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Stability of Radiation Grafted Polymer Electrolyte Membranes for Water Electrolysis Cells

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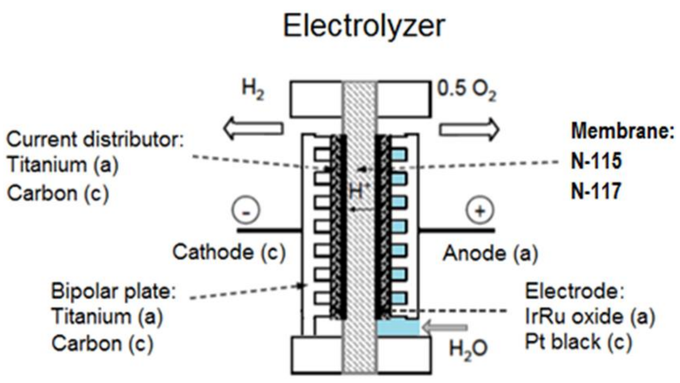
Motivation



Radiation grafted membranes:

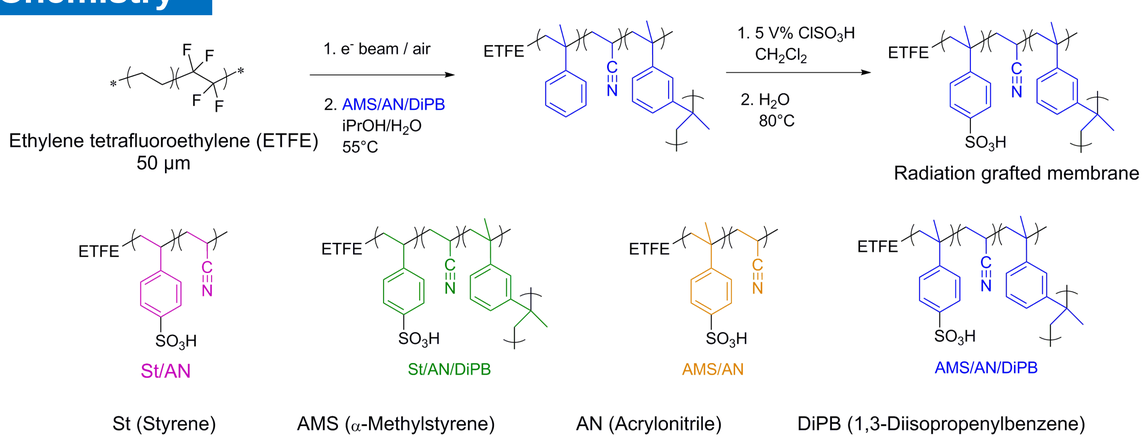
- **Lower gas crossover**[1]
- **Lower resistance**[1]
- **Better mechanical properties**[1]
- **Lower cost**[2]

As alternative for Nafion® membranes

Poly(styrenesulfonic acid) radiation grafted membranes undergo swelling-induced detachment in water at 85 ºC and 95 ºC[3]

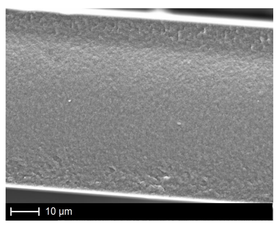
Are radiation grafted membranes unsuitable for water electrolyzer application?

