



First Project Workshop

In Pilsen and Online

Optimization of cell efficiency

for aqueous organic electrolyte

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New Technologies - Research Centre
University of West Bohemia
3rd March 2022*



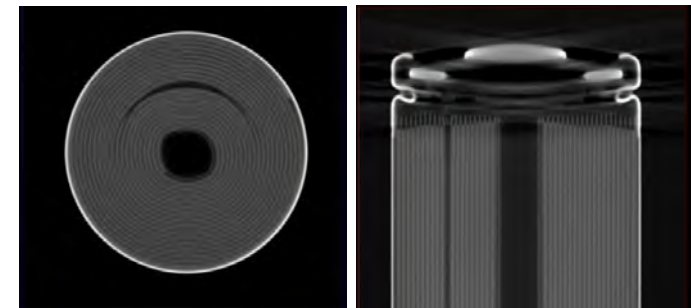
*The research leading to these results has
received funding from the European Union
under Grant Agreement no. 875613*

CONFIDENTIAL

HIGREEW - 875613 – 1st Project workshop

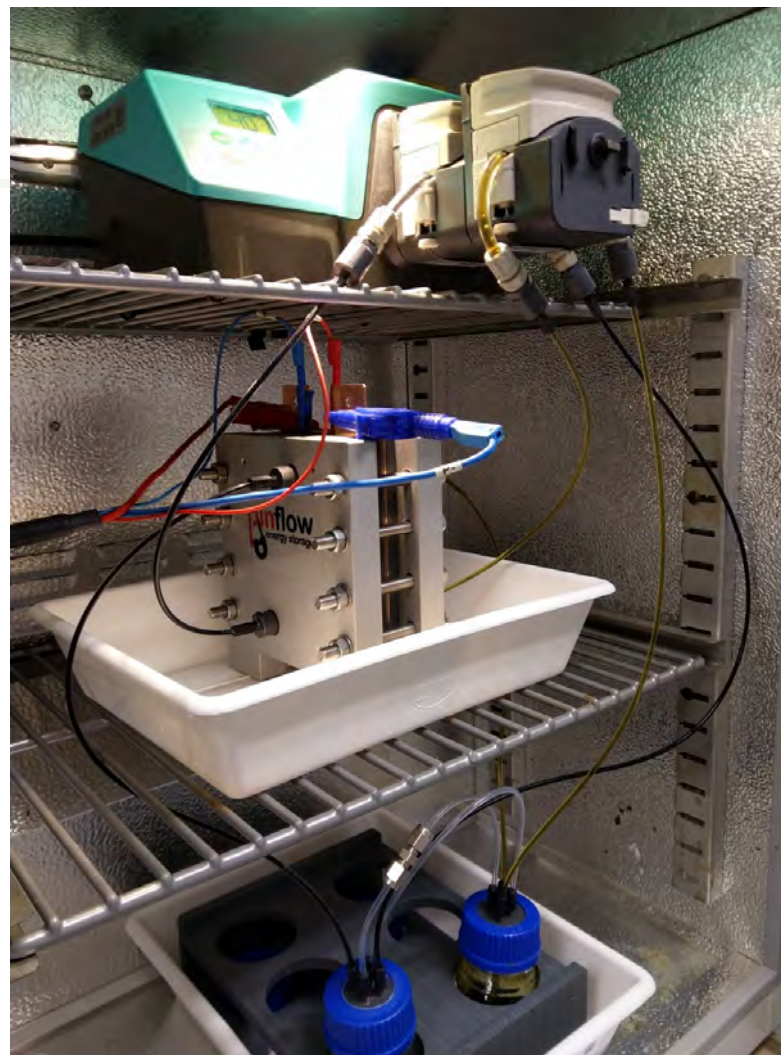
Engineering of electrochemical processes

- Battery and cell testing facilities
 - 10 channels
- Computed microtomography
 - in situ measurement available
- Scale up of new battery concepts
 - Zn-air
- Development of VRFB stack
 - know how licensed to Pinflow



