Novel geopolymeric support for microfiltration membranes applied in wastewater treatment

A. Filipponi, S. Bandini, G. Masi, M.C Bignozzi

Department of Civil, Chemical, Environmental and Materials Engineering,
University of Bologna, via Terracini 28, 40131 Bologna (Italy)

BACKGROUND

Microfiltration membranes are widely used in wastewater treatment and are typically made of ceramic or polymeric materials. Despite the great durability of ceramic membranes, polymeric membranes are very often preferred due to production costs. By using geopolymers, however, it is possible to obtain microfiltration membranes with durability characteristics similar to those of ceramic materials, but with considerably reduced production costs since geopolymers do not require sintering treatment at high temperature.

Aims of the study:

- Understanding the **behavior of these new** membrane **supports** when a solution is flowing;
- **Measuring the permeability** to pure water and ethanol-water solutions;
- **Define** the **hydrophilic or hydrophobic** behavior of the geopolymer material.

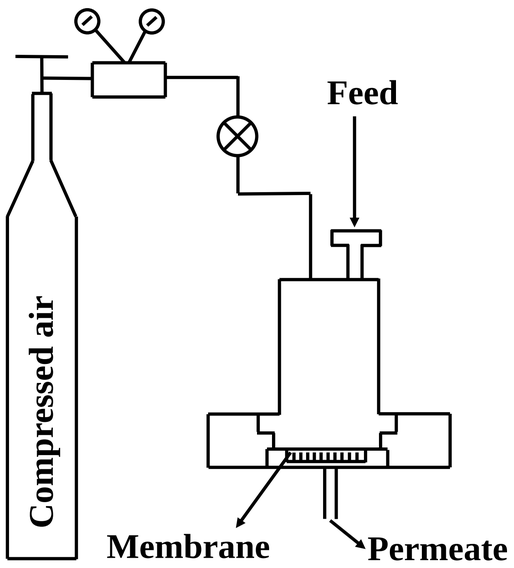
MATERIALS AND METHODS

Geopolymer support

- **Metakaolin** and anhydrous **sodium silicate** as raw materials;
- Sprayed with **12 wt% H_2O**;
- Uniaxial pressed at **2** and **5 MPa**;
- Cured at **70 °C for 24 hours** and 6 days at room temperature;
- Thickness of **2.2 mm**.

Membrane apparatus

- **Dead-end** apparatus geometry;
- Transmembrane pressure varies from **0.2 to 0.5 bar**;
- Tested with **pure water**, and **ethanol-water solutions** (100 and 200 g/L).



Volumetric flux equation

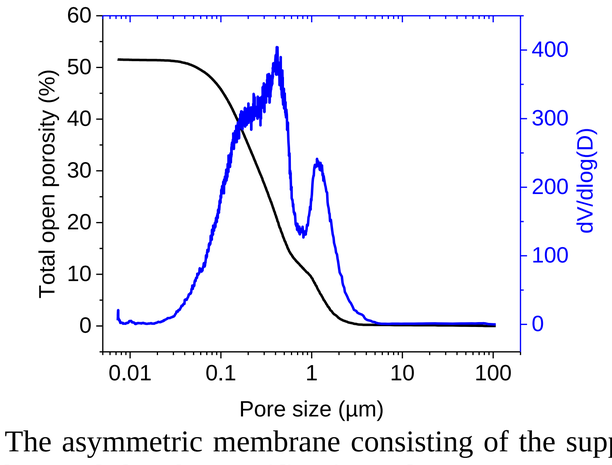
$$J_v = \frac{\varepsilon R^2 \Delta P}{8 \mu \delta_m} = L_p \Delta P$$

J_v – Volumetric flux
ε – Membrane porosity
R – Pores radius
ΔP – Transmembrane pressure
μ – Viscosity
δ_m – Membrane thickness
L_p – Hydraulic permeability

CONCLUSIONS AND FUTURE WORKS

- **Curing conditions** affect the performance of the support;
- The developed geopolymer supports have an **excellent permeability**;
- As the material is less permeable to ethanol than to pure water, the geopolymer support is therefore **hydrophilic**;
- The support obtained has characteristics compatible with **microfiltration;**
- A **minimum pressure** is required to have flow through the support.

Future studies are ongoing to develop geopolymer **selective layers by dip coating** to be applied on geopolymer supports.

