

# Tech Deck

experts in polymeric  
membranes based on ionic  
liquids for custom applications

# Who we are

## Liquionic

Research group/spin-off of the University of Murcia

Experts in polymeric membranes based on ionic liquids for industrial and custom applications

Patented know-how (ES2964257) for a new generation of PFAS-free, PGM-free, high-performance polymeric membranes

Deep expertise in green chemical engineering to deliver versatile and high-performance solutions for sustainable industrial processes



UNIVERSIDAD DE  
MURCIA



# Our expertise

## Ionogel membrane technology

We deliver **innovative solutions (TRL 4)** through **advanced ionogel membranes**, a composite material composed of organic polymers and ionic liquids (IL) or deep eutectic solvents (DES)

The versatility of this technology allows for precise tailoring of membrane properties for diverse industrial applications, demonstrating **exceptional performance in the energy sector and chemicals separation**



Polymer



Ionic liquid(IL)



Polymer/IL based ionogel



*Ionogel membrane*

# Our expertise

## Ionogel membrane applications

1

### Membranes for electrochemical applications (MEA)

- ✓ High purity hydrogen production (electrolyzers, ELY)
- ✓ High energy density under dry conditions (fuel cells, PEM)

2

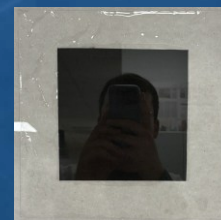
### Selective separation membranes

- ✓ Separation of organic compounds, gases, salts, and metal ions

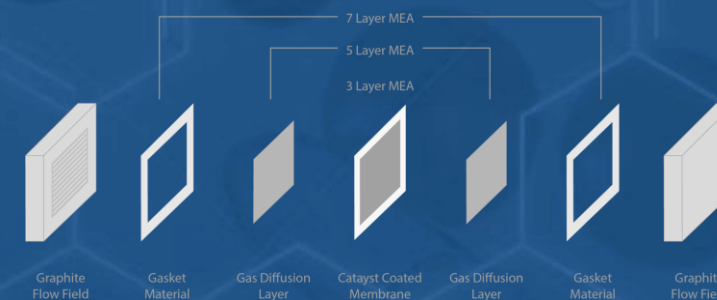
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### Membranes for biocatalyst and catalyst immobilization

- ✓ To significantly enhance activity and stability in biocatalytic processes



MEA-3 /  
MEA-5



## Bibliography

New application of polymer inclusion based on ionic liquids as proton exchange membrane in microbial fuel cell. Hernández-Fernández et al., Separation and purification technology, 160 (2016) 51-58.

Development and characterization of a new embedded ionic liquid based membrane-cathode assembly for its application in single chamber microbial fuel cells. Hernández-Fernández et al., Energy, 93 (2015), 1748-1757.

New membranes based on ionic liquids for PEM fuel cells at elevated temperatures. Ye et al., J. Power sources 178 (2008) 651-660.

High-temperature proton conducting membranes based on perfluorinated ionomer membrane-ionic liquid composites. Doyle et al., J. Electrochem. Soc. 147 (2000) 34-37. membrane.

Dynamic potential response and SEM-EDX studies polymeric inclusion membranes based on ionic liquids. Tomás-Alonso et al., Int. J. Electrochem sci. 8 (2013) 4955-4969.

Physically gelled ionic liquid: solid membrane materials with liquid like CO<sub>2</sub> gas transport. Voss et al., Chem. Mater. 21 (2009) 3027-3029.

On the selective transport of nutrients through polymer inclusion membranes based on ionic liquids. Hernández-Fernández et al., Processes, 7 (2019), 544.

Polymeric inclusion membranes based on ionic liquids for selective separation of metal ions. Hernández-Fernández et al., Membranes (2023), 13, 79.

New efficient laccase immobilization strategy using ionic liquids for biocatalysis and microbial fuel cells applications. Hernández-Fernández et al., Journal of Chemical Technology and Biotechnology, 93(2018), 174-183.

A New Way to Improve the Activity and Stability of Candida antarctica Lipase B. Hernández-Fernández et al., Molecules 2020, 25, 3233.

