elyntegration

NEW SEPARATOR CONCEPTS FOR A RADICAL IMPROVEMENT OF THE GAS QUALITY IN ALKALINE WATER ELECTROLYSIS (AWE)

Wim Doyen and Yolanda Alvarez Gallego

Flemish Institute for Technological Research (VITO), Mol, Belgium

Advanced Alkaline Water Electrolyser technology (AWE) is a well-established technology with systems up to MW scale already commercially available. This technology could be used to smoothen the fluctuating power output of renewable energy sources (RES) in oversupply situations. However, some technological issues still need to be addressed; one of them is the poor gas quality at a current density below 0.2 A/cm² and/or at very high pressure (above 50 bar). This limitation can be substantially mitigated with a new separator membrane concepts tailored for the purpose.

The problem of gas impurity in high-pressure AWE (Fig. 1):

- In steady-state: HTO & OTH diffusion are constant and independent of load (A/cm²)
- $D_{H_{2},\,30\%\,KOH}$ = 3,25 x $D_{O_{2},\,30\%\,KOH}$ → **gas crosscontamination is always worst at O_2 side (% HTO)!**
- At high current density diffused-gas portions are diluted and the issue is mitigated automatically
- At low current density and/or high P, diffused-gas portions can lead to critical %HTO values

→ **Operation at low load and high P requires dedicated separator development** 2 CONCEPTS

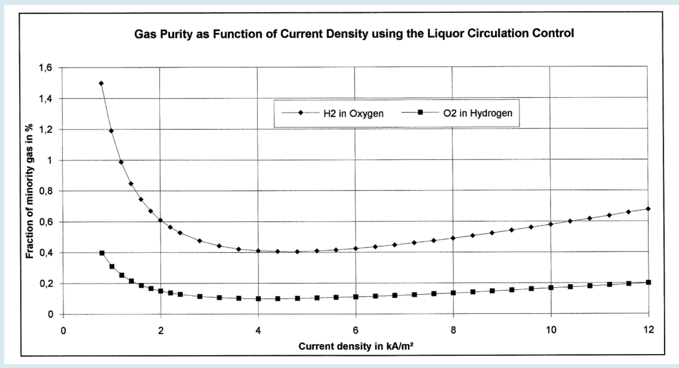


Figure 1: Gas Purity as a function of Current Density, from [1]

[1] *Int. J. Hydrogen Energy* ***1998*** *23(12) 1119.*

Concept 1:"e-bypass separator"

Rationale:

- Single-piece separator featuring two Zirfon® (ZrO_2/Polysulfone composite) layers spaced apart with an internal electrolyte chamber → e-by-pass channel
- Lye flows from the internal chamber towards the anolyte and the catholyte compartment, counteracting HTO and OTH diffusion processes (Fig. 2).

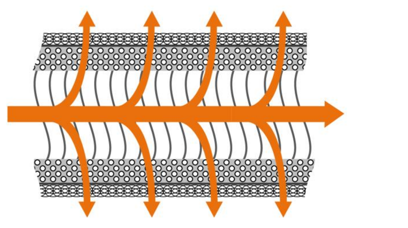
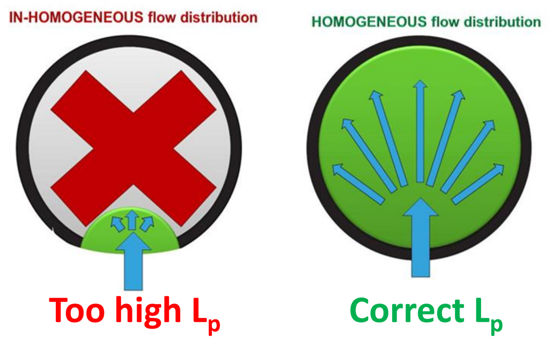
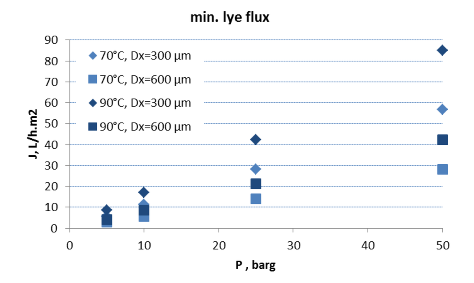


Figure 2: Double-layer separator (2500 µm) which is "backwashed with lye solution" during electrolysis.

