Membrane Characterization in Electrolyte

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MOTIVATION

- New ionomer membranes and separators are being developed for emerging electrochemical processes especially in the field of energy storage and conversion such as **REDOX FLOW BATTERIES**
- A commercial cell for *ex situ* membrane characterization in relevant environment is needed

OBJECTIVE

Develop a versatile tool to support membrane R&D used with liquid environments. Desired features:

- 4-electrode to eliminate non-ohmic impedance sources
- Small electrolyte volume
- Small sample size
- Easy assembly/disassembly
- Compatible with wide range of environments

SOLUTION: *Commercial H-Cell*

Design Features

- 4-electrode with removable REs
- High-surface area Pt CE &WE
- 30 mL electrolyte volume per half
- Ports for gas inlet/outlet & Temp
- Adjustable Luggin probe position
- Chemically resistant materials

Correcting $R_{measured}$ for electrolyte resistance, $R_{electrolyte}$

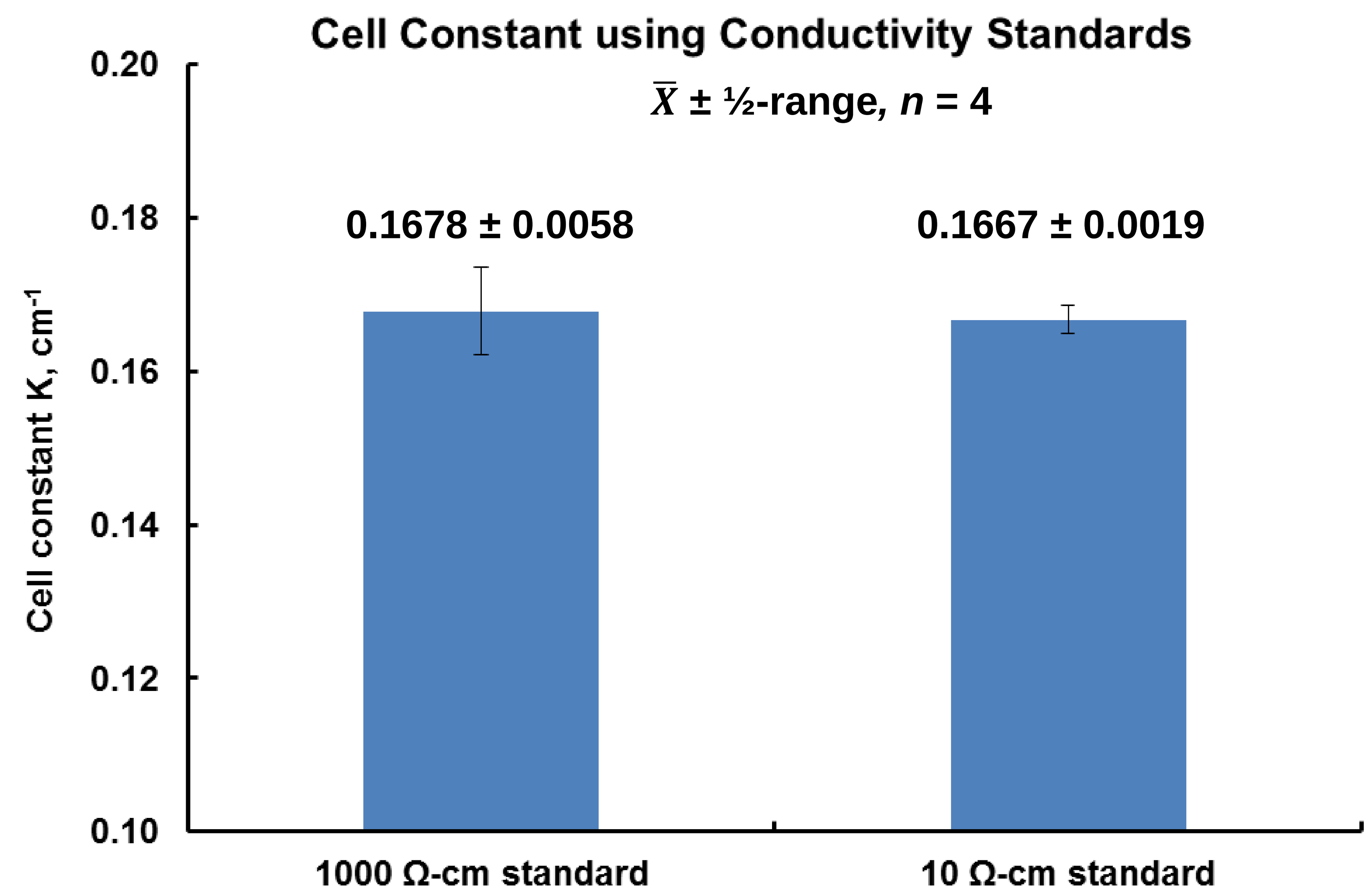
$$\sigma_{membrane}(S/cm) = \frac{t}{R_{membrane} \cdot A}$$

