

Single Pore Engineering & Measurement of Permeation Rates *via* Visualisation

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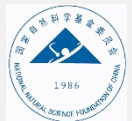
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Question's & Outline

How do we measure permeation in the lab?

Why do we measure permeation in this way?

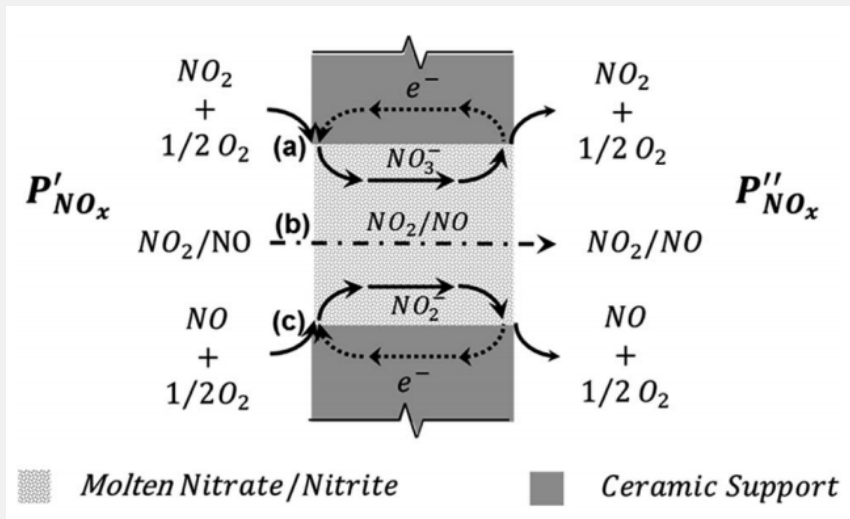
Can we do better?

Background to single pore engineering.

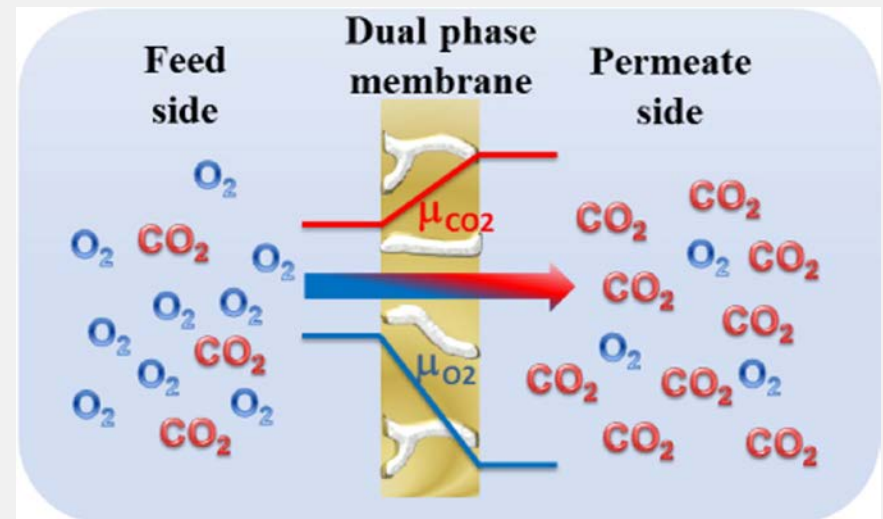
Present a new method for measuring permeation rates.

Dual Phase Membranes

NO_x separation.



CO₂ separation.

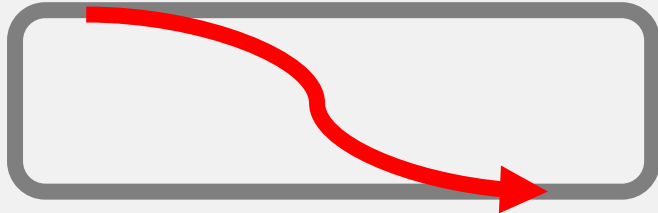


As with any membrane, the development of rigorous permeation data is necessary for scale-up – e.g. flux – driving force relationship.

