

## Ecological low-cost ceramic membranes based on olive stones as pore former

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### Short Introduction

Ceramic membranes offer unique advantages due to their good properties, such as mechanical strength, thermal stability and resistance to harsh chemical conditions. However, their high cost has traditionally limited their use in cost sensitive processes, such as environmentally related applications (Baker 2004, Burggraf 1996).

The main objective of this research is to manufacture ceramic membranes with lower cost than the commercial ceramic ones, more sustainable and competitive and use them in potential micro or ultrafiltration applications. The composition of the ceramic membranes is based on agricultural and industrial wastes, such as olive stones (from olive oil production) used as pore former, marble powder (from quarrying and processing of marble) and chamotte (from fired tile scrap).

One important factor when determining membrane's properties deals with the influence of the waste material characteristics, as waste content and particle size. The influence of wastes used as pore former (olive stones) are analysed in the present study, as well as the influence of the sintering temperature on membrane properties.

### Material and Methods

The ceramic membranes developed in this project are based on raw materials normally used in the ceramic tile industry (basically clay), mixed with agro-industrial wastes in elevated proportions (higher than 40 wt%). From these materials, different compositions have been formulated, modifying the proportion and particle size of olive stones introduced as pore former.

Olive stones were collected from different olive mills of Castellon province (Spain). After drying them, they were milled at different particle size in a pendular roller mill.

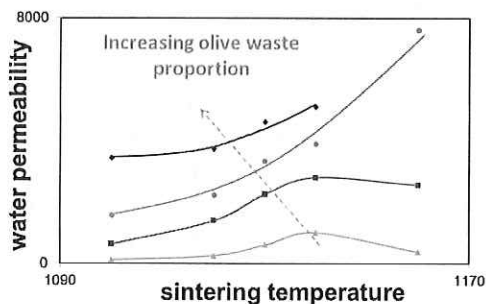
Ceramic flat-sheet membranes have been manufactured by extrusion. Initially, each batch of raw materials for the extruded membranes was kneaded and allowed to stand for 24 h to achieve uniform moisture in the mass. Test pieces were shaped using a laboratory auger with a de-airing chamber. Then, samples were dried at room temperature for 24 h, and oven-dried at 110°C. Next, the membranes were sintered in a laboratory electric kiln with different thermal cycles and their properties were determined.

## Results and Discussion

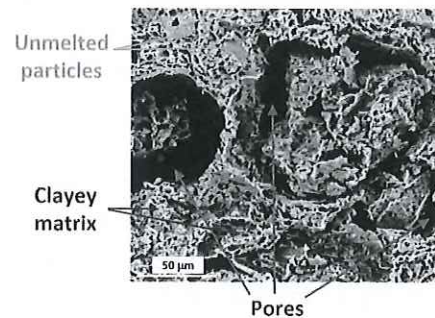
Porosity of sintered membranes increases with olive stone content, since the stones' combustion gives rise to pores. Porosity is also affected by the olive stone particle size: as the olive stone particle increases, the densification during sintering decreases and the porosity increases. The porosity also depends on the sintering temperature, decreasing when temperature rises.

Pore size also changes with olive stone addition; in particular, mean pore size strongly increases when olive stone proportion is raised. On the other hand, when the olive stone particle size increases, the pore size slightly enlarges, being the effect less evident at higher sintering temperatures. Finally, when temperature grows, a coarsening of pores is detected as a consequence of the Ostwald's Ripening effect (Kang 2005).

Finally, water permeability depends on porosity and pore size. Consequently, the lower the olive waste particle size, the lower the water permeability. On the other hand, the higher the olive waste content, the higher the water permeability, as can be seen in figure 1. Finally, water permeability also depends on sintering temperature.



**Figure 1.** Influence of olive waste content and sintering temperature on water permeability.



**Figure 2.** Microstructure of the sintered membranes (by SEM).

## Conclusions

The results show the great influence that characteristics and content of waste introduced as pore former exerts on the properties of the recycled ceramic membrane, as well as the sintering temperature. The membranes analysed in this study can be used as microfiltration membranes or as support where to apply a selective layer to reduce the pore size of the final membrane.

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## References

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