t = membrane thickness (cm)
A = membrane area (cm²)

- Resistance *R* (Ω) determined using LSV (±0.1 V *vs*. OCV, 50 mV/s)
- $R_{measured} = R_{membrane} + R_{electrolyte}$
- $R_{electrolyte}$ = Uncompensated electrolyte resistance
- $R_{electrolyte}$ obtained by
  - Measuring H-cell resistance without a membrane
  - Calculating from electrolyte conductivity $\sigma_{electrolyte}$ (S/cm) and the cell constant K_{cell} (cm^{-1})

$$R_{electrolyte} = \frac{K_{cell}}{\sigma_{electrolyte}}$$

- K_{cell} depends only on cell geometry (Luggin probe location, cell cross-section) and is independent of $\sigma_{electrolyte}$
- Conductivity standards used to obtain K_{cell}



Environments: Cell Design and Procedure

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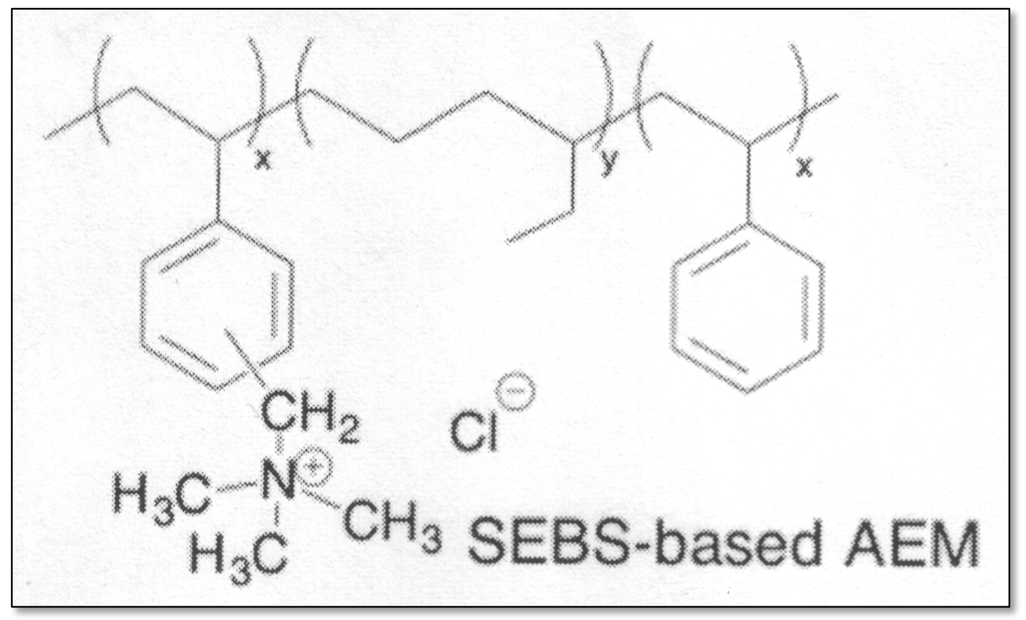
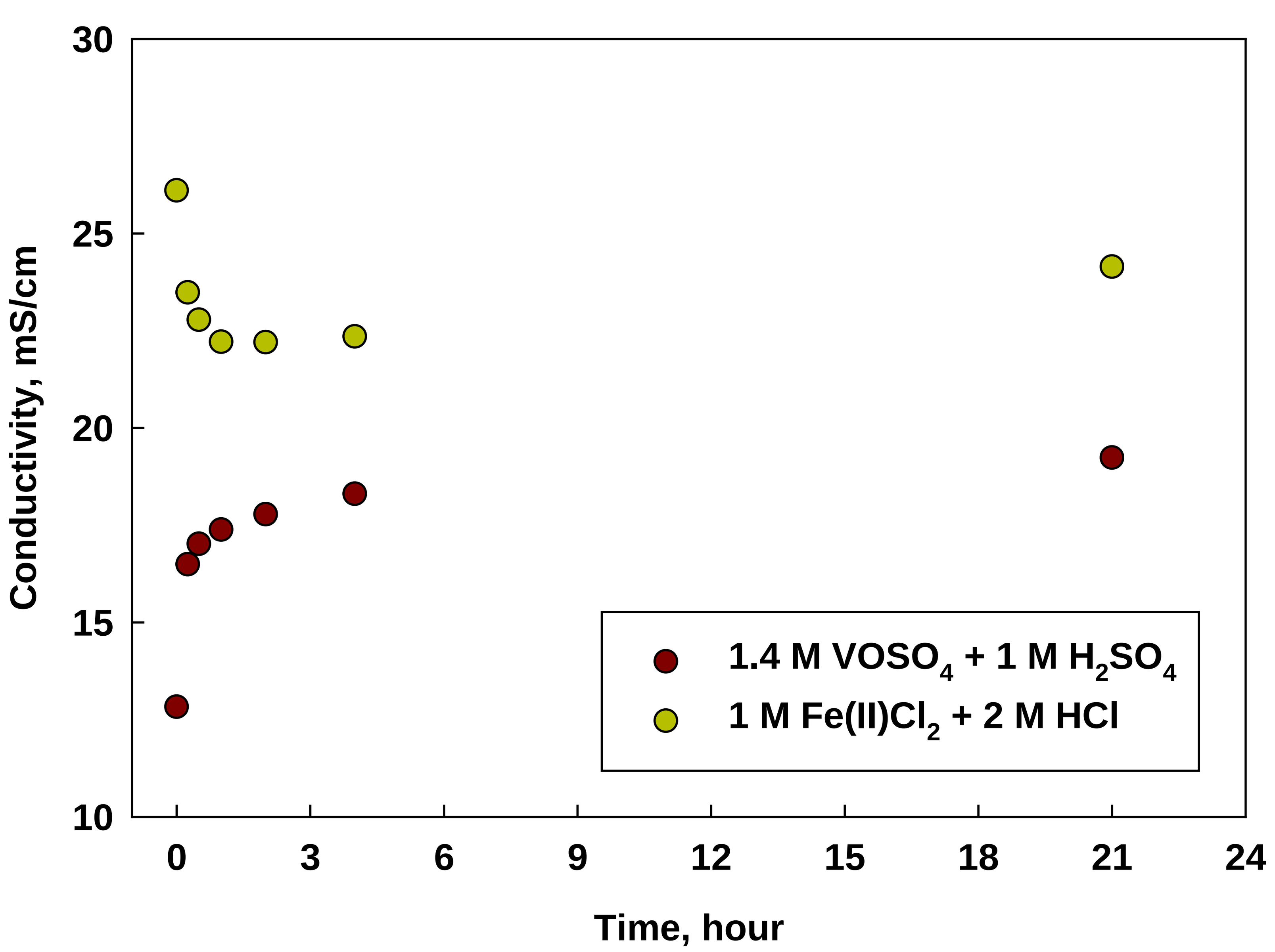
EVALUATION OF NOVEL AEM FOR RFBs