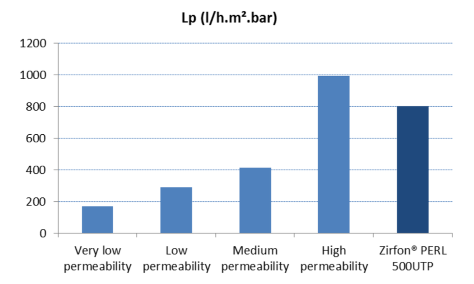
Key specifications:

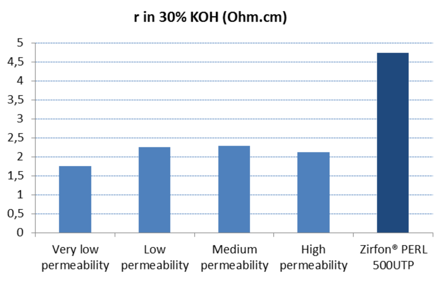
- Minimum lye flux for stopping diffusion of HTO is calculated from: $J_{H2}(T,P) = D_{H2,KOH30\%}(T) \cdot \frac{\Delta c_{H2}}{\Delta x}$
- L_p must be low enough to ensure uniform flux distribution!



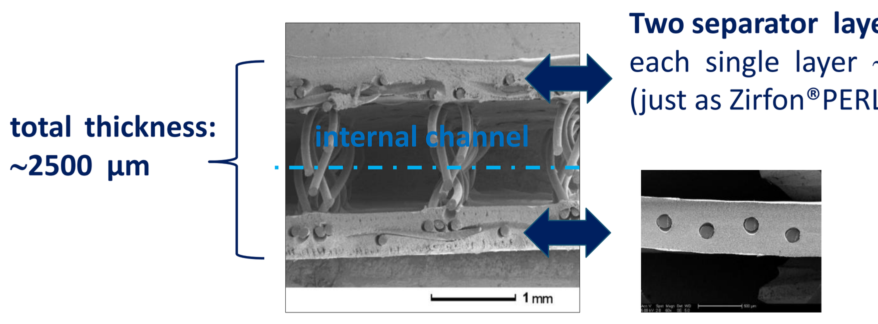


Three types of e-bypass separators were realized with different permeabilities:

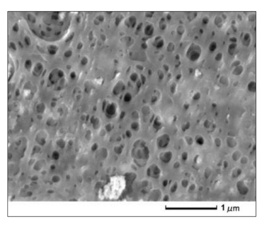




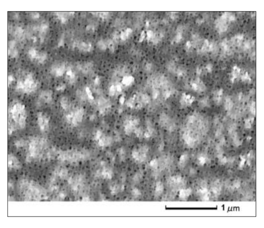
Typical cross-section of an e-by-pass separator:



Top-surface of different versions:



high L_p ~ 1000 l/h.m². bar

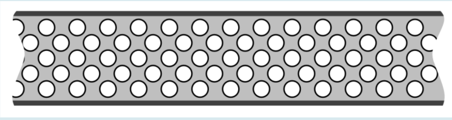


low L_p ~ 300 l/h.m².bar

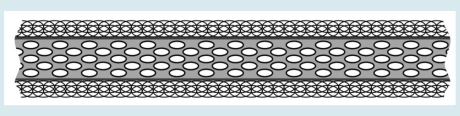
Concept-2: tighthened single-layer separator

Rationale:

- Single layer Zirfon® (ZrO_2/Polysulfone composite) separator
- Highly porous, compressible structure→gas tightness thanks to compression in the electrochemical cell
- A pore template is used; two different template sizes:
  - nanoparticles with primary grain size 60 nm
  - micrometer sized particles, with size 3000 nm (i.e. 3 µm)
- Final separator thickness (uncompressed): 750 µm, 1000 µm, 1250 µm

