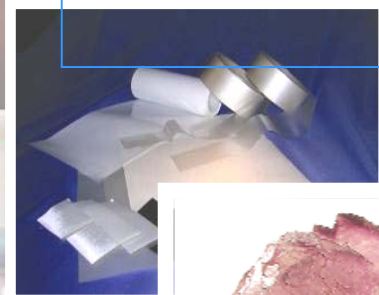




**AQUIVION™**  
**The short-side-chain and low-EW  
PFSA for next-generation PEFCs  
expands production and utilization**

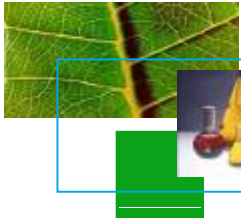
Fuel Cell Seminar 2009

Dr. Ing. Matthias Gebert  
with  
A. Ghielmi, L. Merlo,  
M. Corasaniti, V. Arcella



Solvay  
Solexis





## Solvay Solexis' Industrial Materials for PEFC and VHT-PEFC\*

**Ionomer Membrane & Dispersion**

**low-EW PFSA ...AQUIVION™**

**Membrane Subgaskets / "Rims"**

**customized Ajedum LLC Films**

**Stack Cooling**

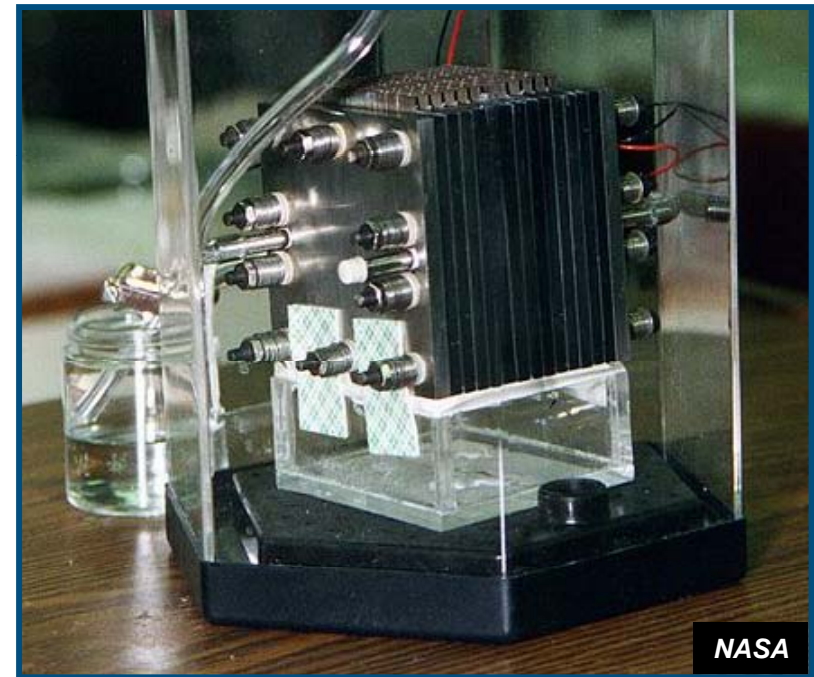
**failsafe H-Galden® Fluids**

**GDL Hydrophobization**

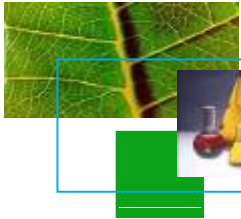