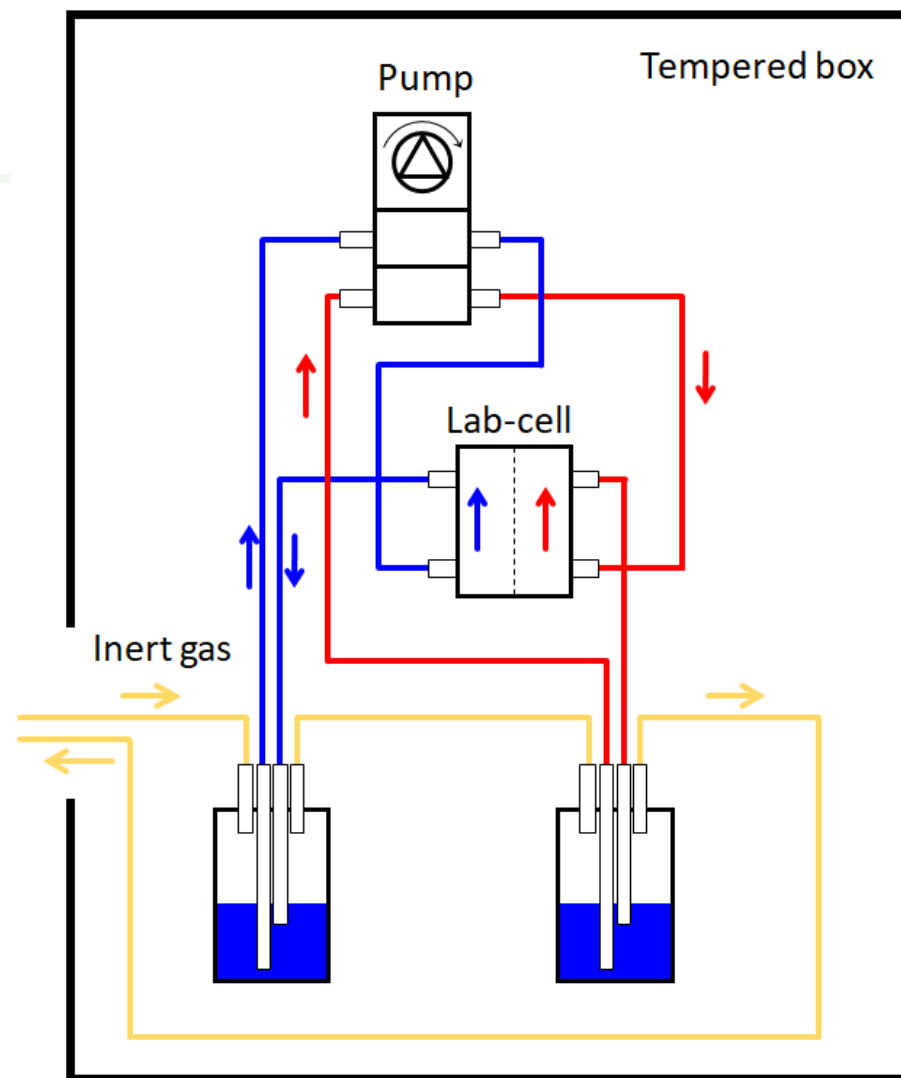
Introduction

- Studied system
 - 0.9M (SPr)₂V – 0.9M Fe(CN)₆
 - Supporting electrolyte – NH₄Cl
- Lab cell
 - Pinflow design
- Atmosphere
 - Inert gas – N₂
- Pump
 - Watson – Marlow – Peristaltic



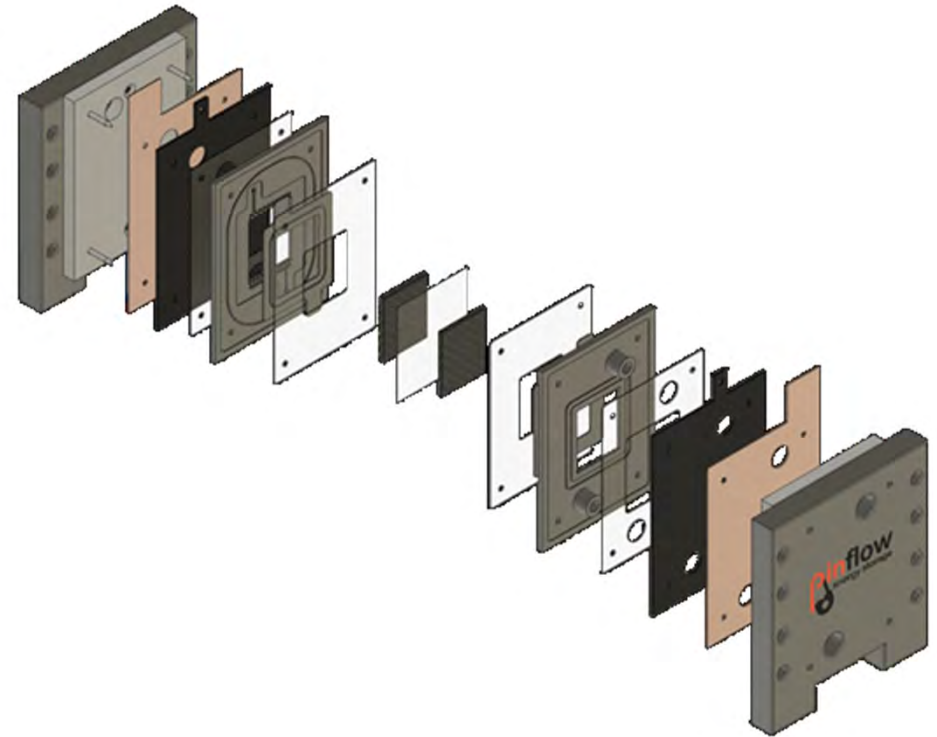
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Pinflow lab cell

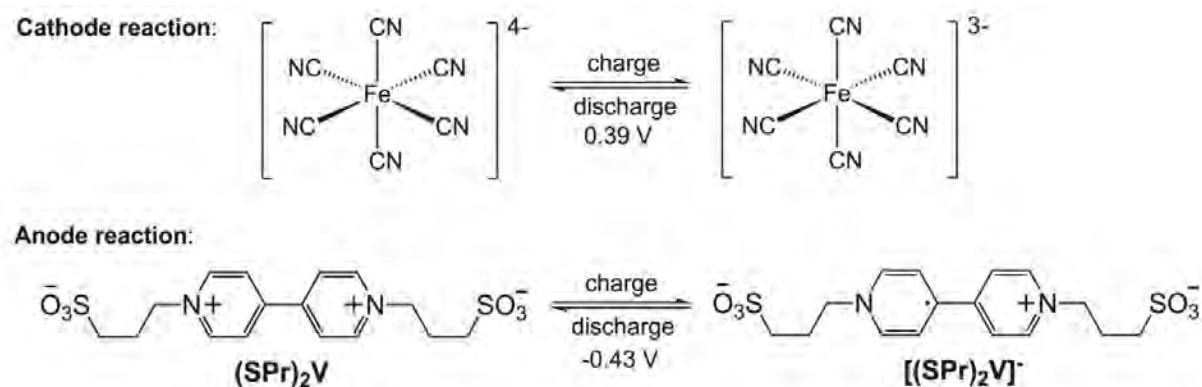
- Scaling cell
 - 2x2 cm² → 4x5 cm² → industry scale
- End plate →
 - copper current collector →
 - carbon polymer composite →
 - seal → flow frame → felt →
 - seal → membrane ...