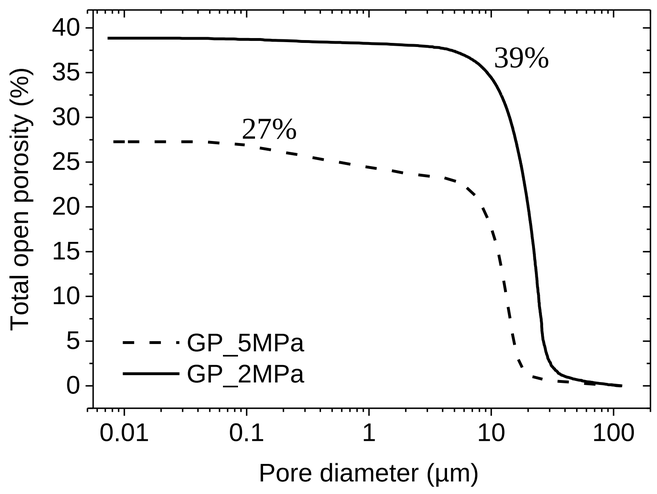


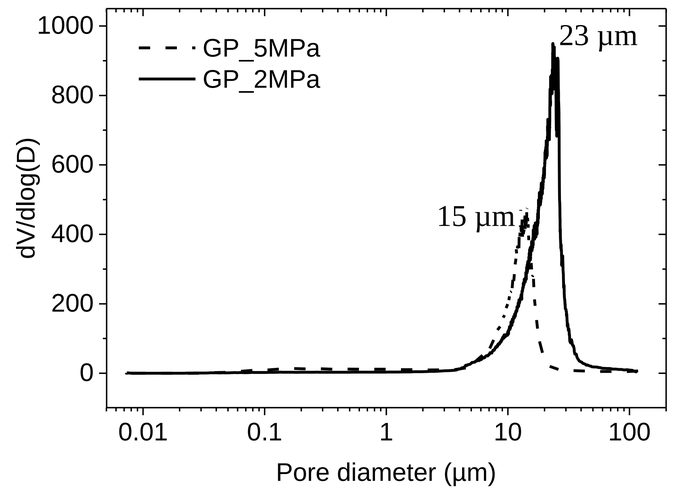
Pore size distribution of the geopolymeric selective layer that will be deposited by dip coating above the support in order to obtain an asymmetric microfiltration membrane.

The asymmetric membrane consisting of the support and the selective layer will be used for the **purification of wastewater** and the **separation of oil/water emulsions**.