**Algoflon® PTFE dispersions**

**Gasket materials**

**Tecnoflon® fluorinated rubbers**



\* Very High Temperature PEFC



# Solvay Solexis' Industrial Materials for PEFC and VHT-PEFC\*

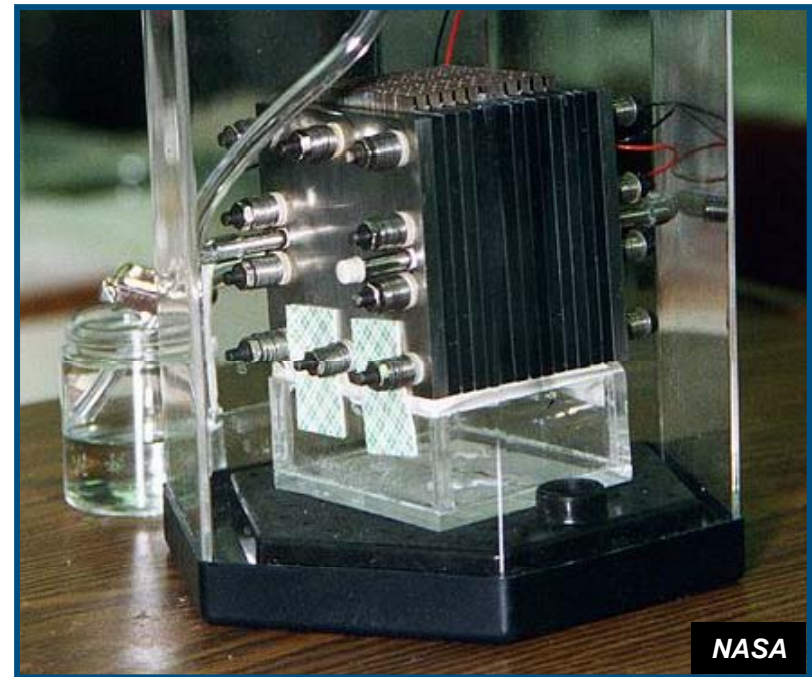
## Ionomer Membrane & Dispersion **low-EW PFSA ...AQUIVION™**

Membrane Subgaskets / "Rims"  
customized Ajedium LLC Films

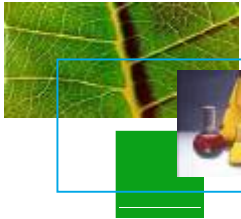
Stack Cooling  
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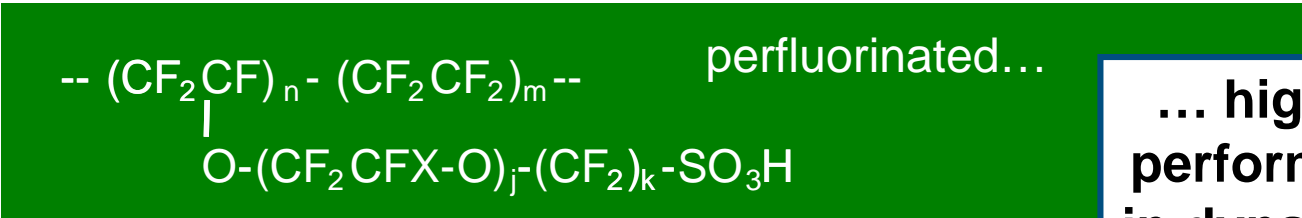
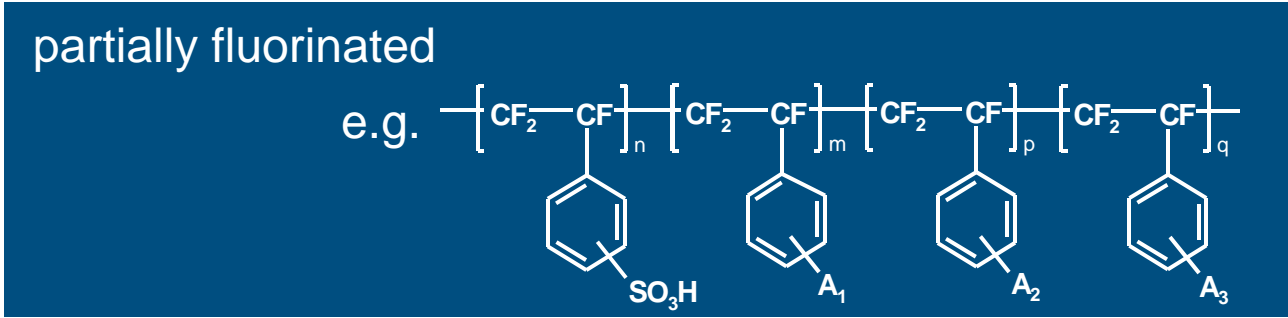
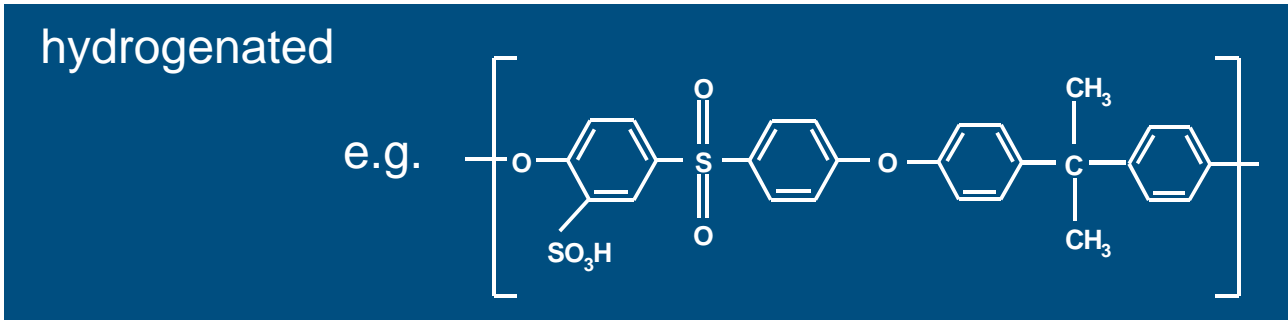
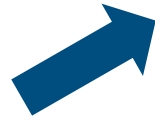