Introduction

Studied system

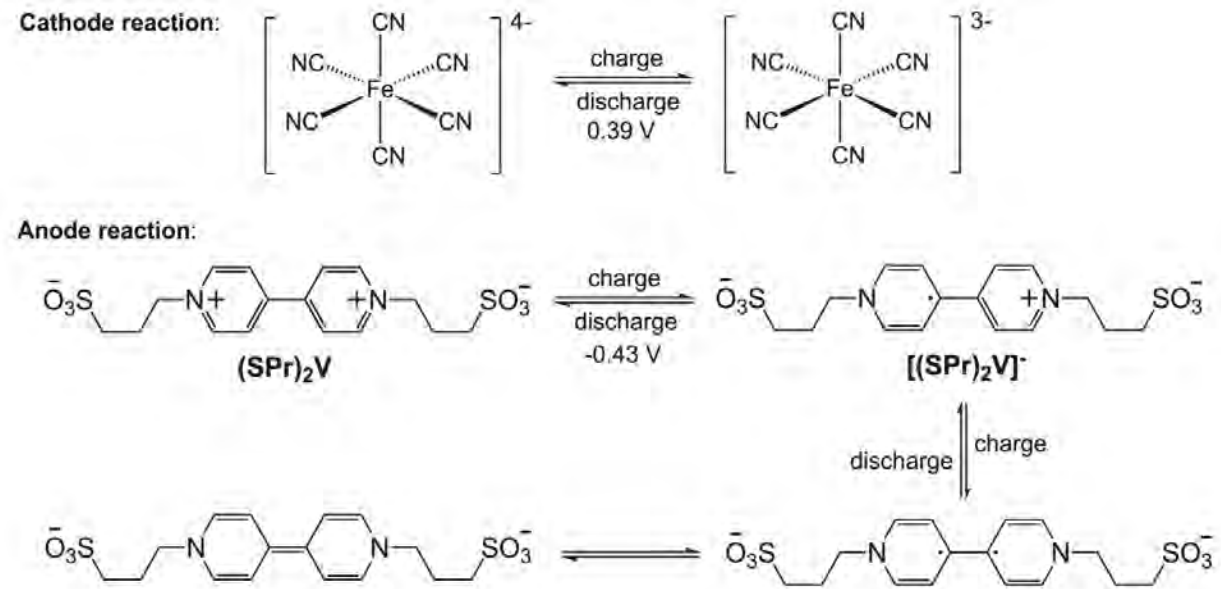
- 0.9M (SPr)₂V – 0.9M Fe(CN)₆
- Supporting electrolyte – NH₄Cl
- Membrane – Fumasep FS950
- Felt – SGL GFD 4.6EA
- Carbon-polymer composite – PPG86



Introduction

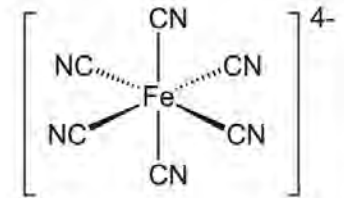
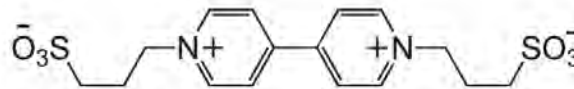
Studied system

- 0.9M (SPr)₂V – 0.9M Fe(CN)₆
- Supporting electrolyte – NH₄Cl
- Membrane – Fumasep FS950
- Felt – SGL GFD 4.6EA
- Carbon-polymer composite – PPG86
- Maximum voltage – up to 1.2 V



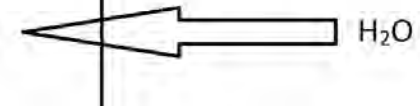
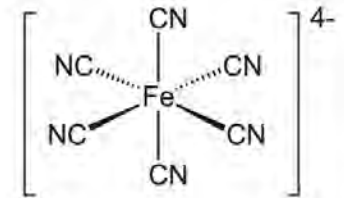
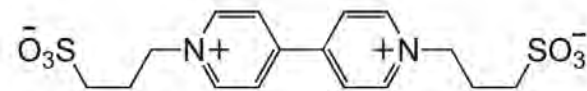
Targets

- Finding best conditions
 - Optimal temperature
 - Flow management
- Looking for best performance
 - Highest Voltage Efficiency
 - Lowest resistance of the system
 - Predictable behavior during cycling