Measuring Permeation

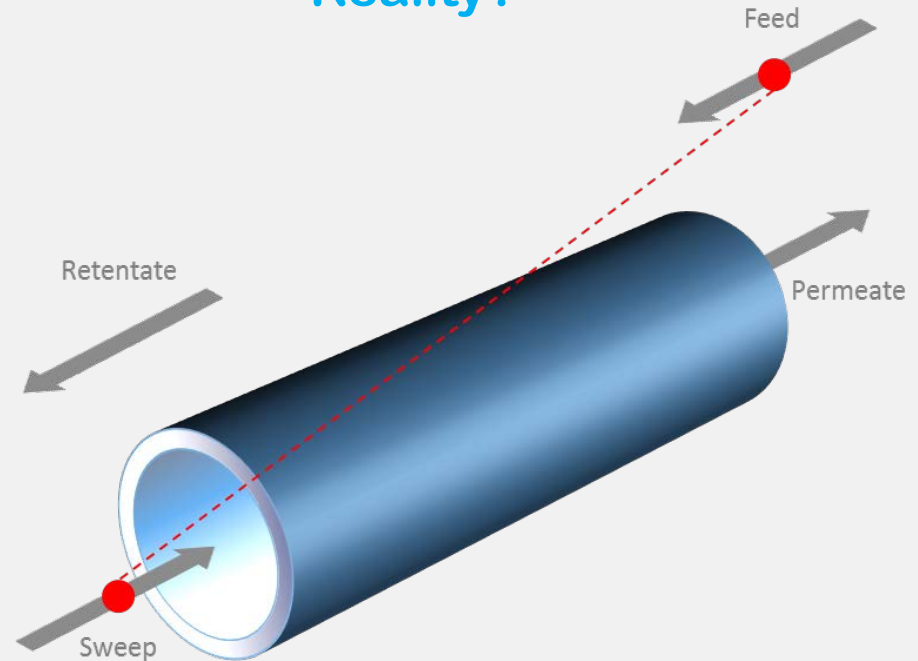
Laboratory

50% CO_2/N_2



Ar

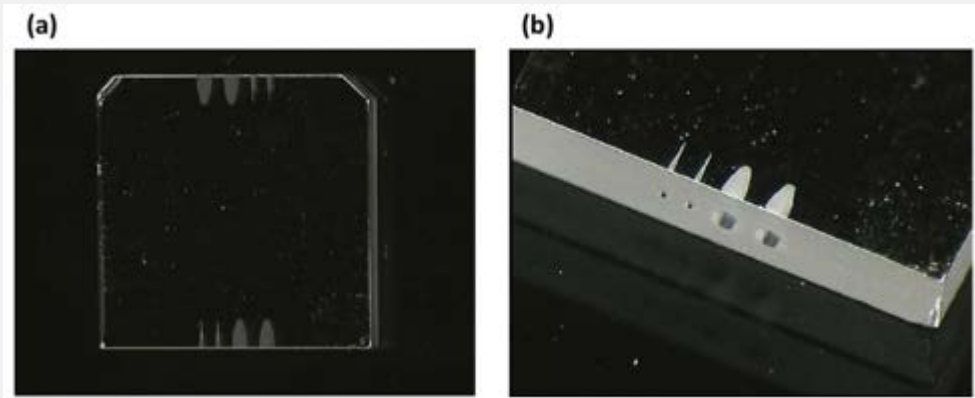
Reality?



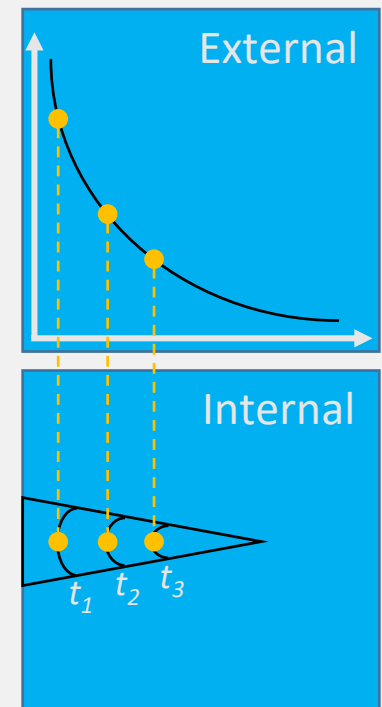
Can we do better?