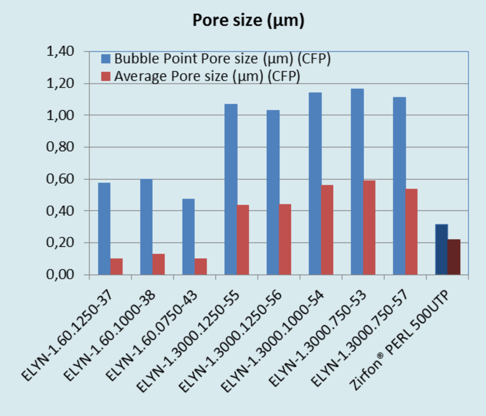


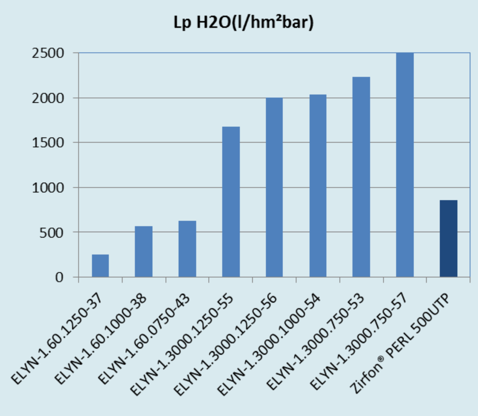
Separator in un-compressed form (750-1250 µm)

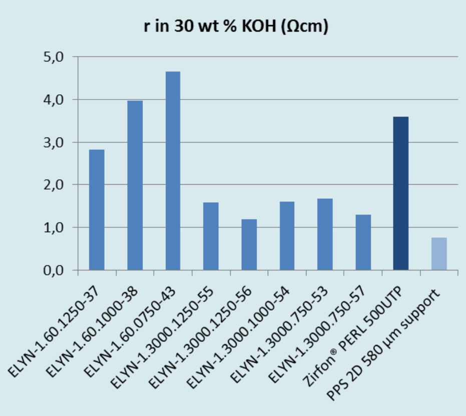


Separator compressed in the cell to ~600 µm

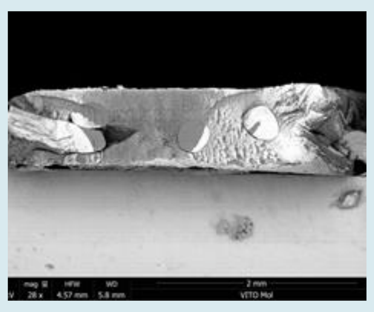
Separator properties:

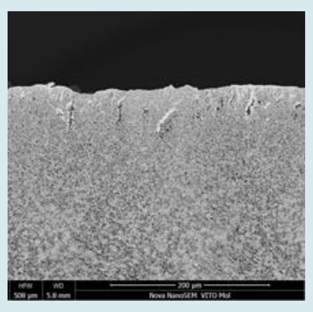






Cross-section of a compressible separator:





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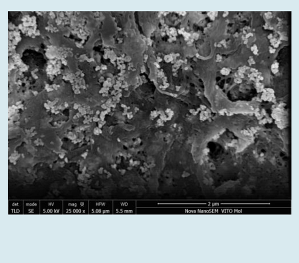
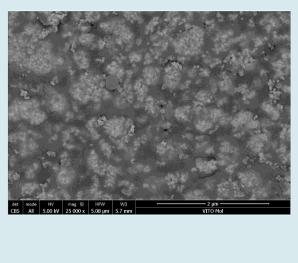


3000 nm template



60 nm template

Electrochemical testing:

Concept-1 [2] : e-by-pass separator

- e-bypass separator with very low Lp (~200 l/hm²bar);
- lye flux from inner compartment ~40 l/hm²;
- HTO < 0.2% at 10 bar, practically independent of load;
- HTO < 0.4% at 30 bar and load > 0.25 A/cm²;

[2] Public final report RESelyser, http://www.fch.europa.eu/project/hydrogen-res-pressurised-alkaline-electrolyser-high-efficiency-and-wide-operating-range.

Concept-2 : compressible separator

- With all types cell potential was virtually the same as with Zirfon® PERL UTP, despite of thickness 1.5 to 2.5 larger;
- HTO reduction: 13% lower than with Zirfon® PERL UTP

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VITO NV | Boeretang 200, BE-2400 Mol | Tel. + 32 14 33 55 11 | vito@vito.be | www.vito.be