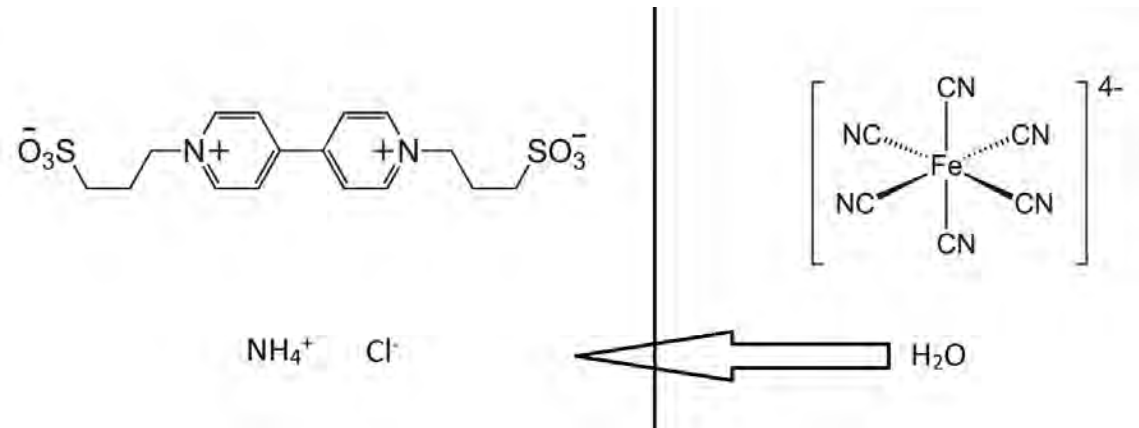
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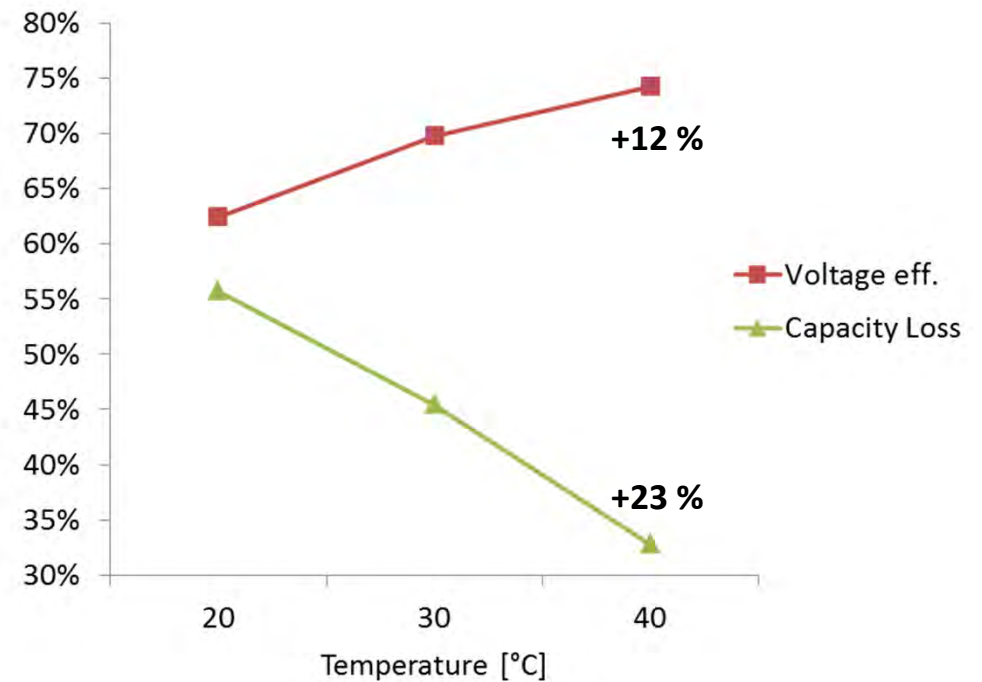
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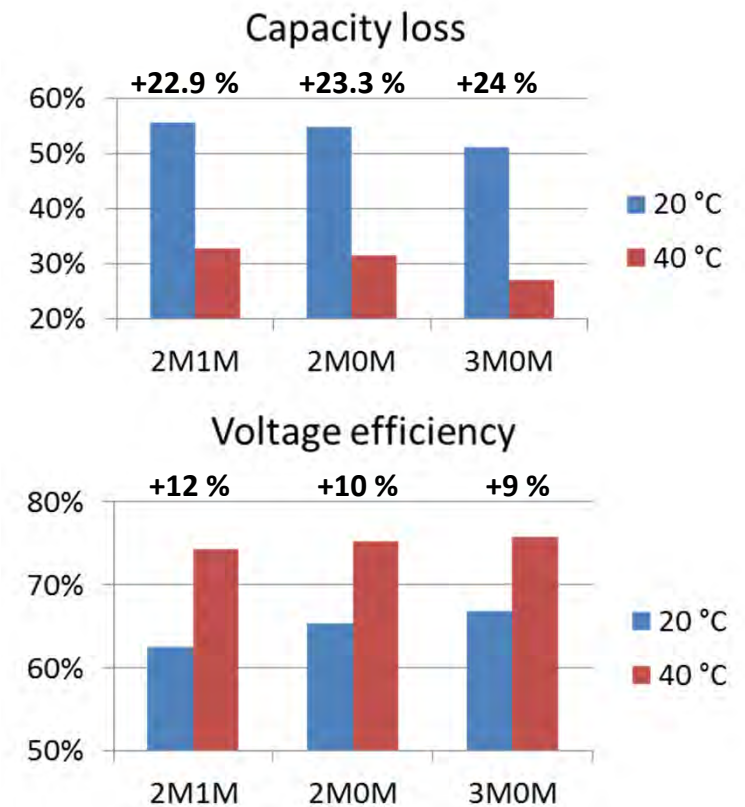
Temperature – cell 2x2 cm²

- Amount of supporting electrolyte
 - 2 M NH₄Cl in (SPr)₂V, 1M NH₄Cl in Fe(CN)₆
- Flow, Voltage
 - 20 ml/min; 0.6 – 1.15 V
- Tested temperature
 - 20, 30 and 40 °C
- Result
 - 20 and 40 °C → cell 4x5 cm²



