Hydrocarbon-based membrane-electrode-assemblies for fuel cells and electrolysers: current status and challenges

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CTO & co-founder ionysis GmbH

06.11.24, Workshop "Beyond Elements – PFAS in Membranen, Dichtungen und …?"

Who are we?

- Operational start in September 2022
- From its roots in Freiburg‘s academic ecosystem, ionysis has grown to a team of 27 people
- Diverse backgrounds in electrochemistry, physics, chemistry, engineering and economics

36 %
Female employees

9
Nationalities

Hahn Schickard
universität freiburg
Bundesministerium für Bildung und Forschung
Bundesministerium für Digitales und Verkehr
Ministerium für Wirtschaft, Arbeit und Tourismus Baden-Württemberg
Funded by the European Union

ionysis business & purpose

Material suppliers

Membranes & polymers

Catalysts

Additives

Supply

R&D services

ionysis

Catalyst-coated membranes (CCM) development & production

Integration of materials into electrode inks

Coating of electrodes onto membranes

PFAS-free materials

High performance electrode inks

Cost-efficient coating

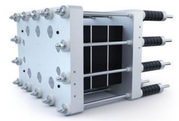
MEA sales*

CCM sales

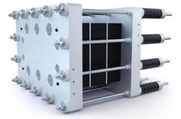
R&D services

Stack/system manufacturers

Fuel cell



H_2 electrolyzer



CO_2 electrolyzer

OEMs

Fuel cell vehicles

H_2 production plant

Carbon capture utilization storage

End users

Mobility/transport

Energy sector

Chemistry/ heavy industry

Strategy

- Develop and produce the performance deciding component of electrochemical converters: CCMs
- Focus on novel, PFAS-free materials
- Use synergies between CCMs for fuel cells, electrolysis and CCUS

Sources: EKPO

*Up to 7-layer MEA fabrication at scale with our network with Optima, university of applied science Kempten, Fraunhofer ISE, ZSW

Where are we? ionysis is part of Freiburg‘s hydrogen biosphere

Freiburger Innovationszentrum (FRIZ) – Our facilities

- Chemistry Lab
- Electrolysis Testing Lab
- Fuel cell Testing Lab
- Prototyping Clean room (ISO 7)
- Roll-to-roll CCM coating clean room (ISO 5)

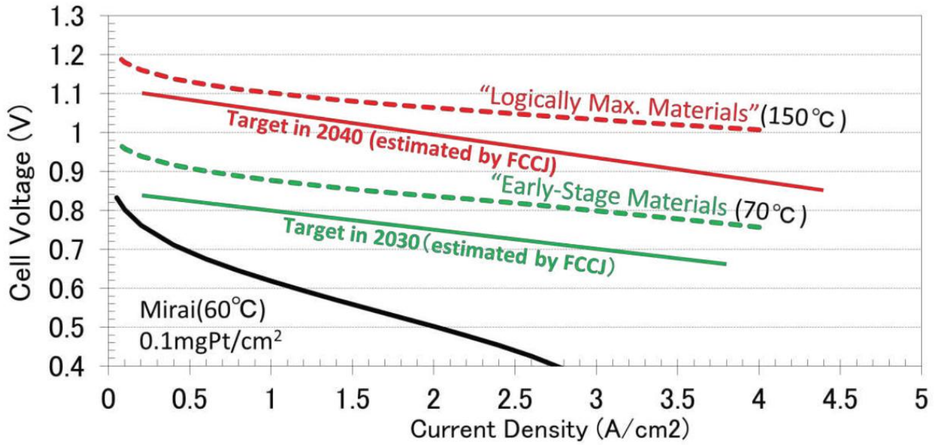
CCM prototyping clean room

R2R CCM coating clean room

Motivation for PFAS-free materials in fuel cells and electrolyzers

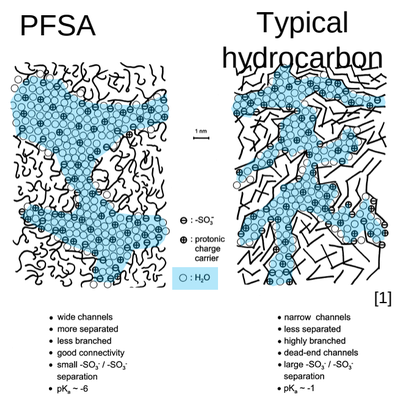
Motivation 1: Higher operation temperatures, lower gas crossover

- **Fuel cells:** Many required innovations may not be fulfilled by PFSA ionomers & membranes:
  - **Increase temperature** towards 120 °C or even 150 °C
  - Increase OCV: Minimize gas crossover
  - Both adressable by HC materials



Suzuki, T., et al., (2019). Toward the Future Fuel Cell-Challenge for 2040. *ECS Transactions*, *92*(8), 3.