Single Pore Engineering

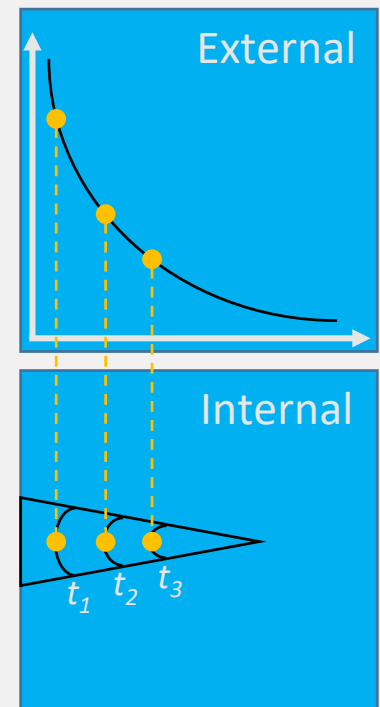
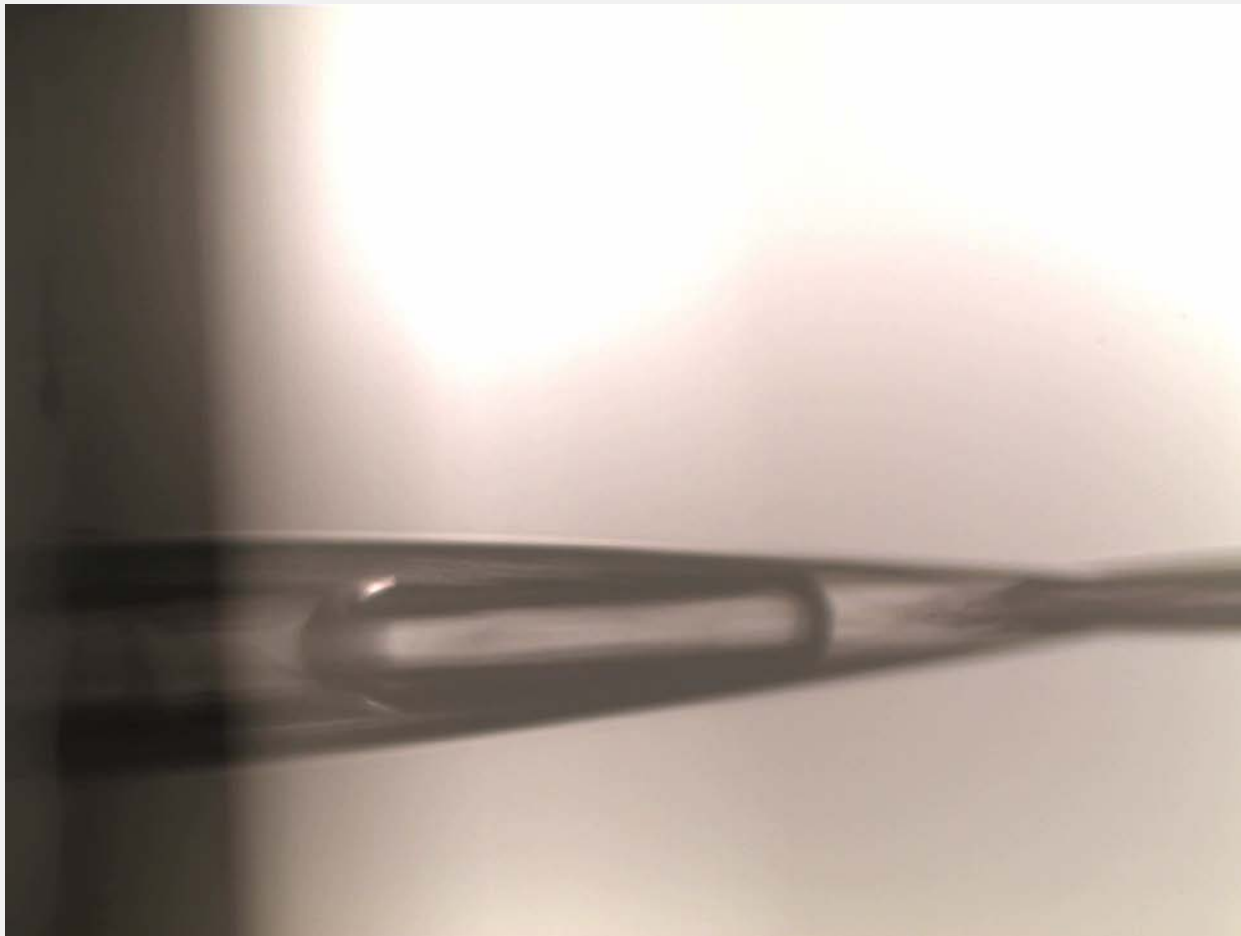
Can we do better?