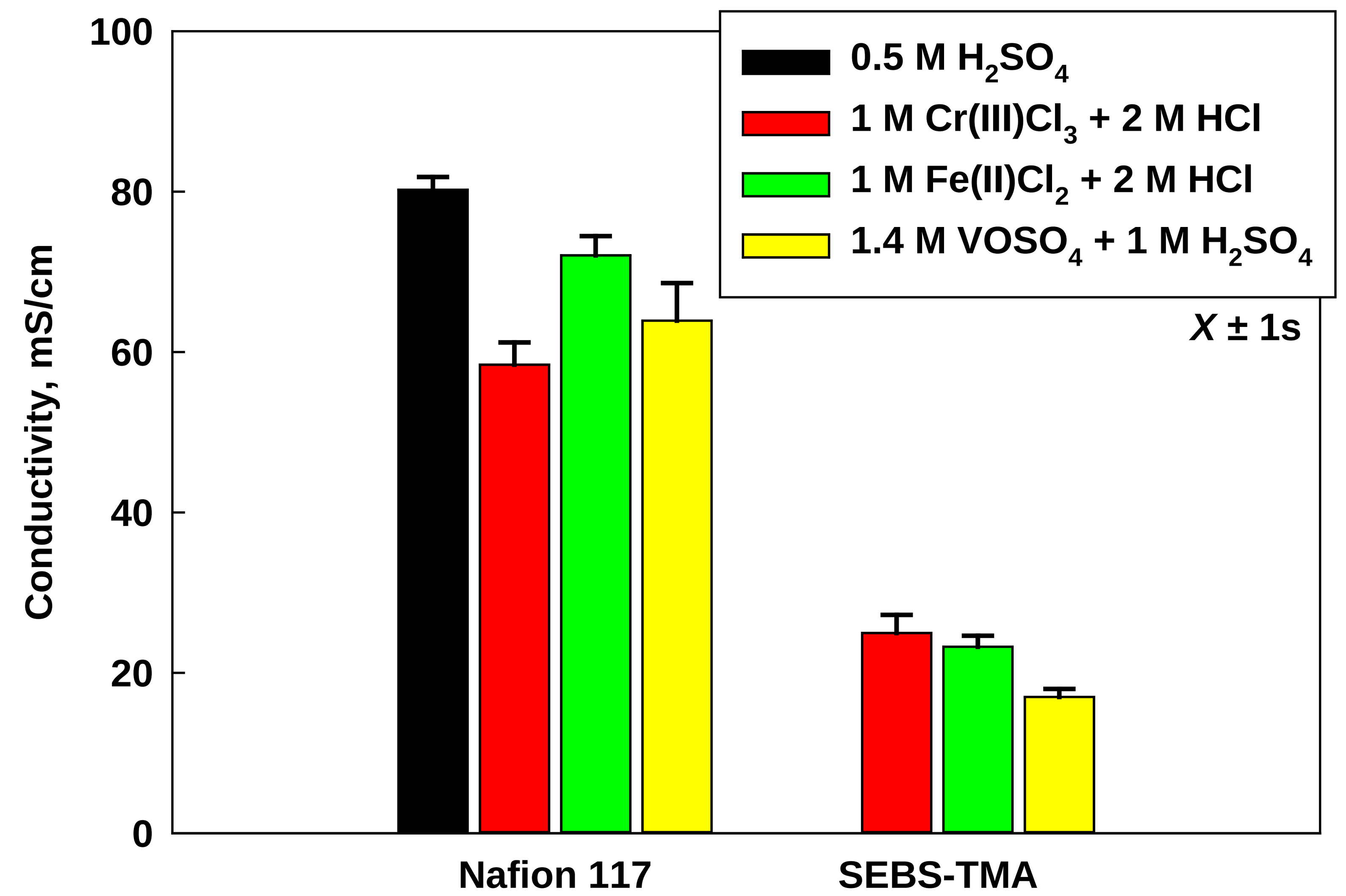
- Polymer backbone: polystyrene-*block*-poly-(ethylene-*ran*-butylene)-*block*-polystyrene (SEBS)
- Functional group: trimethylamine (TMA)



SEBS-TMA Properties	
IEC (mmol/g)	1.35 ± 0.02
Water uptake	52%
Permselectivity	73%
Transport no. (t_{Cl^-}; t_{K^+})	(0.87; 0.13)
Tensile strength (MPa)	1.83
Elongation at break	350%