# Electrochemical applications

**Unique selling points versus other companies that also offer PFAS-free membranes**

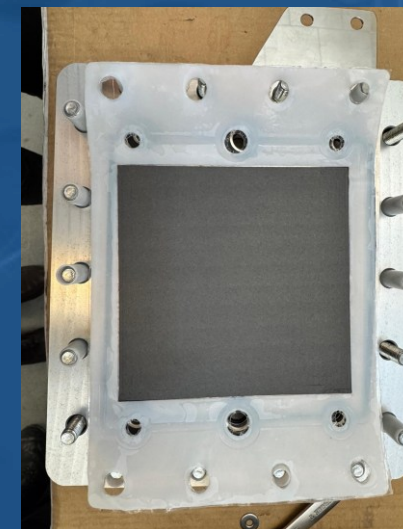
- ✓ Low-cost membranes
- ✓ Low-cost catalyst
- ✓ Hydration-free technology enables stable operation at high temperatures (>120°C)

**Our in-house lab capabilities cover the entire stack from ionic liquids to final MEAs (MEA-3 & MEA-5), ensuring full performance control**

**Our casting production method is proven and easily scalable to produce continuous rolls and custom formats**



MEA 3



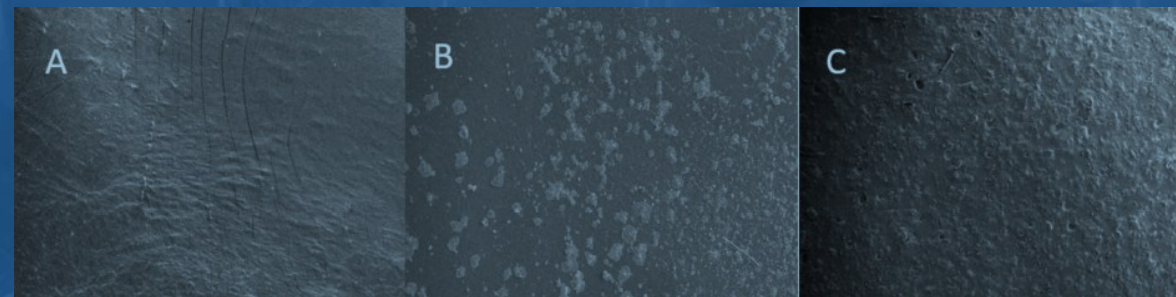
MEA 5



# Electrochemical applications

## Precise Catalyst & Architecture Control

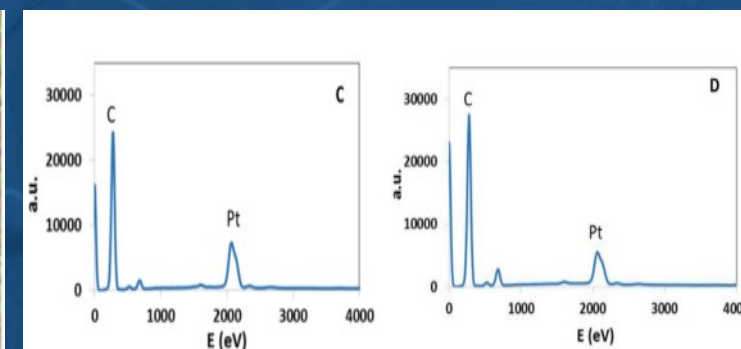
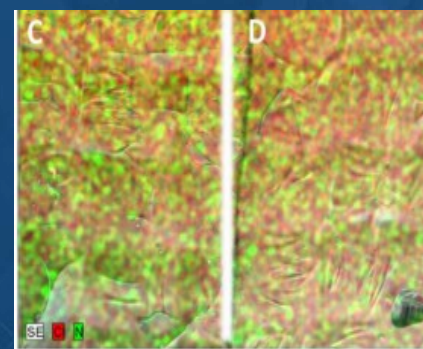
- ✓ **Total Catalyst Control:** Precisely embed particles in the bulk or immobilize them on the surface
- ✓ **No Short-Circuit Risk:** Ionogel matrix encapsulates and isolates particles, preventing short-circuits
- ✓ **High Mass Transport:** Optimized structure ensures efficient transport to encapsulated catalyst sites



## PGM-Free Performance

- ✓ **IL Environment Boosts Activity:** Alters the ORR mechanism to enhance catalyst performance
- ✓ **Proven PGM-Free Catalysts:** Tested La, Co, Cu catalysts achieve 60-70% of Platinum's activity
- ✓ **Fully PGM-Compatible:** Also highly effective for immobilizing traditional Pt and Ir catalysts