\* Very High Temperature PEFC

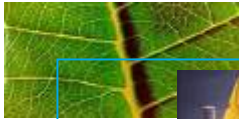


# Perfluorinated Polymers for Ionomer Development

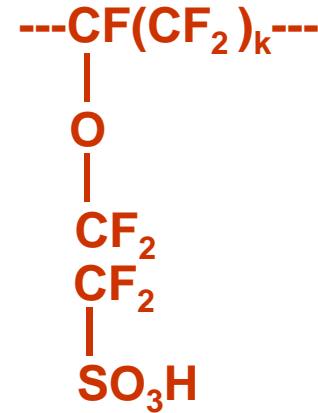
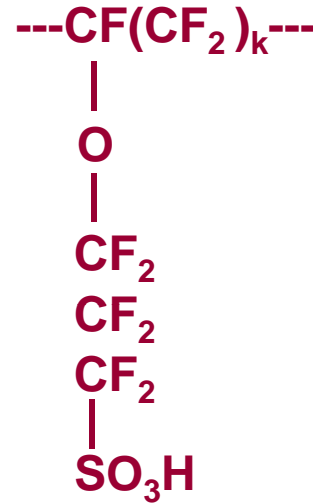
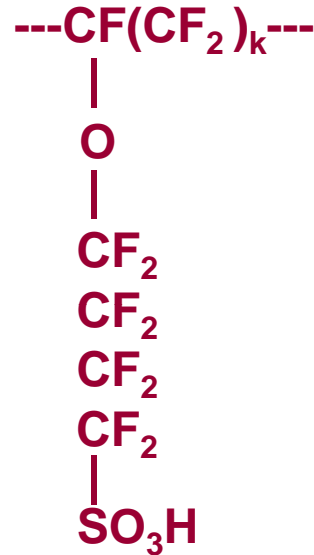
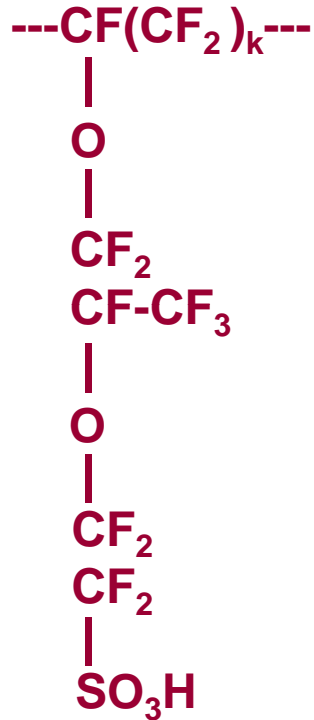
Ionomers