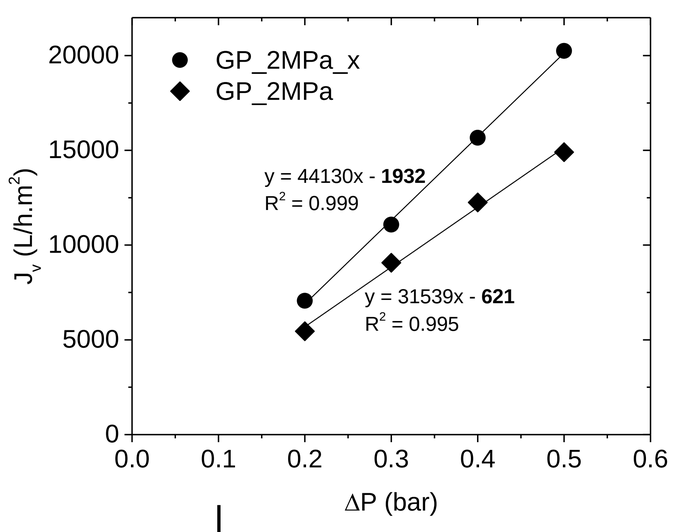
RESULTS

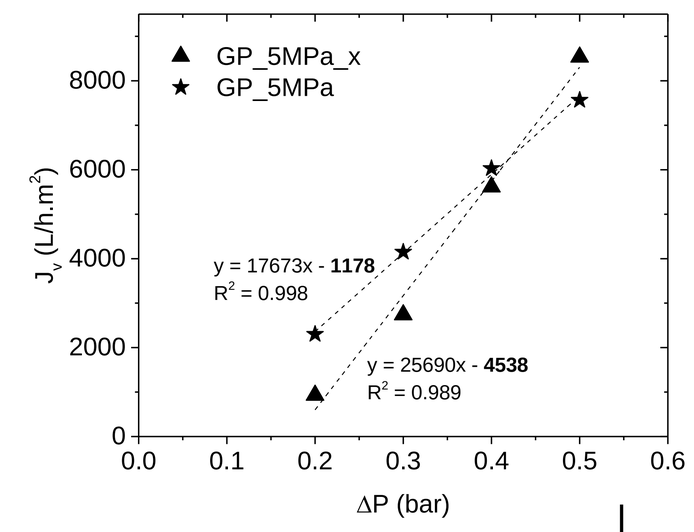
Porosity characterization





Hydraulic permeability to pure water

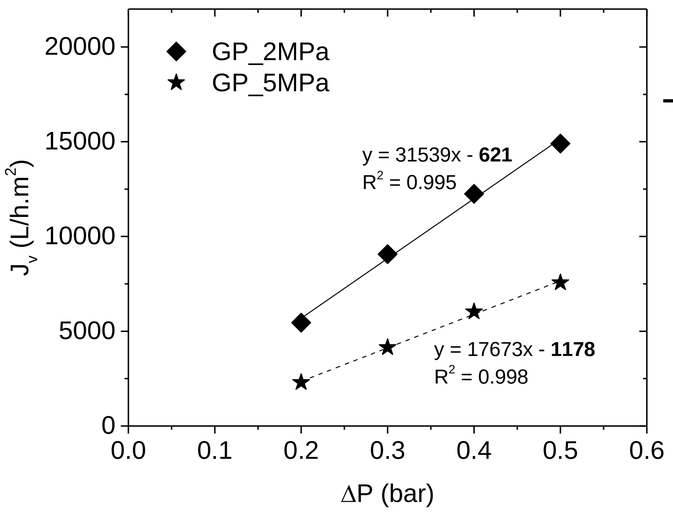




Effect of the curing condition and surface planarity

GP_2MPa_x GP_5MPa_x	→	70 °C – 24 hours
GP_2MPa GP_5MPa	→	70 °C – 24 hours 25 °C – 6 days Cured under load

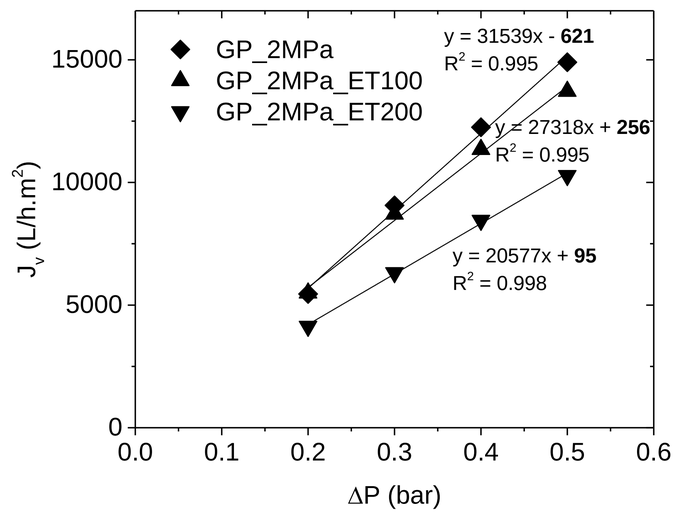
- Optimized samples (GP_2MPa and GP_5MPa) have an **intercept** of the regression **closer to zero**;

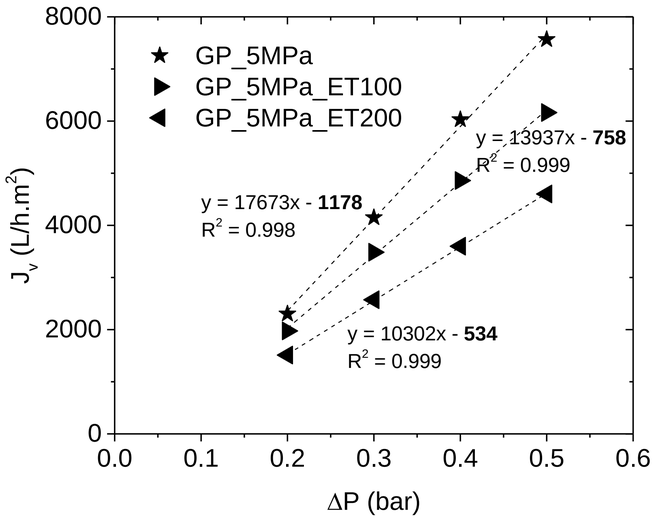


→ Effect of pressure load

- Increasing the forming pressure leads to a **decrease in hydraulic permeability**;
- Less porous support (GP_5MPa) shows a more negative regression intercept value.

Permeability to water-ethanol solutions





Increasing the ethanol concentration in the solution leads to a decrease in permeability, highlighting the **hydrophilicity** of the material.