LOW-COST CERAMIC MEMBRANES: INFLUENCE OF PORE GENERATOR TYPE AND PROPORTION

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1. INTRODUCTION

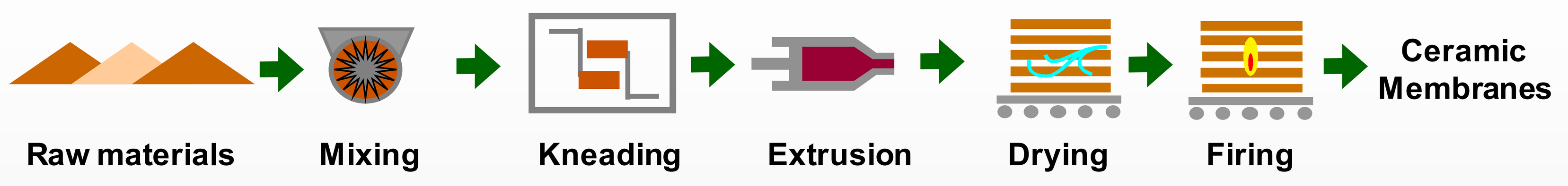
Low-cost ceramic membrane compositions are usually based on clayey raw materials, less expensive and used in the traditional ceramic sector (manufacture of tiles, sanitary ware, earthenware, porcelain, ...). Moreover, the composition includes a pore-forming agent that burns during the firing stage, generating an additional porous network that modifies the pore size distribution that could be obtained with the ceramic composition by itself and increases the permeability of the membrane. Starch is one of the most frequently used pore-forming agents, as it is a natural polymer that oxidizes easily (at temperatures close to 500°C), cheap and environmentally friendly. Whether the ceramic support acts directly as a membrane or whether selective layers are applied on it, the addition of starch to the support allows the porosity and pore size to be designed and controlled, so that the permeability and selectivity are adapted to the separation process for which it is intended.

In the present study, starches of different nature (potato, corn and pea) have been used in different proportions (20-30 wt%) to obtain ceramic membranes by extrusion, analysing how the nature of the starch (mainly the particle size) affects the unfired and fired properties of the supports, especially the final porosity, as well as the pore size and water permeability.

The membranes developed have been used in the recovery treatment of waste streams rich in Zn or Cu generated in different industrial sectors of the Valencian Region (metalworking and toys and related industries), in the conditioning stage (microfiltration) prior to electrodeposition.

2. MATERIALS AND METHODS

Mixtures of a ceramic composition and starch have been prepared by the following route:



Materials:

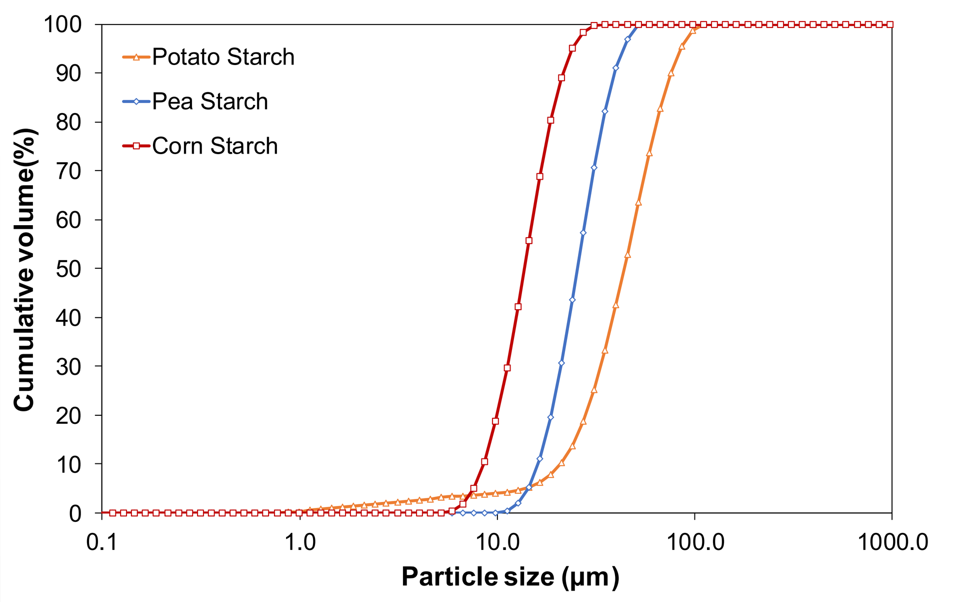
- Ceramic composition, provided by Euroarce-Samca (www.euroarce.com).
- Potato starch, purchased from Quimidroga (www.quimidroga.com).
  - Added in 3 different proportions: 20, 25 and 30 wt%.
- Pea and corn starch, provided by Roquette (www.roquette.com).
  - Added each in 2 different proportions: 20 and 30 wt%.

Starches have been characterized by means of particle size distribution.

