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# Membrane gas-liquid contactor for tritium extraction from LiPb


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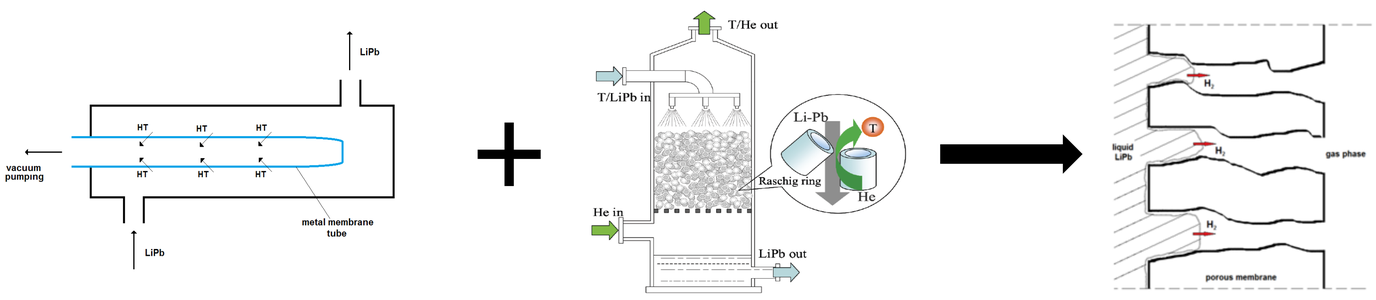
## INTRODUCTION

To extract hydrogen isotopes from liquid LiPb, a Membrane Gas-Liquid Contactor (MGLC) [1] that combines both Gas-Liquid Contactors (GLC) [2] and Permeator-Against-Vacuum (PAV) [3] concepts is presented here. Such a device uses a porous membrane immersed into the LiPb (lithium 15,6 at.%): hydrogen absorbed into the liquid metal are extracted through the membrane by vacuum pumping or purging with inert gas. In fact, the liquid metal penetrates the pores of the porous membrane then realizing a gas-liquid interface through which the hydrogen isotopes mass transfer takes place. The average pore size of this membrane (2,8 μm) has been selected according to the Washburn equation so that the LiPb behaves as a "non-wetting liquid" and does not enter the vacuum/inert gas phase where leaks of liquid metal are not allowed.
In such a way, a direct gas-liquid interface is realized inside the membrane pores where the transport of hydrogen isotopes takes place with mass transfer resistance lower than in the PAV.

## CONCEPT

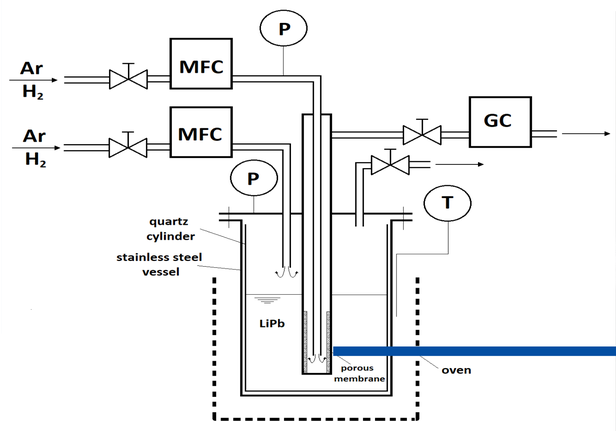
**PAV** + **GLC** → **MGLC**



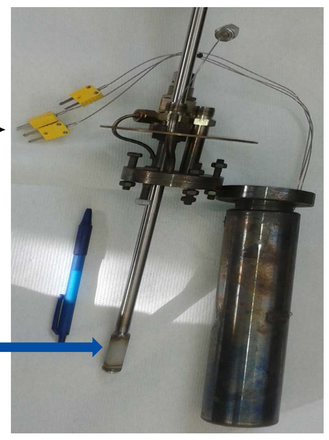

from Fukada et al. (2015) [4]

## EXPERIMENTAL

**Scheme of the experimental setup**




**View of the stainless vessel and the porous membrane**



**Test procedure:**

1. Both the gas phases over the PbLi and that into the membrane lumen are purged with hydrogen at 100 kPa before the system is heated,
2. Once the PbLi is liquefied, the porous membrane is immersed into the liquid metal and then the system is further heated up to the test temperature (in these conditions the hydrogen pressure both over the LiPb and into the membrane lumen is around 160 kPa),
3. Hydrogen is bubbled from the membrane into the LiPb until the gas phase over the liquid metal achieves the pressure of about 270 kPa,
4. The membrane lumen is purged with Ar (0.1 L/min for 5 min) in order to remove all the hydrogen,
5. The membrane lumen is again purged with Ar (0.1 L/min for 5 min) and a first GC measurement is carried out,
6. After a time "t" a second gas sampling from the membrane lumen is extracted using an Ar stream (0.2 L/min for 4 min) and a new GC measurement is performed.