Chemistry



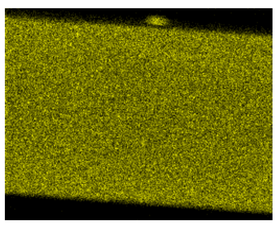
Distribution of Grafts

SEM image of **AMS/AN/DiPB** cross-section

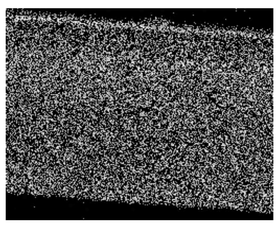


EDX mapping

Sulfur



Nitrogen

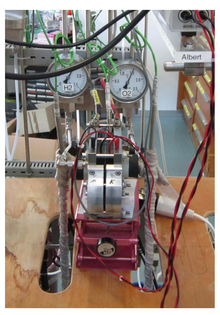


Thermal Stress Test

Membrane 30 cm²
100 ml water
90 ºC
Under stirring

Membrane in hot water for 5 days

Property Map

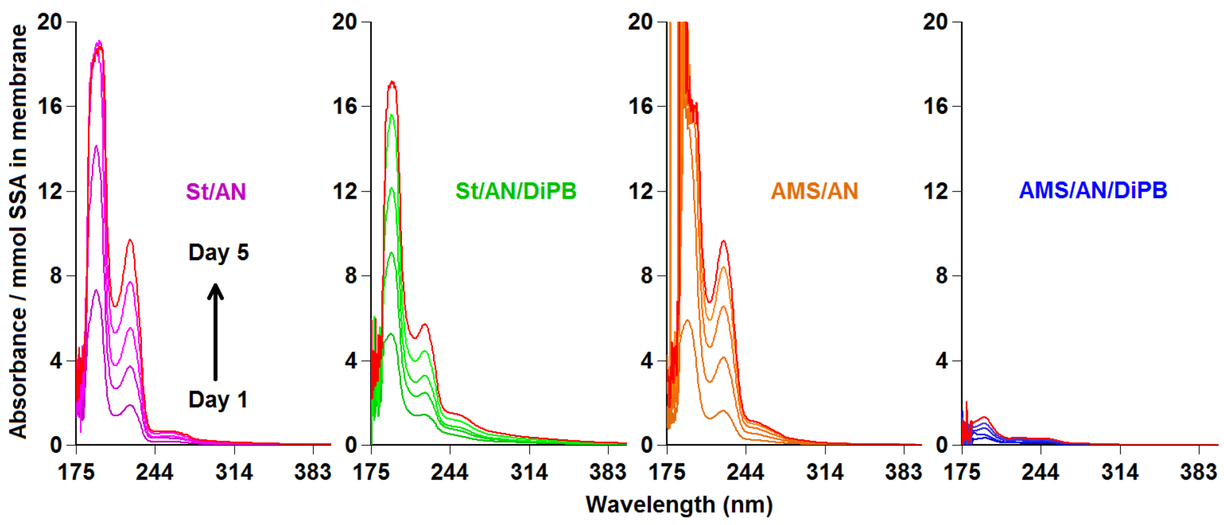


Fuel Cell
$H_2/N_2(O_2)$
80 ºC
2.5/2.5 bar_a
RH 100%

H_2 crossover and area resistance measurements

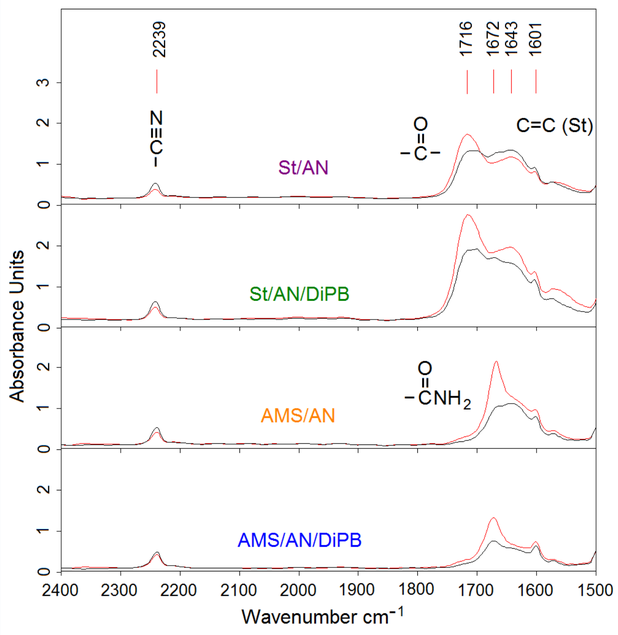
Thermal Stress Test – Water (UV-Vis)

*SSA (Styrene Sulfonic Acid)