... highest potential for performance & durability in dynamic FC conditions



Shorter side chains → make EW reduction possible



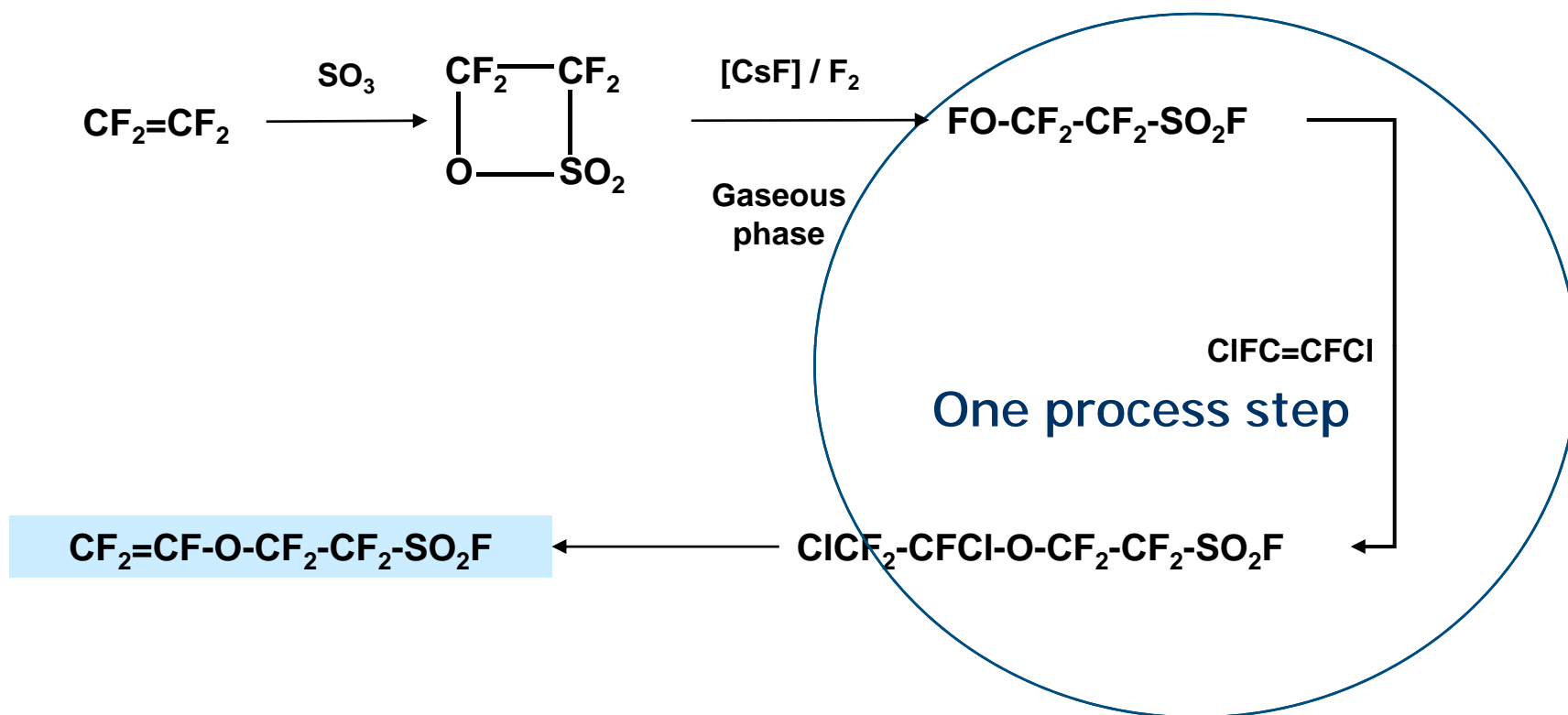
**AQUIVION™**

... better mechanical properties at same IEC.  
 ... or higher IEC at same mechanical properties.

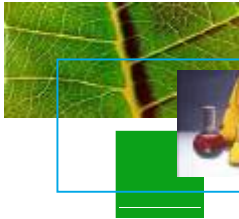
IEC: ion-exchange capacity



## Aquivion™ : Efficient monomer production



- Only 4 major reactions to make the co-monomer for Aquivion™
- No low-yield step delivers major quantities of undesired by-products
- Very efficient use of necessary raw materials



## Ionomer features to leverage Size & Cost Reduction :

- **Higher Proton Conductivity**

- **LESS ACTIVE AREA** necessary → Pt savings
- ...also in **DRY** operating conditions



- **Stronger Water Retention**

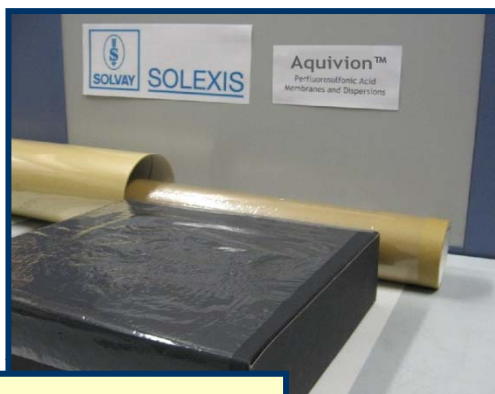
- **AUTO-HUMIDIFICATION**  
despite operation with dry gases
- **QUICK START-UP** after idling periods  
(CCM dry-out problem)