Seven compositions have been studied, analysing the influence of type and proportion of starch on unfired and fired bulk density, open porosity, mean pore size (mercury porosimetry) and water permeability. Sintering temperature is equal for all compositions.

3. RESULTS

3.1. STARCH CHARACTERIZATION



Starch	D_{50} (μm)
Potato	44.0
Pea	25.6
Corn	13.7

Figure 1. Particle size distribution and mean pore size of different starches.

3.2. CHARACTERIZATION OF SUPPORTS

Next tables and figures summarize the results obtained. In table 1 unfired properties of compacts are shown, seeing that unfired bulk density decreased when starch content was increased, depending the variation on the type of starch.

Table 2 indicates fired properties of compacts, at the same sintering temperature. The addition of starch reduced the bulk density and increased the linear shrinkage, LOI and open porosity, depending the variation on the type of starch.

Figures 2 and 3 show the dependence of open porosity and water permeability on the starch content. Figure 4 presents the variation on mean pore size with average starch particle size, indicating a exponential relationship between both diameters.

Table 1. Unfired properties of samples prepared with different type and content of starch.

Starch	Potato			Pea		Corn	
Starch proportion (wt%)	20	25	30	20	30	20	30
Bulk density (g/cm^3)	1.58	1.50	1.49	1.66	1.51	1.64	1.49

Table 2. Fired properties of samples prepared with different type and content of starch.

Starch	Potato			Pea		Corn	
Starch proportion (wt%)	20	25	30	20	30	20	30
Linear shrinkage (%)	5.8	6.2	6.3	6.4	8.0	7.6	10.2
Loss on ingnition (%)	23.10	27.82	32.71	23.07	32.82	23.25	32.63
Bulk density (g/cm^3)	1.47	1.33	1.24	1.56	1.31	1.65	1.47
Open porosity (%)	41.0	47.0	50.7	37.8	48.0	34.8	42.2

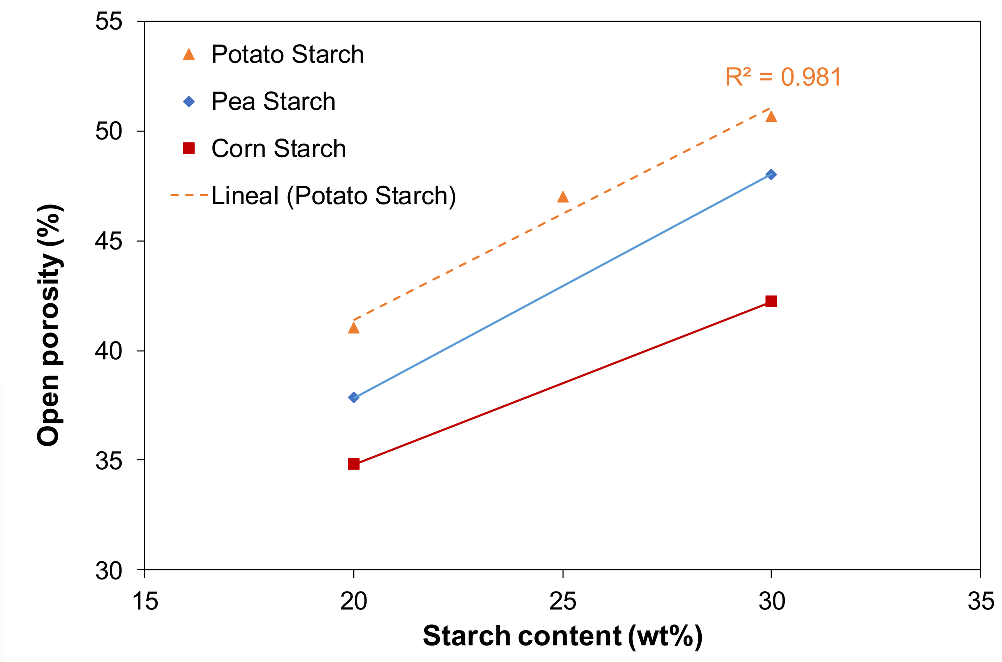


Figure 2. Relationship between open porosity of the compositions and starch content, for the different type of starches.