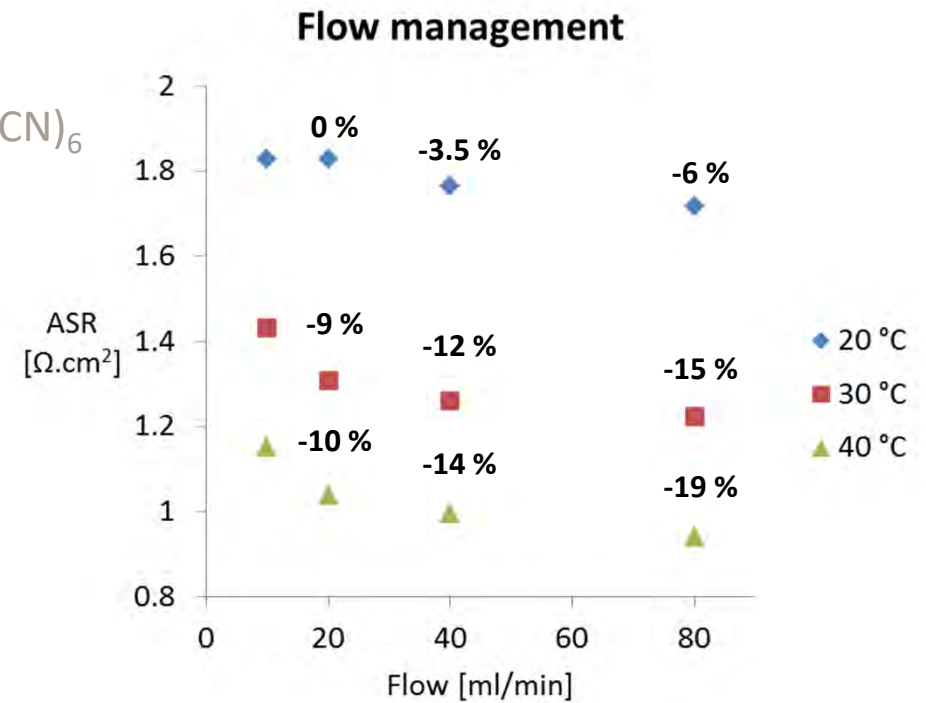
Best performance – cell 2x2 cm²

- Amount of supporting electrolyte
 - 2 M or 3M NH₄Cl in (SPr)₂V, 1M or 0M NH₄Cl in Fe(CN)₆
- Flow, Voltage
 - 20 ml/min; 0.6 – 1.15 V
- Tested temperature
 - 20 and 40 °C
- Result
 - 40 °C
 - More than 20 % initial capacity from theoretical maximum
 - + 10 % Voltage efficiency
 - Ideal concentration of NH₄Cl – which one is the best ??

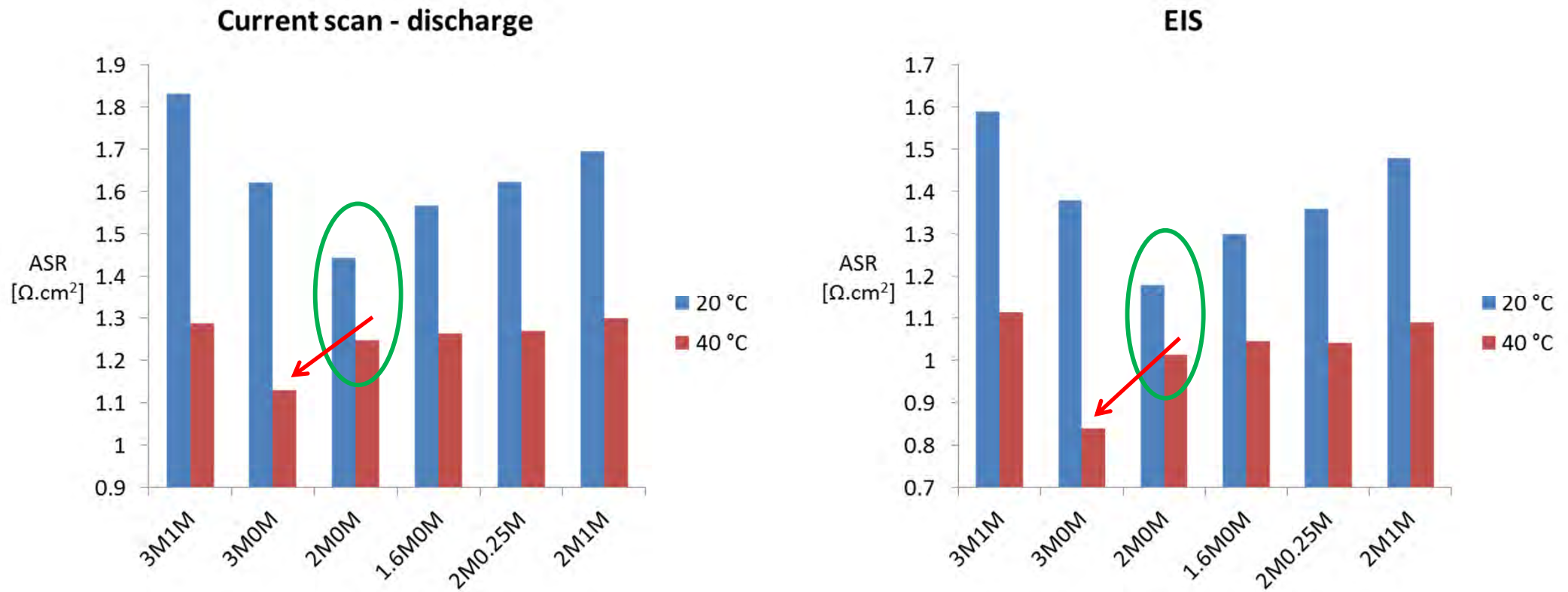


Flow management – cell 2x2 cm² – SoC 50 %

- Amount of supporting electrolyte
 - 2M1M == 2 M NH₄Cl in (SPr)₂V, 1M NH₄Cl in Fe(CN)₆
- Flow range
 - From 10 to 80 ml/min
- Tested temperature
 - 20, 30 and 40 °C
- Result
 - 40 ml/min → cell 4x5 cm²