- **Better Thermal Stability**

- **LESS AREA** needed  
for heat-exchange
- **SMALLER** cooling systems  
with high-Temperature PEFCs



## Commercial Aquivion™ Products as of Nov. 2009



**Membranes**

**E87-05S**  
**E87-10**

**870 g/eq EW**  
50 to 100  $\mu\text{m}$  Thickness

**E79-03S**

**790 g/eq EW**  
30  $\mu\text{m}$  Thickness



**Dispersions**

**D83-06A**

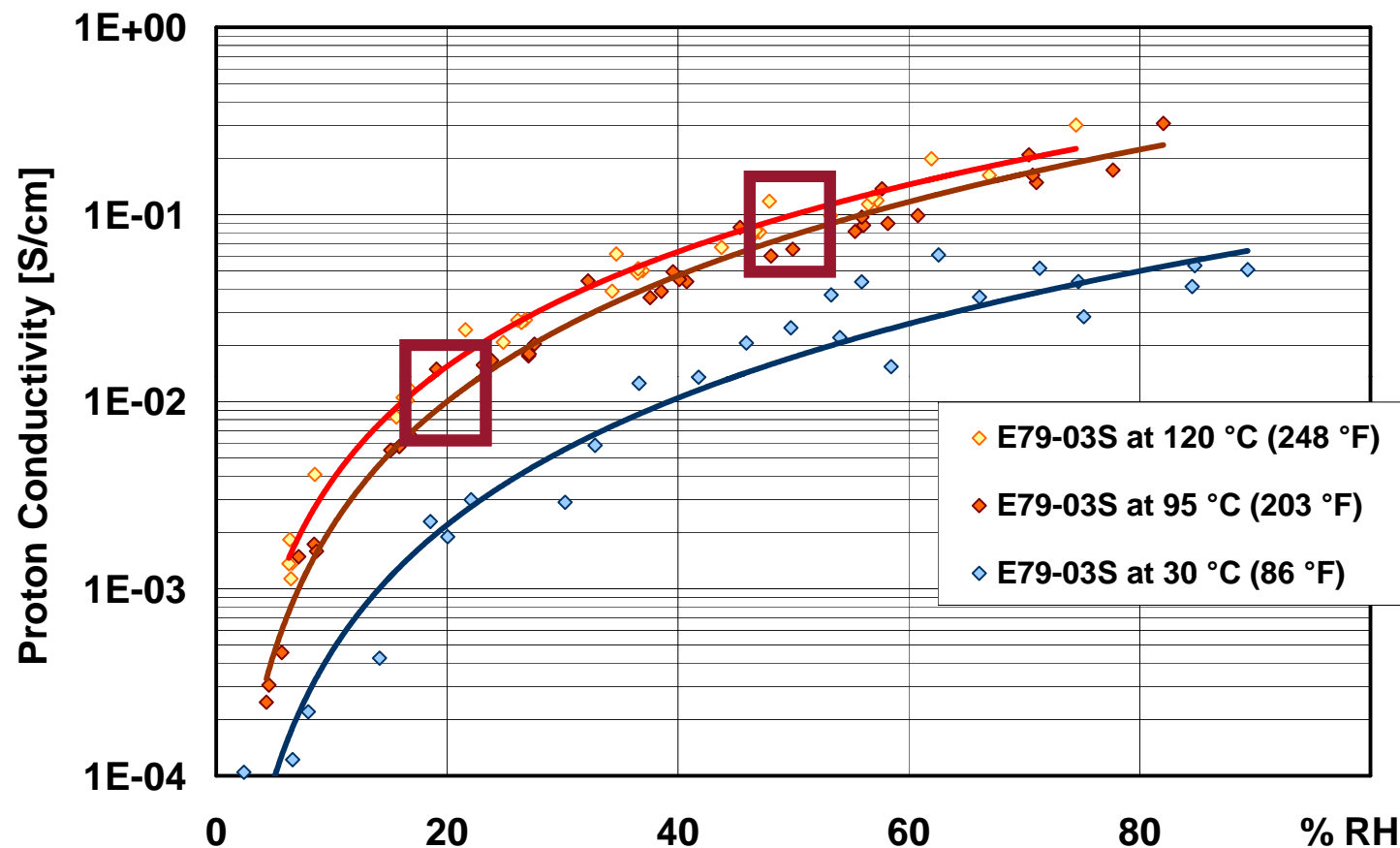
**830 g/eq EW**  
6 % ionomer concentration