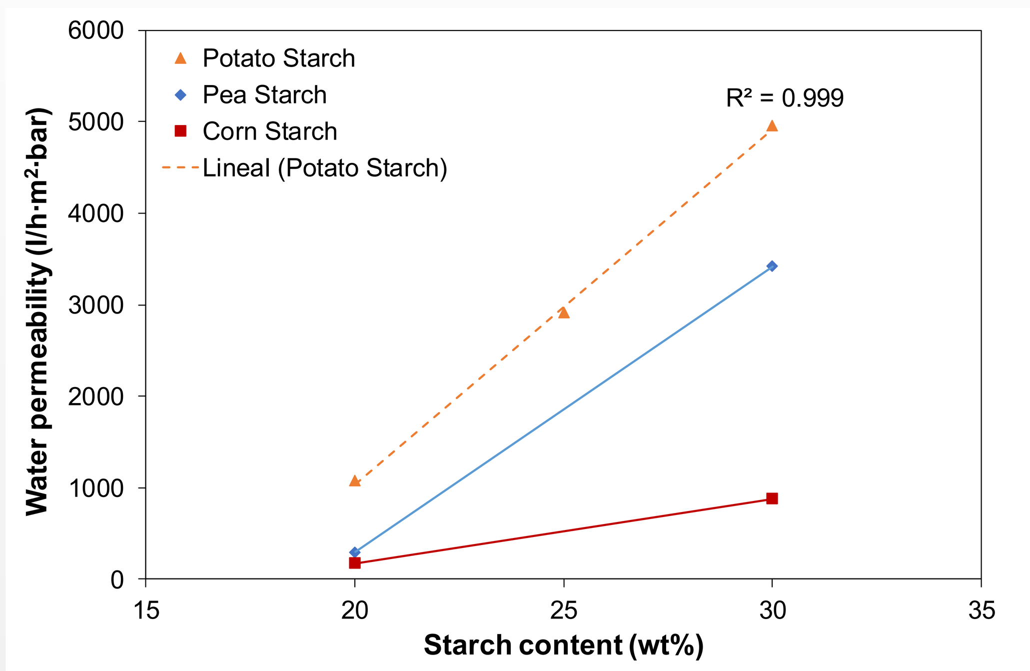


Figure 3. Dependence of water permeability on starch content, for the different types of starches studied.

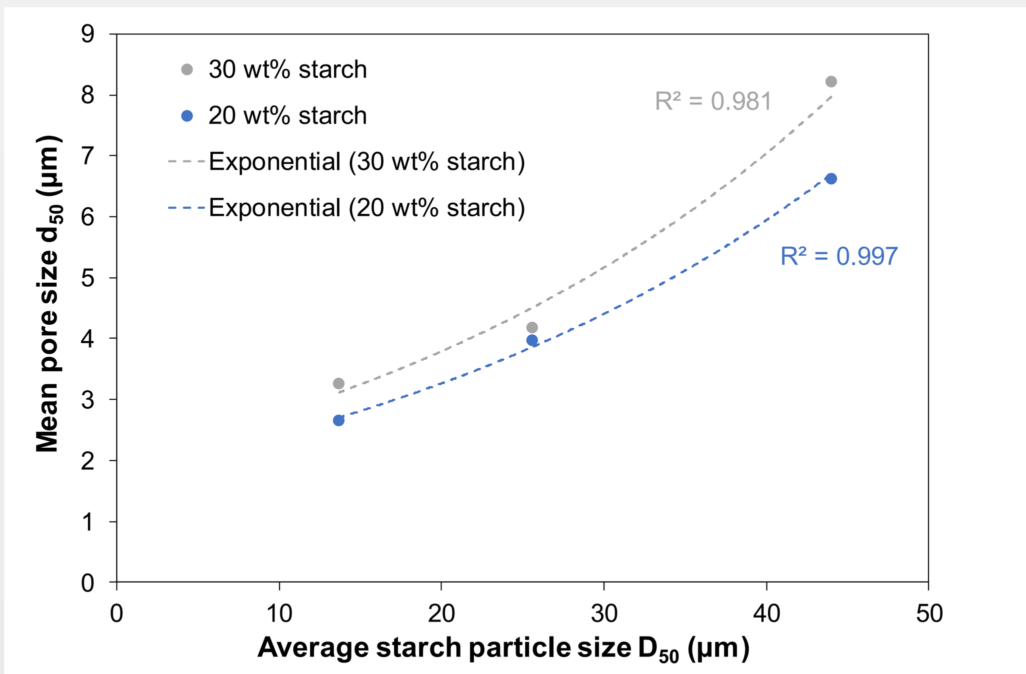


Figure 4. Variation of mean pore size with average starch particle size for different starch contents.

4. CONCLUSIONS

⇒ Starches of different natures presented different particle size .

⇒ Nature and content of starches greatly influenced the unfire and fired properties of low-cost ceramic membranes.

⇒ Unfired properties: The higher the starch content, the lower the bulk density.

⇒ Fired properties:

- The higher the starch content, the lower the bulk density.
- The higher the starch content, the higher the linear shrinkage, loss on ignition and open porosity

⇒ Open porosity and water permeability increased linearly with starch content, being the increase higher when the starch particle size was coarser.

⇒ Mean pore size obtained by mercury porosimetry increased exponentially with starch particle size.

⇒ The influence of starch type on the water permeability was very strong, owed to the influence of starch particle size in both: mean pore size and open porosity.

5. REFERENCES

[1] M.-M. Lorente-Ayza et al., Role of starch characteristics in the properties of low-cost ceramic membranes (2015) https://doi.org/10.1016/j.jeurceramsoc.2015.02.026

[2] M.-M. Lorente-Ayza et al., Influence of starch content on the properties of low-cost microfiltration ceramic membranes (2015) https://doi.org/10.1016/j.ceramint.2015.07.092

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