PEM-Catalyst Assembly (P1) (IMTOA*  CI-I-PVC-(Cu <sub>0.2</sub> Co <sub>0.7</sub> )Co <sub>2</sub> O <sub>4</sub> )								
Peak Element	Weight % A	Atomic % A	Weight % B	Atomic % B	Weight % B*	Atomic % B*	Weight % C	Atomic % C
C K	56.25	74.46	53.87	75.30	16.69	33.55	40.16	65.15
N K	1.57	1.78	-0.43	-0.51	3.11	5.36	2.45	3.40
O K	8.23	8.18	3.62	3.81	-	-	4.38	5.34
Na K	1.82	1.26	4.54	3.32	22.75	23.89	-	-
S K	-	-	0.79	0.41	0.49	0.37	1.64	1.00
Cl K	31.65	14.20	34.22	16.22	51.03	34.76	37.88	20.82
K K	-	-	0.80	0.34	0.44	0.27	-	-
Ca K	-	-	2.13	0.89	0.84	0.51	2.16	2.05
Co K	0.36	0.10	0.38	0.11	0.37	0.15	6.49	2.15
Cu K	0.13	0.03	0.07	0.02	0.07	0.03	0.62	0.9
Zr K	-	-	-	-	4.22	1.12	4.22	0.9



# Electrochemical applications



## Superior Low Resistance (HFR) and High Ionic Conductivity

- ✓ Achieved >10x lower HFR (18 Ω vs 200 Ω) and comparable ionic conductivity (98.32% vs 99.80%) to the Nafion® 117 benchmark

## Minimal H<sub>2</sub> Crossover

- ✓ Preliminary tests with high-sensitivity detectors confirm our membranes have extremely low H<sub>2</sub> crossover. Formal quantification studies are now underway to finalize the precise permeation rate

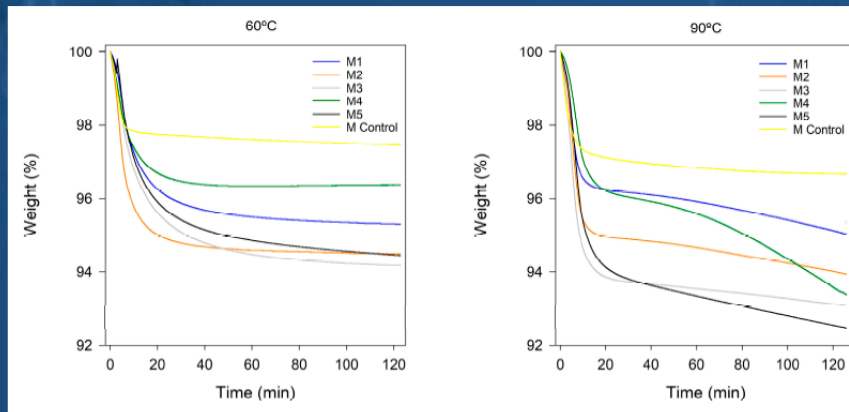
## Long-Term Stability & Leaching Mitigation

- ✓ Our membranes' thermal stability (confirmed by TGA at 60-90°C) is achieved because our proprietary ionogel matrix physically and chemically traps the ionic liquid, preventing leaching even in high-water electrolysis environments

Comparison of the internal resistance calculated by FRA and polarization curves.

Membrane	Internal resistance <sub>FRA</sub> (Ω)	Internal resistance <sub>Polarization curves</sub> (Ω)	Maximum power (mW m <sup>-3</sup> )
[MTOA <sup>+</sup> ][Cl <sup>-</sup> ]	1100	1111.9	235.9
[OMIM <sup>+</sup> ][PF <sub>6</sub> <sup>-</sup> ]	840	874.6	118.7
[P <sub>4,4,4,1</sub> <sup>+</sup> ][MeSO <sub>4</sub> <sup>-</sup> ]	60	239.9	494.2
[P <sub>14,14,14,1</sub> <sup>+</sup> ][TOS <sup>-</sup> ]	18	209.3	794.7
Nafion 117	200	403.9	755.5

Membrane	I <sub>0</sub> (A)	I <sub>f</sub> (A)	% I <sub>ionic</sub> /I <sub>total</sub>
[MTOA <sup>+</sup> ][Cl <sup>-</sup> ]	5.19 × 10 <sup>-03</sup>	2.25 × 10 <sup>-04</sup>	95.66
[OMIM <sup>+</sup> ][PF <sub>6</sub> <sup>-</sup> ]	1.06 × 10 <sup>-03</sup>	1.88 × 10 <sup>-04</sup>	82.30
[P <sub>4,4,4,1</sub> <sup>+</sup> ][MeSO <sub>4</sub> <sup>-</sup> ]	2.23 × 10 <sup>-04</sup>	2.74 × 10 <sup>-05</sup>	87.70
[P <sub>14,14,14,1</sub> <sup>+</sup> ][TOS <sup>-</sup> ]	4.51 × 10 <sup>-03</sup>	7.57 × 10 <sup>-05</sup>	98.32
Nafion 117	4.93 × 10 <sup>-03</sup>	9.96 × 10 <sup>-06</sup>	99.80