**D83-20B**  
**D83-15C**  
**D83-10E**

**830 g/eq EW**  
10 to 20 % ionomer concentration



## Remarkable Ionic Conductivity at 30 ... 95 ... 120 °C



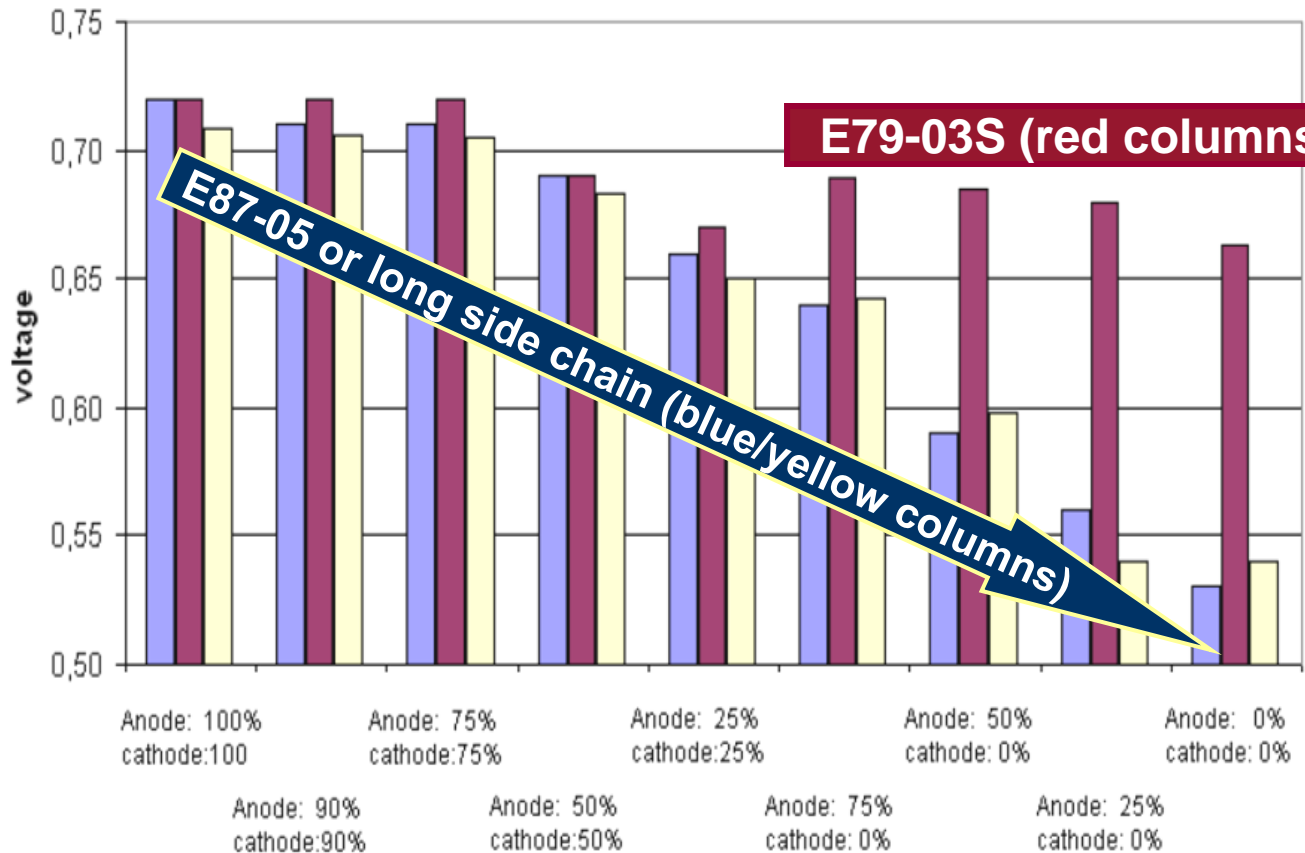
**70-100 mS/cm at 95 °C and 50 % relative humidity**  
**10 mS/cm at 95 °C and 20 % relative humidity**

*4-probe in-plane  
ex-situ measurement  
in absence of air*



# E79-03S → strong Water Retention at high Temperature

90 °C – 1.1 bar abs – 50 cm<sup>2</sup> – 0.6 A/cm<sup>2</sup>



E79-03S (red columns)