- **Electrolysis:** HC membranes: lower gas crossover = thinner membranes = higher efficiency
- Higher dispersed phase separation in typical HC membrane morphology (more pronounced phase dispersion vs. lamellar-like PFSA structure) reduces gas crossover
- Enables reduction of HFR: thinner membrane & lower ohmic losses -> higher efficiency



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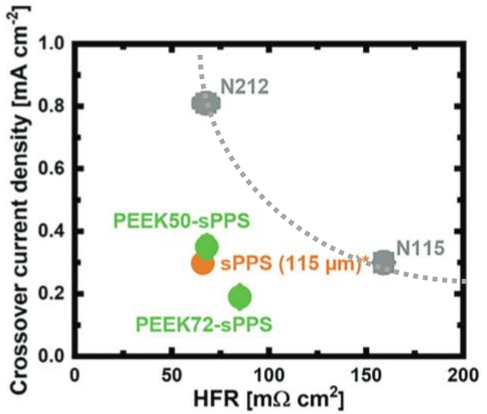


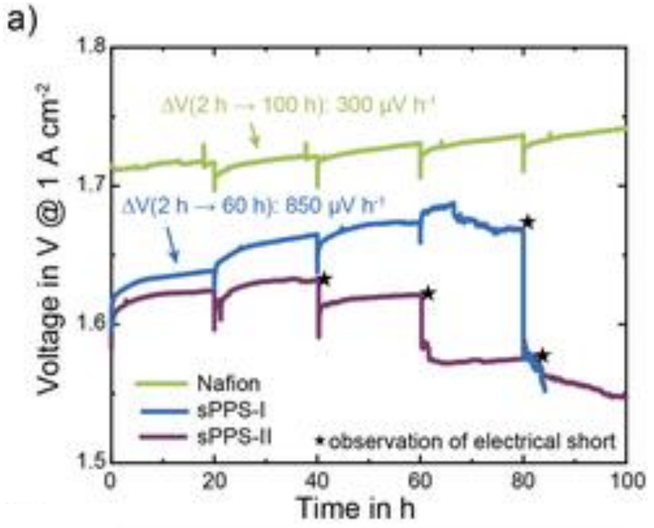
K.D. Kreuer, Journal of Membrane Science **2001**, 185, 29–39.

Qelibari, R., Ortiz, E. C., van Treel, N., Lombeck, F., Schare, C., Münchinger, A., ... & Vierrath, S. *Advanced Energy Materials,* **2023**, 2303271. (modfifed with grey guide to the eye line)

Motivation 2: promising progress in cell durability with PFAS-free materials (example: PEM electrolysis)

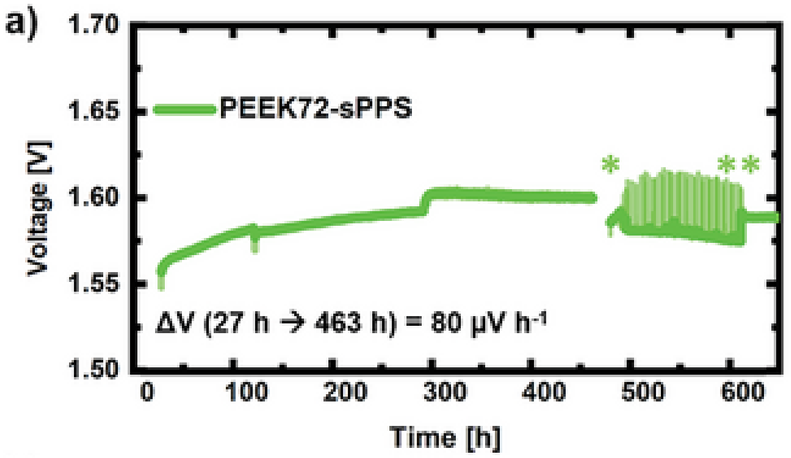
- Hydrolytic stability of HC membranes at elevated temperatures used to be a major issue → show stopper for electrolysis
- Considerable improvements in the past years in the stabilization of hydrocarbon membrane materials (reduction of water uptake)

Status 2020: Dead after ~60-100h



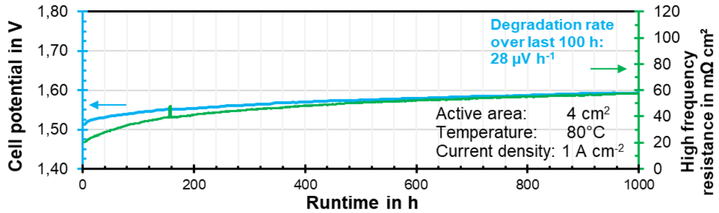
Klose, C., Saatkamp, T., Münchinger, A., Bohn, L., Titvinidze, G., Breitwieser, M., ... & Vierrath, S., **2020,** *Advanced Energy Materials*, *10*(14), 1903995.

Status 2023: stable ~ 600h



Qelibari, R., Ortiz, E. C., van Treel, N., Lombeck, F., Schare, C., Münchinger, A., ... & Vierrath, S., **2023,** *Advanced Energy Materials*, 2303271.

Status 2024: stable > 1000 h



4 cm² cell size, 80 °C, constant current operation at 1 A cm^{-2}, atmospheric pressure
Not-yet published data, tests currently running

Thank you for your attention!

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