# Electrochemical applications



## Excellent Mechanical Flexibility & Robustness

- ✓ Our ionogel membranes are inherently more flexible than rigid benchmarks like Nafion 212 (~18 MPa), which we leverage as a key design feature

## Proven High-Pressure Operation

- ✓ Our PVC/IL membrane (2.1 bar at RT; 1.0 bar at 60°C) is validated to operate under significant differential pressure, proving comparable performance to the Nafion 212 benchmark (1.46 bar at 60°C)

## Mitigation & Reinforcement Strategy

- ✓ For high-demand applications, we integrate the ionogel into reinforced porous supports, adding mechanical stability without compromising high performance.

Referencia: Nafion 212 (Número de probetas: 4)				
	Fmax [N]	Def max [%]	Módulo (De Young automático) [MPa]	Referencia
2	16,89	266,91	17,86	Nafion 212
12	18,79	296,03	18,68	Nafion 212
13	18,44	285,55	19,62	Nafion 212
14	18,24	273,31	15,52	Nafion 212
Media	18,09	280,45	17,92	
Desviación estándar	0,83	12,95	1,75	

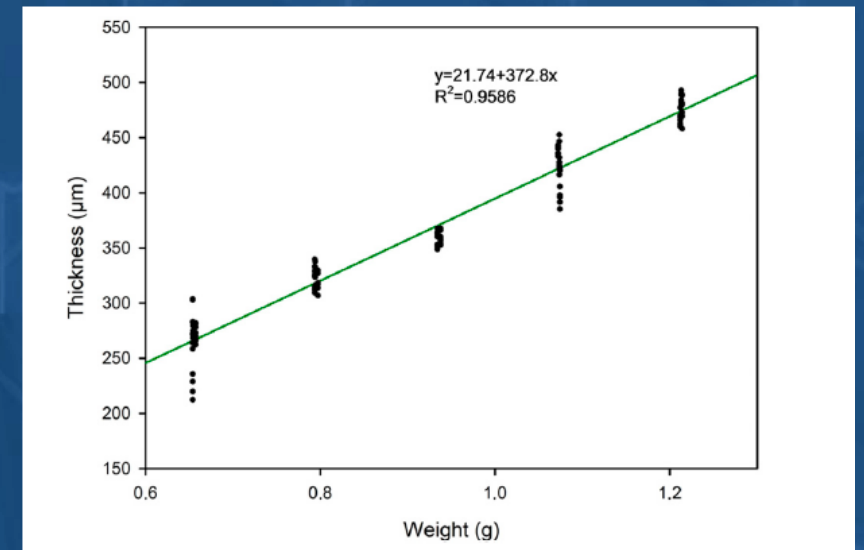
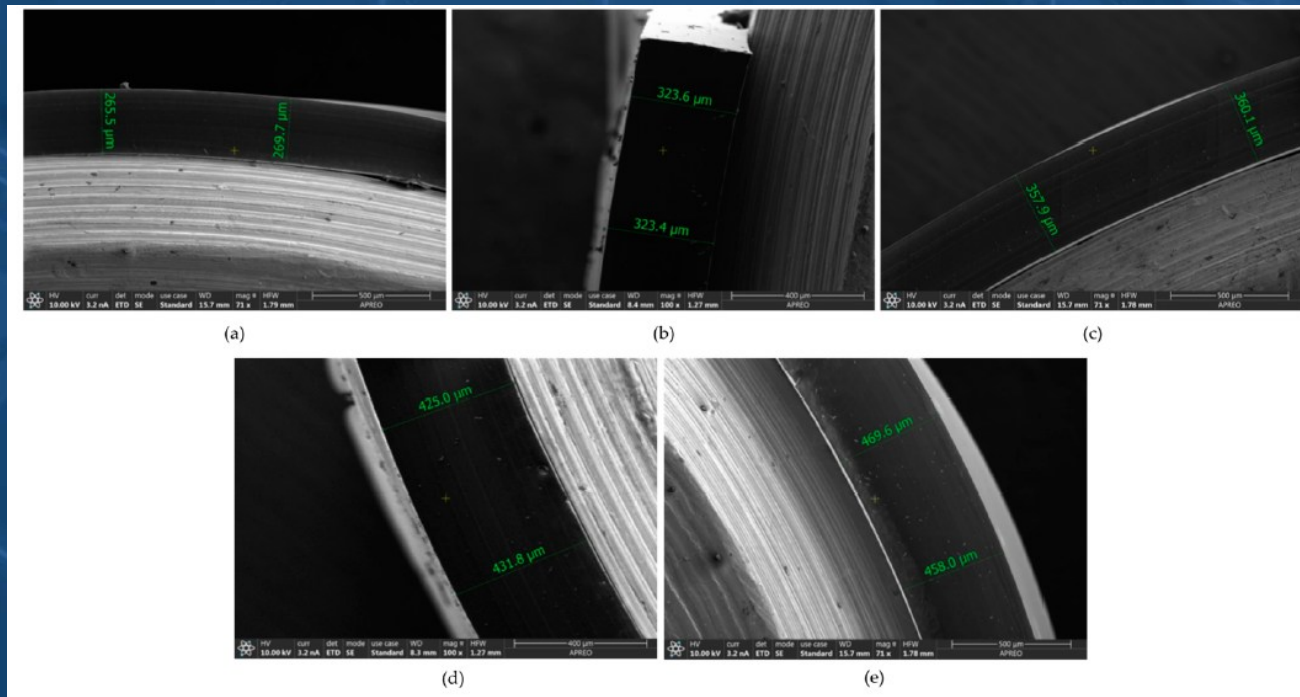
Referencia: Celulose acetate butyrate (Número de probetas: 4)				
	Fmax [N]	Def max [%]	Módulo (De Young automático) [MPa]	Referencia
5	15,40	148,63	1,49	Celulose acetate butyrate
18	16,84	147,92	1,79	Celulose acetate butyrate
19	13,09	130,00	1,79	Celulose acetate butyrate
20	17,66	154,52	1,70	Celulose acetate butyrate
Media	15,75	145,27	1,69	
Desviación estándar	2,00	10,60	0,14	