E87-05 or long side chain (blue/yellow columns)

Air stoichiometries:  
2.0 on anode side  
2.5 on cathode side  
Sigracet® 10BC GDLs

WET

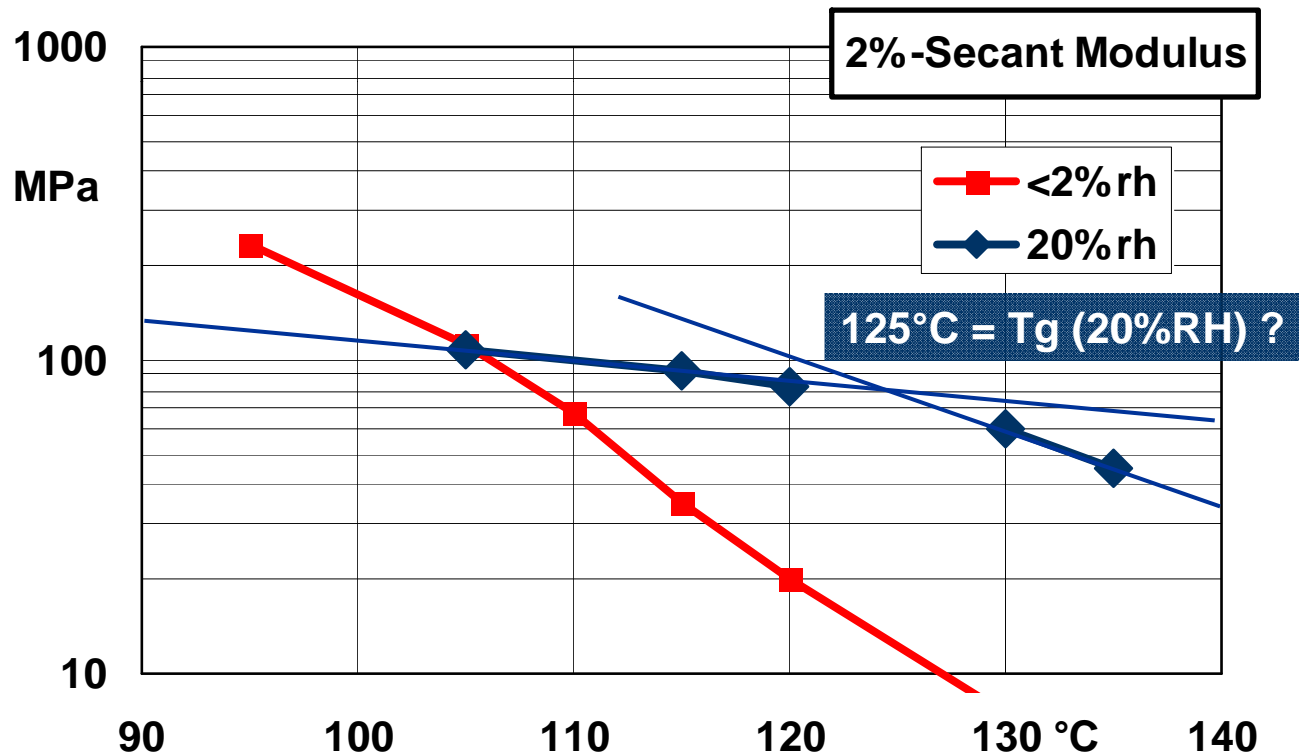


DRY



## E79-03S → Extending PFSA's Thermal Stability

- Dry T-scan shows reduced modulus when approaching  $T_g$  @  $140^\circ\text{C}$ 
  - DMS-scan (3 samples) → glass transition temperature “at 0 % rh”
- 20% RH T-scan reveals mechanical stability change around  $125^\circ\text{C}$  :