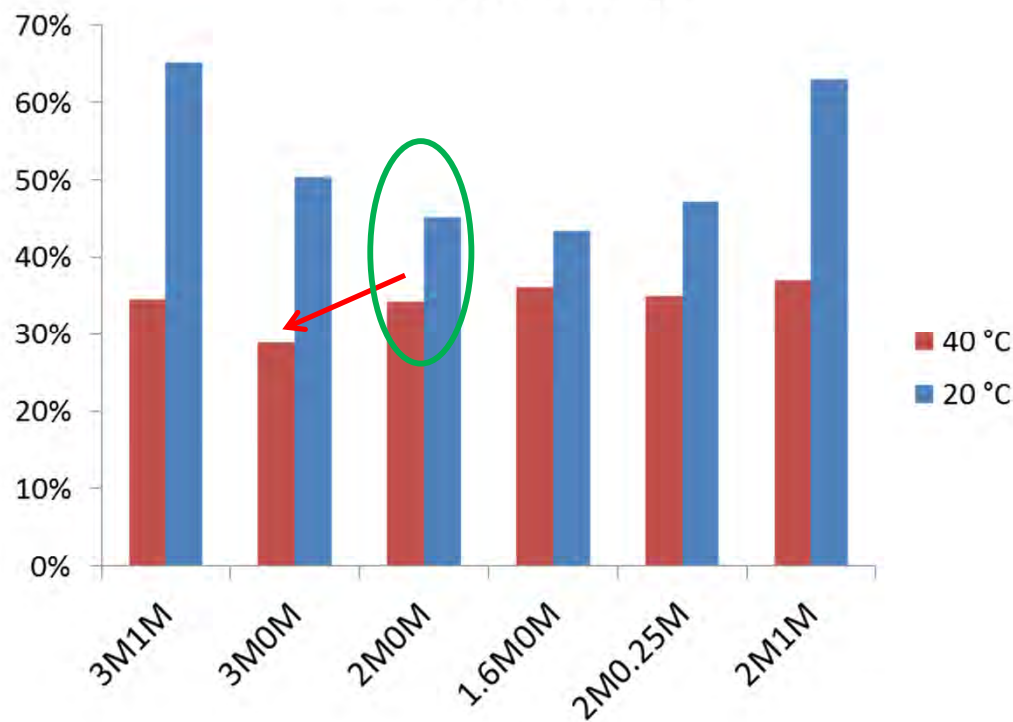
Impedance – cell 4x5 cm² – State of charge 50 %



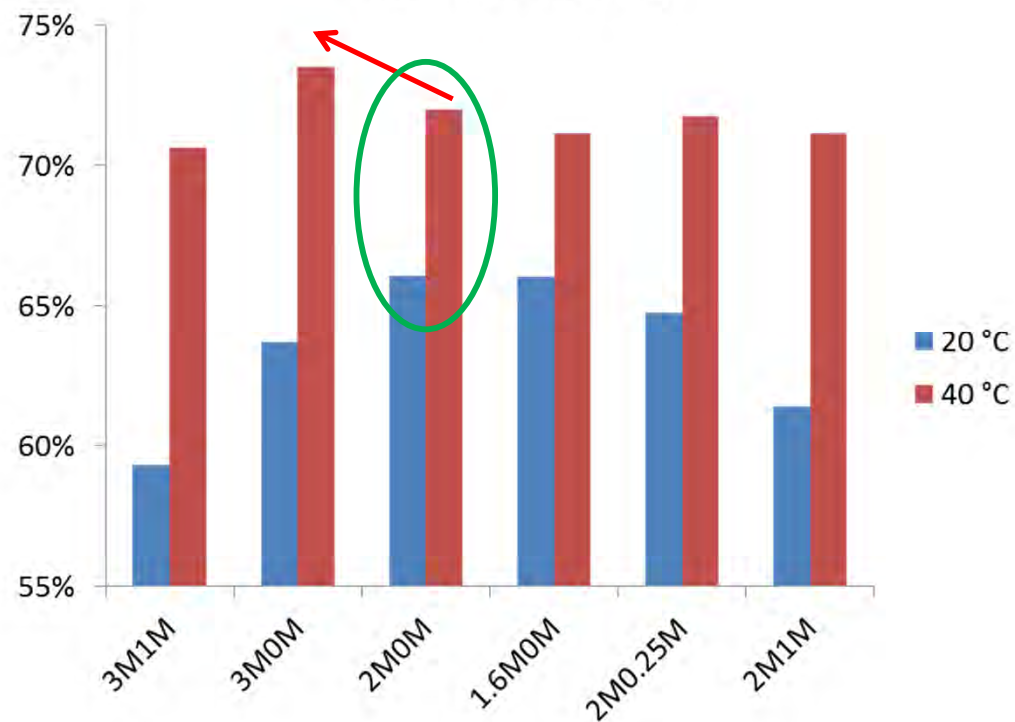
Note: 2M1M == 2 M NH₄Cl in (SPr)₂V, 1M NH₄Cl in Fe(CN)₆

