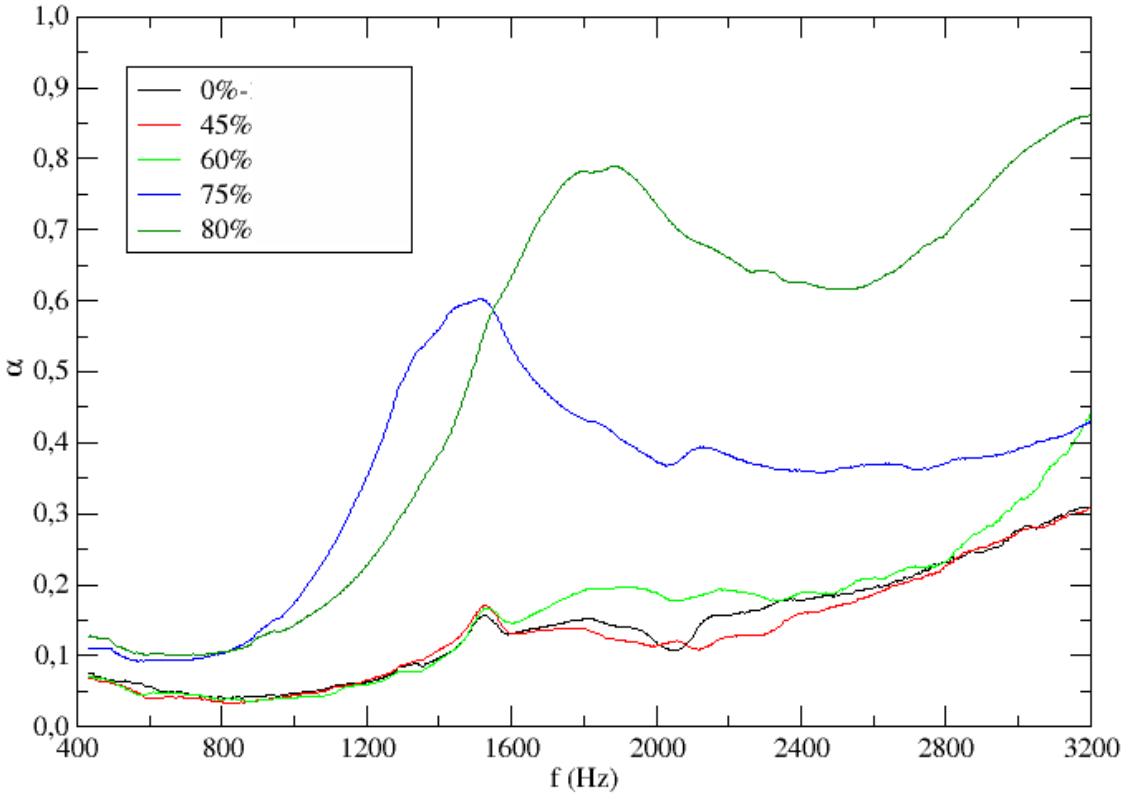


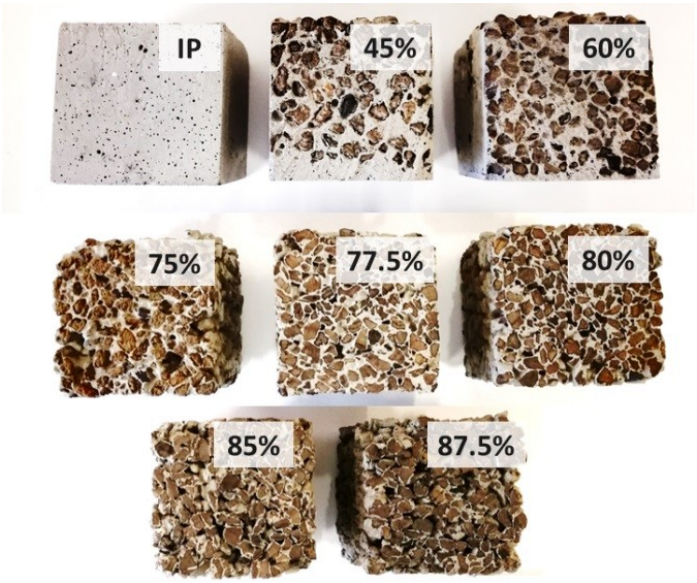




Cork-geopolymer composit characterization

Acoustic insulation





Novais *et al.*, *Unpublished results.*

Collaboration with:
Ana María Lacasta (Universitat Politècnica de Catalunya)

Conclusions

- Cork, an extraordinary renewable resource, was used **for the first time** as lightweight aggregate to produce **multifunctiona**l cork-geopolymer composites showing:
  - **ultra-low density** (260 kg/m^3)
  - **low thermal conductivity** (0.072 W/m K)
  - **good humidity regulation ability** (MBV = 1.64 g/m^2 Δ%HR)
  - **high acoustic absorption** (α= 0.6-0.85 (1600-3200 Hz))

- This novel and sustainable material may **decrease the energy losses** inside buildings, **decrease energy consumption** and **enhance the interior acoustic comfort** for inhabitants.

Thank you for your attention!

jal@ua.pt