## Commercial Aquivion™ Products as of Nov. 2009



**Dispersions**

**D83-06A**

**830 g/eq EW**  
6 % ionomer concentration

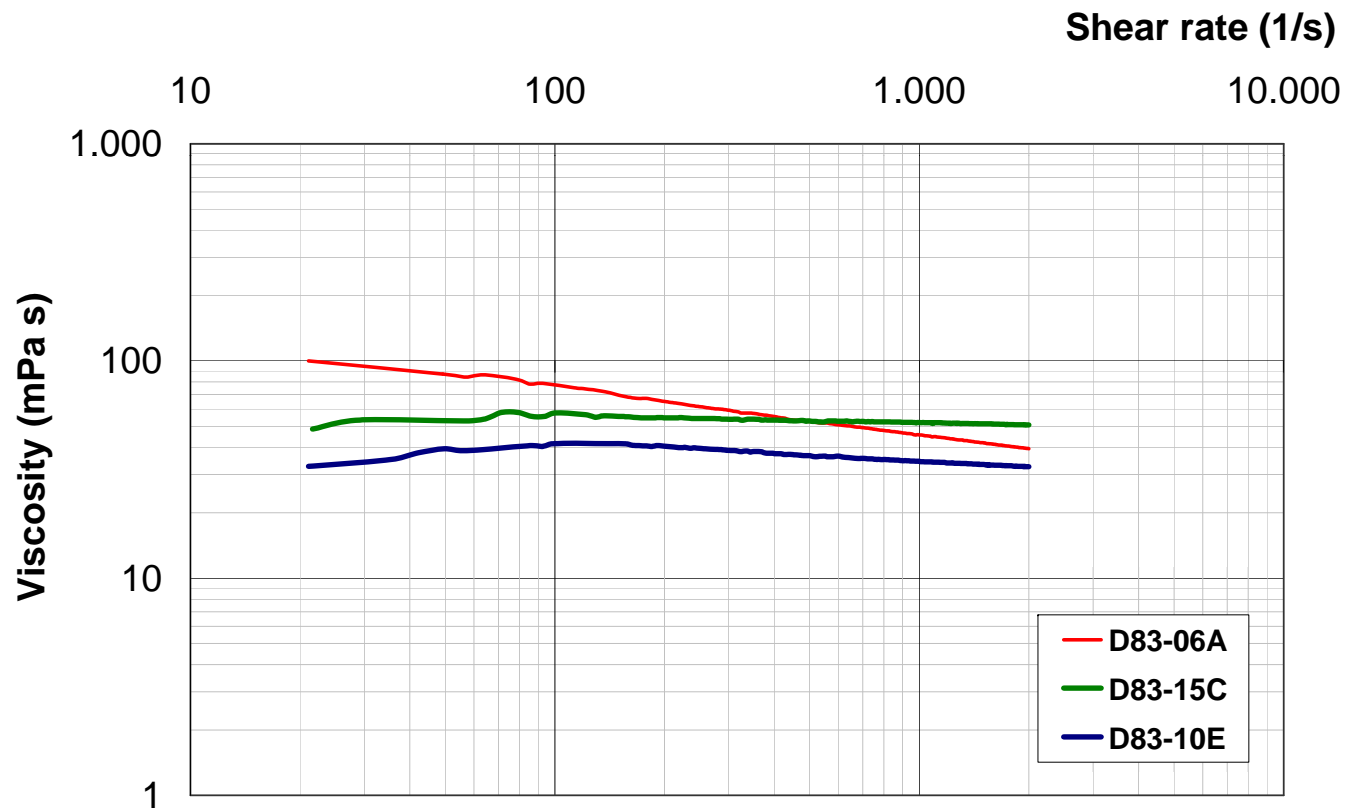
**D83-20B**  
**D83-15C**  
**D83-10E**

**830 g/eq EW**  
10 to 20 % ionomer concentration



## Aquivion™ Dispersion Rheology

- **D83-06A: Thickening under low-shear possible**
- **D83-15C and D83-10E: Substantially Newtonian behavior**





## Aquivion™ Dispersions in 0.5, 5 or 60-liter containers

0.5 ltr

- **Possible uses:**
  - Electrode ink development
  - Membrane recasting
  - Surface hydrophilization



- **5-liter** jerricans ready for worldwide air freight



5 ltr

- **60-liter** drums available



60 ltr

- **4-8 weeks** delivery time for larger quantities



## Worldwide accessibility and qualification

- Sold to over 20 countries
- Hubs in Philadelphia, Shanghai, Seoul, Tokyo
- Sample-volume purchases processed via [www.ajedium.com](http://www.ajedium.com) based in Newark/DE, USA



[www.aquivion.com](http://www.aquivion.com)

Aquivion™ is accessible  
worldwide via email to

[solexis.ionomers@solvay.com](mailto:solexis.ionomers@solvay.com)

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of Solvay Solexis



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