Referencia: PVC (Número de probetas: 4)				
	Fmax [N]	Def max [%]	Módulo (De Young automático) [MPa]	Referencia
3	13,18	276,79	0,79	PVC
15	16,30	408,13	0,70	PVC
16	13,95	291,69	0,80	PVC
17	15,22	363,71	0,72	PVC
Media	14,66	335,08	0,75	
Desviación estándar	1,38	61,74	0,05	

# Electrochemical applications

## Membrane Thickness: Precision & Control

- ✓ Our manufacturing process offers precise, predictable thickness control, which is reliably adjusted by material weight (proven by  $R^2=0.9585$  linear correlation). We have successfully manufactured and validated membranes in the  $\sim 200 \mu\text{m}$  to  $500 \mu\text{m}$  range, as verified by SEM images



$$T = [21.74 + 372.8 \times W] \pm \sqrt{6.72^2 + [W \times 7.07]^2}$$

# Electrochemical applications

Our materials and configurations have been **successfully validated in both Microbial Fuel Cells (MFC) and Hydrogen Fuel Cells (HFC)** applications, delivering robust, measurable results

In HFC applications, our membranes achieved a high power density of  $0.5 \text{ W/cm}^2$

In MFC applications, we successfully operated at a 300 L pilot scale, achieving 80-90% TOC reduction & simultaneously producing  $600 \text{ mW/m}^3$  of energy

Now, we are **expanding into electrolysis (PEM-ELY)**. In operando performance testing on our new lab-scale electrolysers is scheduled to begin in the coming weeks



# Liquionic is looking for...



- ❑ **Industry joint-ventures to scale-up our membrane technology,** particularly for PEM electrolyzers applications
- ❑ **Smart funding and advisors** to keep on exploring the possibilities of our membrane technology

# Liquionic team



**Manuel Tárraga**  
Technology Transfer  
Officer

Experienced innovation and technology transfer specialist with a strong background in engineering and business development. Bridging the gap between scientific excellence and industrial application.

 [CV LinkedIn](#)



**Francisco Hernández**  
Principal Investigator  
Head of Research Group

Experienced researcher in green chemistry, ionic liquids, fuel-cells, and membrane technology. Strong leadership in R&D, and strategic vision for scaling innovative fuel-cell solutions.

 [CV Google Scholar](#)



**Antonia Pérez de los Ríos**  
Principal Investigator  
Scientific Coordinator

Distinguished researcher in ionic liquids and membrane technology, with a strong focus on fuel-cells. Strong leadership in R&D, ensuring scientific excellence and competitive advantage.

 [CV Google Scholar](#)

## Contact

**Let's shape the future together!**



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