Cycling performance – cell 4x5 cm²; 40 ml/min; 50 cycles

Initial capacity loss

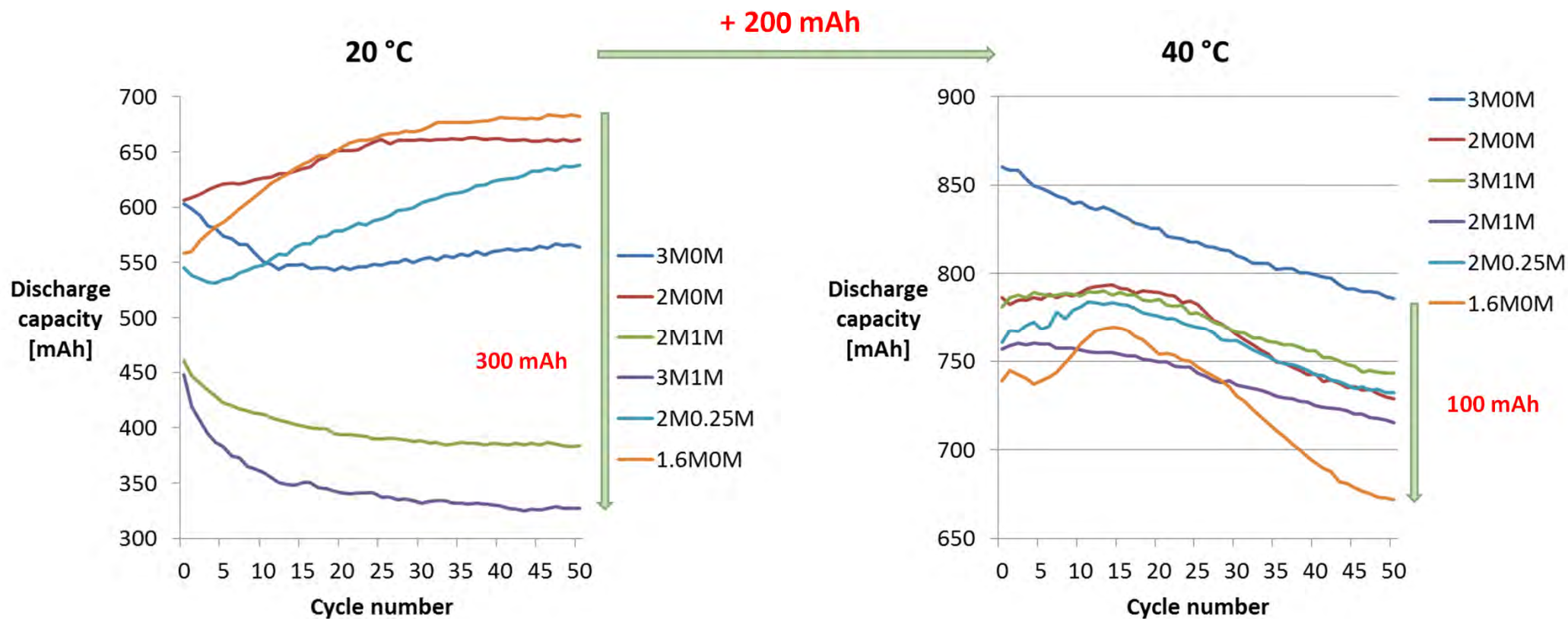


Voltage Efficiency



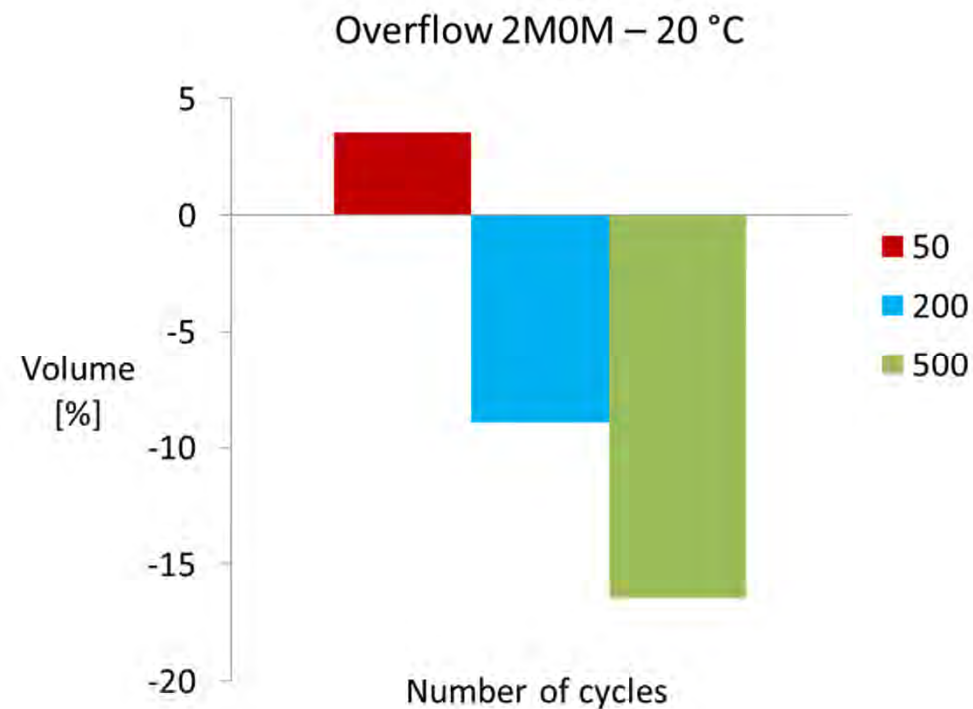
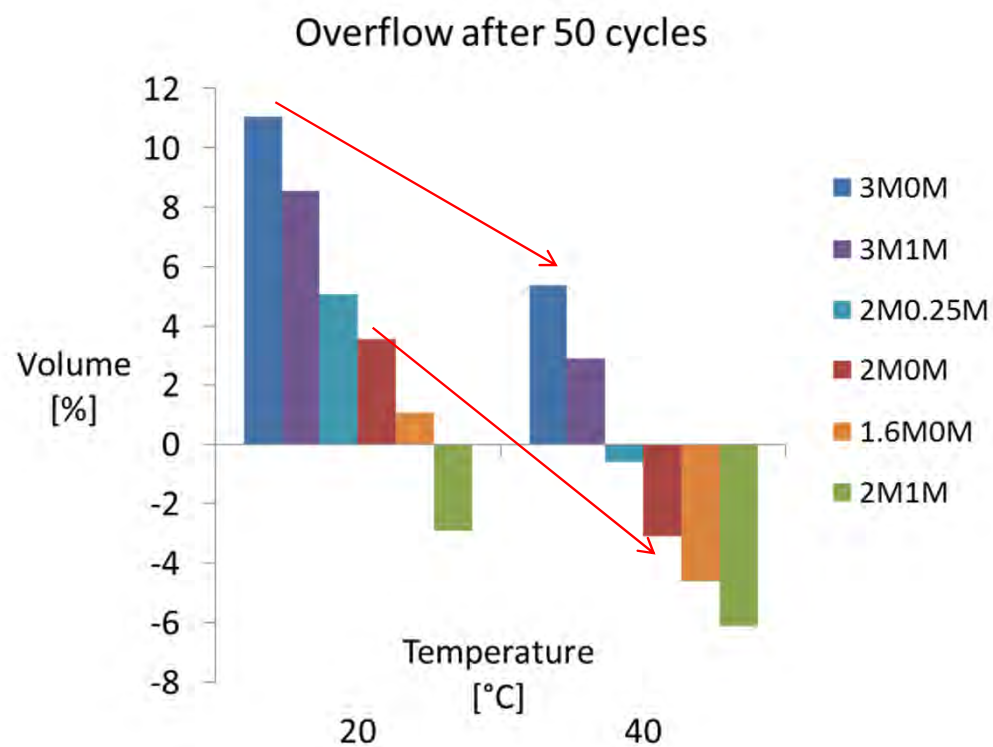
Note: 2M1M == 2 M NH₄Cl in (SPr)₂V, 1M NH₄Cl in Fe(CN)₆

Behavior during cycling – cell 4x5 cm²; 40 ml/min; 50 cycles



Note: 2M1M == 2 M NH₄Cl in (SPr)₂V, 1M NH₄Cl in Fe(CN)₆

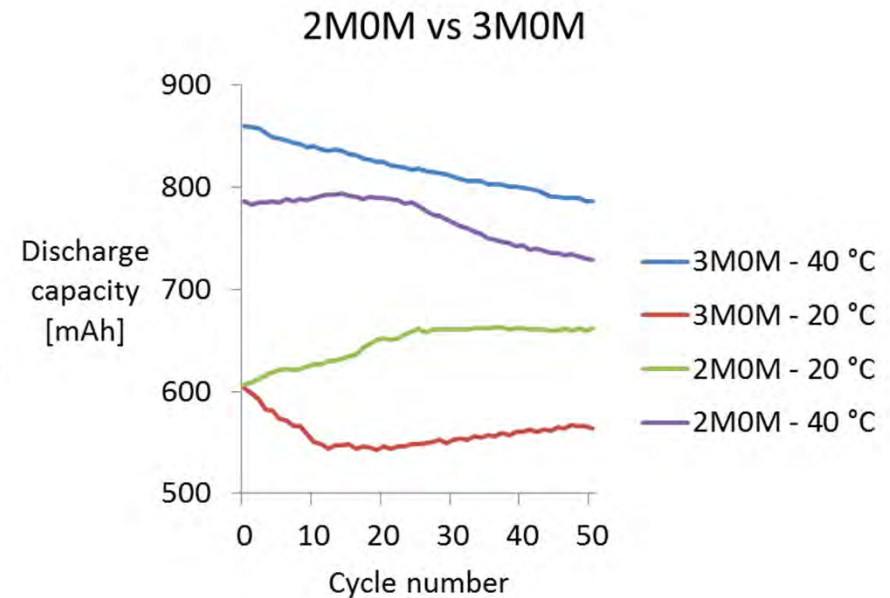
Overflow – cell 4x5 cm²; 40 ml/min



Note: 2M1M == 2 M NH₄Cl in (SPr)₂V, 1M NH₄Cl in Fe(CN)₆

Conclusion

- Flow rate
 - Optimal flow was found with respect to inner resistance
- Temperature
 - 40 °C
 - lesser initial capacity loss
 - higher voltage efficiency
 - lesser resistance of system
 - lesser dependence on concentration of supporting electrolyte
- Supporting electrolyte
 - 2MOM
 - smallest difference in behavior between 20 °C and 40 °C
 - 3MOM
 - the best performance during cycling in 40 °C



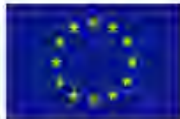


Thank you!



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