Stability St/AN ≈ AMS/AN < St/AN/DiPB < AMS/AN/DiPB

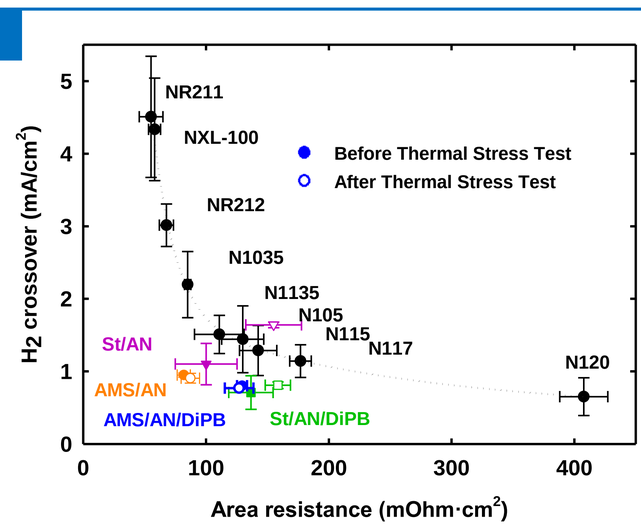
Thermal Stress Test – Membrane (FTIR and Ion Exchange Capacity)



Ion Exchange Capacity (mmol/g)			Swelling (m%)
Before	After	% loss	
1.24 ± 0.01	0.82 ± 0.06	34.1 ± 4.7	66.6 ± 0.9
1.20 ± 0.00	0.67 ± 0.01	44.2 ± 0.8	35.1 ± 3.2
1.65 ± 0.03	1.48 ± 0.00	10.3 ± 0.0	56.5 ± 0.5
1.58 ± 0.00	1.52 ± 0.01	4.2 ± 0.5	31.7 ± 0.6

Stability St/AN ≈ St/AN/DiPB < AMS/AN < AMS/AN/DiPB

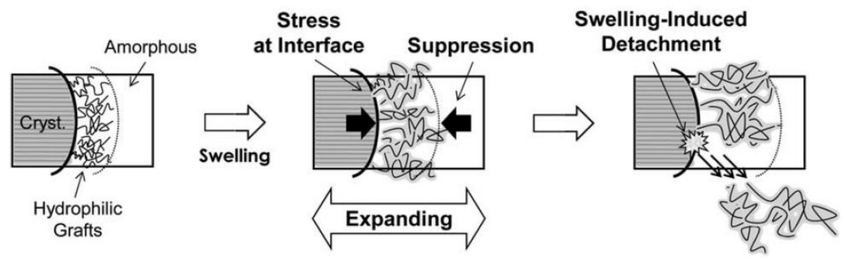
Property Map



Stability St/AN < St/AN/DiPB < AMS/AN < AMS/AN/DiPB

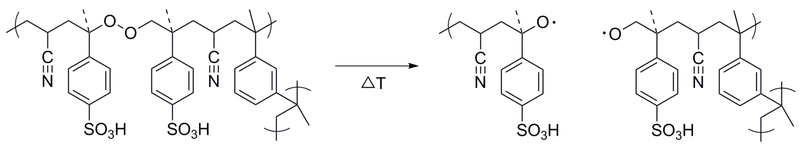
Degradation Mechanism in Hot Water

Swelling-induced Detachment[3]



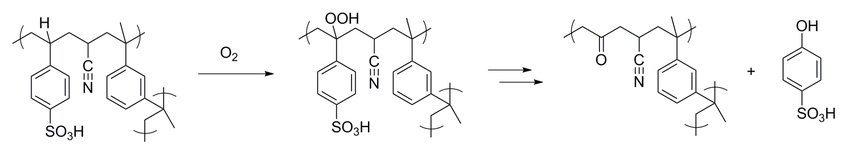
Might not be the main degradation mechanism

Degradation at the Weak Link[4]



St/AN
St/AN/DiPB
AMS/AN
AMS/AN/DiPB

Oxygen-induced Degradation[4]



St/AN
St/AN/DiPB

Conclusion

- Stability of radiation grafted membrane

  St/AN < St/AN/DiPB < AMS/AN < AMS/AN/DiPB ——— Suitable for water electrolyzer

- Degradation mechanism in hot water

  Swelling-induced detachment < weak link < oxygen-induced degradation

Acknowledgement

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[1] A. Albert, A.O. Barnett, M.S. Thomassen, T.J. Schmidt, L. Gubler, ACS Appl. Mater. Interfaces (under review).

[2] L. Gubler, L. Bonorand, ECS Trans. 58, 149 (2013).

[3] K. Enomoto, S. Takahashi, T. Iwase, T. Yamashita, Y. Maekawa, J. Mater. Chem. 21, 9343 (2011).

[4] R.B. Hodgdon, J.R. Boyack, A.B. LaConti, TIS Report 65DE 5, General Electric Company, Lynn, MA (1966).