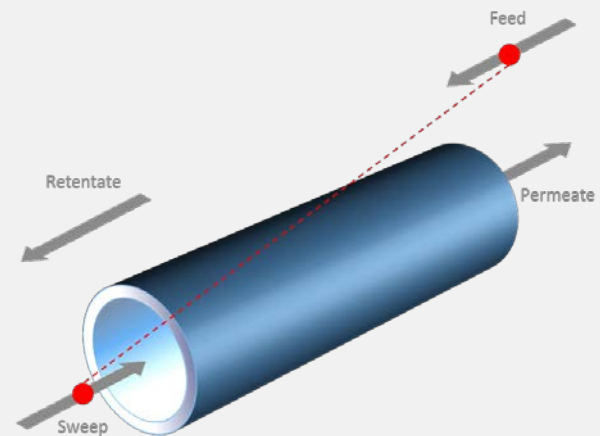
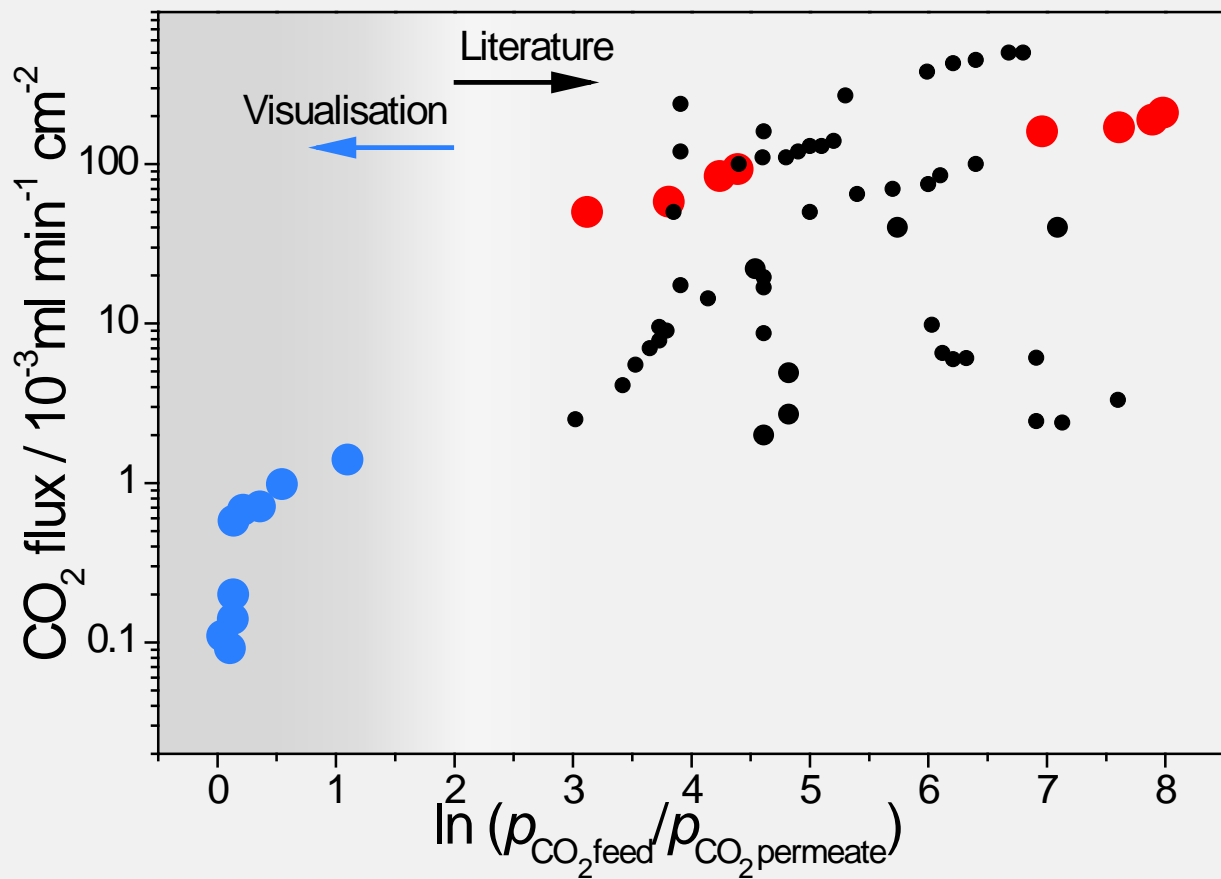
(a) YSZ single crystal (5 mm x 5 mm x 1 mm) and (b) laser drilled single pores.



Looking Inside



Results





Conclusions



Dual Phase Membranes

Promising CO₂ separation.

Visualisation

Single Pore Engineering



Look inside membranes.

Value

Applicable to any liquid.
Allows *in-situ* spectroscopy.
Difficult but real driving forces.

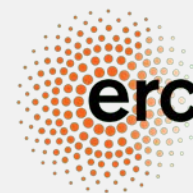
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References:

- G. Zhang, E.I. Papaioannou & I.S. Metcalfe, "Selective, high-temperature permeation of nitrogen oxides using a supported molten salt membrane" *Energy Environ. Sci.*, 2015, 8, 1220.
- E.I. Papaioannou, H. Qi & I.S. Metcalfe, "'Uphill' permeation of carbon dioxide across a composite molten salt-ceramic membrane" *J. Membr. Sci.*, 2015, 485, 87.