

# Polymeric membranes for hydrogen purification: focus on diffusion selectivity or solubility selectivity?

Johannes Carolus Jansen\*, Paola Bernardo

*Institute on Membrane Technology, Via P. Bucci 17/C, 87036 Rende (CS), Italy.*

*\*E-mail: [jc.jansen@itm.cnr.it](mailto:jc.jansen@itm.cnr.it)*

Membrane processes are gaining an increasingly important role in industrial gas separation processes [1]. Gas transport in polymeric membranes is governed by the well known solution-diffusion mechanism, in which the permeability,  $P$ , is the product of the solubility and the diffusivity of the permeating species in the polymer matrix. Consequently, also the selectivity,  $\alpha_{ij}$ , between the two species  $i$  and  $j$  is composed of a solution term and a diffusion term:

$$P_i = S_i \times D_i \quad \text{and} \quad \alpha_{ij} = \frac{P_i}{P_j} = \frac{S_i}{S_j} \times \frac{D_i}{D_j}$$

The design and development of novel membrane materials should take into account the individual contributions of both terms, which often appear to be contrasting one another. In dense and very stiff materials, such as glassy polymers, the diffusion of large molecules is penalized, thus such membranes are predominantly size-sieving. Due to the much faster diffusion, such membranes are hydrogen selective and this behavior can be further enhanced by cross-linking of the polymer phase [2]. In liquid or rubbery membranes, the diffusion rate of all species is comparable and the selectivity is dominated by the difference in solubility of the gas species present in the mixture. Room temperature ionic liquids are liquid salts with negligible vapor tension and this makes them suitable for liquid membranes [3]. Tailoring of the polymer gels based on ionic liquids were recently found to give remarkably high CO<sub>2</sub> over hydrogen selectivity at high IL content [4]. Polymers of intrinsic microporosity [5] are known to have high solubility of readily condensable species, while they promote fast diffusion due to their high free volume and interconnected void structure. Under specific conditions such materials can also be given relatively high diffusion selectivity [6].

In the present paper we will explore the various approaches to purify hydrogen, either by its enrichment in the permeate stream in hydrogen selective membranes, or by its concentration in the retentate stream through selective removal of heavier species.

**Keywords:** Gas separation membrane, solubility, diffusion, permeability

## References

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