**hydrogen permeation flow rate through the membrane, mol/(m² s)**

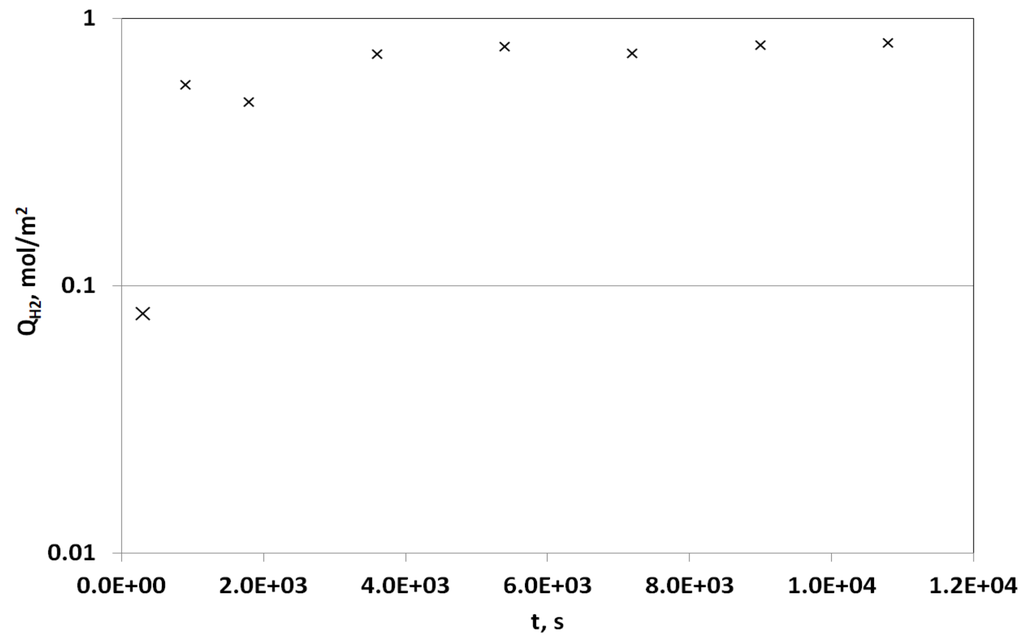
$$F = h\,(c_{T,bulk} - c_{T,wall})\,S$$

**hydrogen recovered by the MGLC per unit of surface area $Q_{H2}$, mol/m²**

$$Q_{H2} = \frac{1}{S}\int_0^t F\,d\tau$$

$c_{T,bulk}$ and $c_{T,wall}$ are the hydrogen concentrations at the bulk LiPb and the wall interface, mol/m³;
**h** is the overall mass transfer coefficient, m/s;
**S** is the membrane area, m²;
**t** is the delay time adopted at step (6) of the experimental procedure.

**Hydrogen recovery at 643 K after 5-15-30-60-90-120-180 min**




**Effect of the temperature by measuring the amount of hydrogen collected through the membrane during 3 hours**

| Temperature K | Hydrogen recovered mol/m² |
|---|---|
| 613 | 0.818 |
| 633 | 0.819 |
| 643 | 0.806 |

## REFERENCES


[1] A. Pozio, S. Tosti, F. Marini, Processo a supporto poroso per l'estrazione di idrogeno ed isotopi da metalli liquidi, e relativo apparato, Italian Patent Application n. 102018000003185 (01.03.2018).

[2] M. Kinjo, S. Fukada, K. Katayama, Y. Edao, T. Hayashi, Experiment on Recovery of Hydrogen Isotopes from Li17Pb83 Blanket by Liquid-Gas Contact, Fusion Science and Technology 71 (2017) 520-526.

[3] B. Garcinuno, Design and fabrication of a Permeator Against Vacuum prototype for small scale testing at Lead-Lithium facility, Fusion Engineering and Design 124 (2017) 871–875.

[4] S. Fukada, T. Muneoka, R. Yoshimura, K. Katayama, Y. Edao, T. Hayashi, Recovery of Hydrogen Isotopes by Liquid-Gas Contactor from Li17Pb83 Blanket, J. Plasma Fusion Res. SERIES, Vol. 11 (2015)


## CONCLUSIONS

1. **MGLC exhibits small hydrogen mass transfer resistances and fast permeation kinetics.**
2. **The stainless steel porous membrane has achieved steady-state conditions in less than 1 hour and showed high permeation fluxes, estimated around $10^{-4}$ mol/(m² s).**
3. **Each test revealed no degradation of the MGLC that exhibited stable values of hydrogen flux along several days of experimental campaign.**
4. **Further reduction of the mass transfer coefficient in a MGLC could be achieved by an improved design of the porous membrane, namely by adopting commercial asymmetric membrane having a bulk with large pores and a top-layer small enough to avoid the penetration of the liquid metal.**