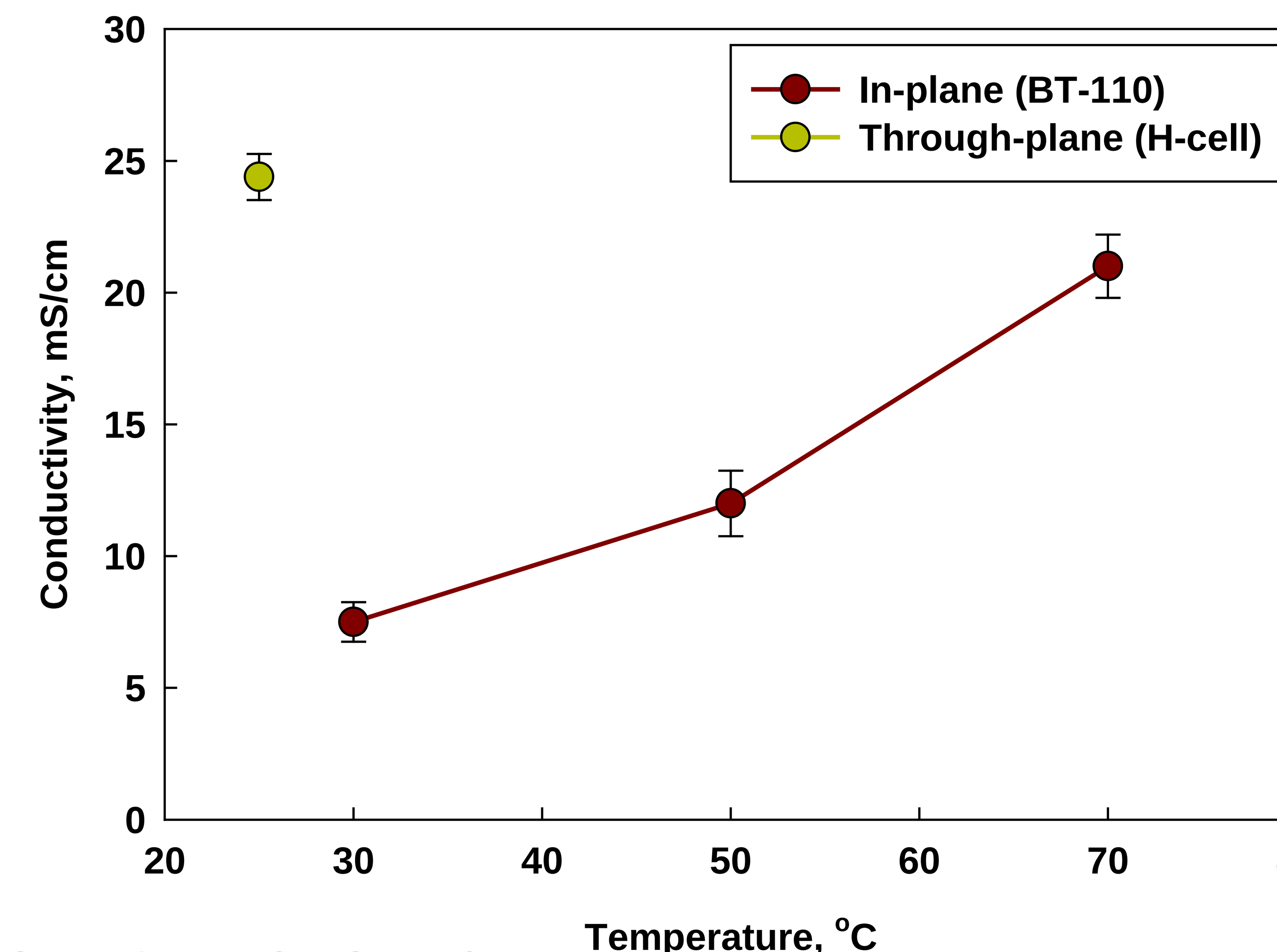


- AEM σ in Cl^- > in SO_4^{2-}
- σ increases slightly over time



- AEM σ in Cl^- > in SO_4^{2-}
- $\sigma_{SEBS-TMA}$ ~ 1/3 σ_{Nafion}

- σ : TP (H-cell in Cl^-) > IP (BT-110 in high purity H_2O)



CONCLUSIONS

- ***H-cell is a viable cell design for reproducible through-thickness resistance and conductivity measurement of ion exchange membranes and separators in liquid electrolytes***
- ***4-electrode measurement allows simple DC measurement (LSV) with straight forward data analysis of resistance***
- ***Reproducible, accurate results obtained with Nafion and an experimental AEM in multiple RFB-type electrolytes***

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