HIGREEW

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
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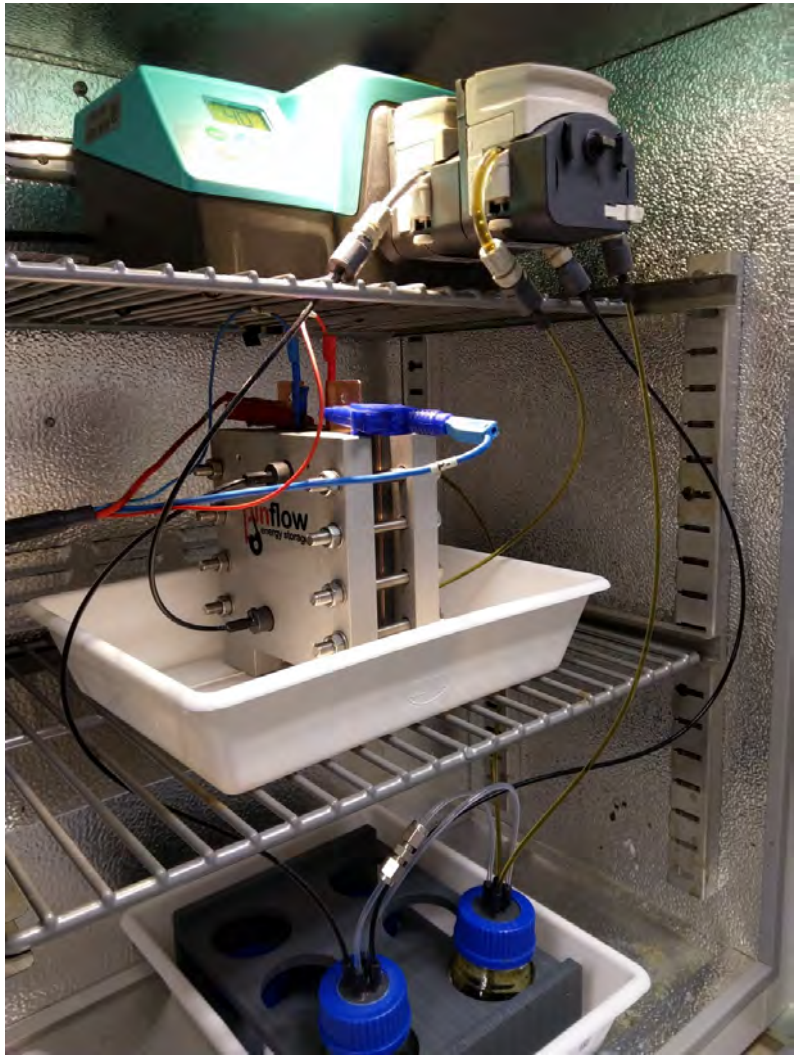
NEW TECHNOLOGIES
RESEARCH CENTRE
UNIVERSITY
OF WEST BOHEMIA

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 – NH_4Cl
- Lab cell
  - Pinflow design
- Atmosphere
  - Inert gas – N_2
- Pump
  - Watson – Marlow – Peristaltic



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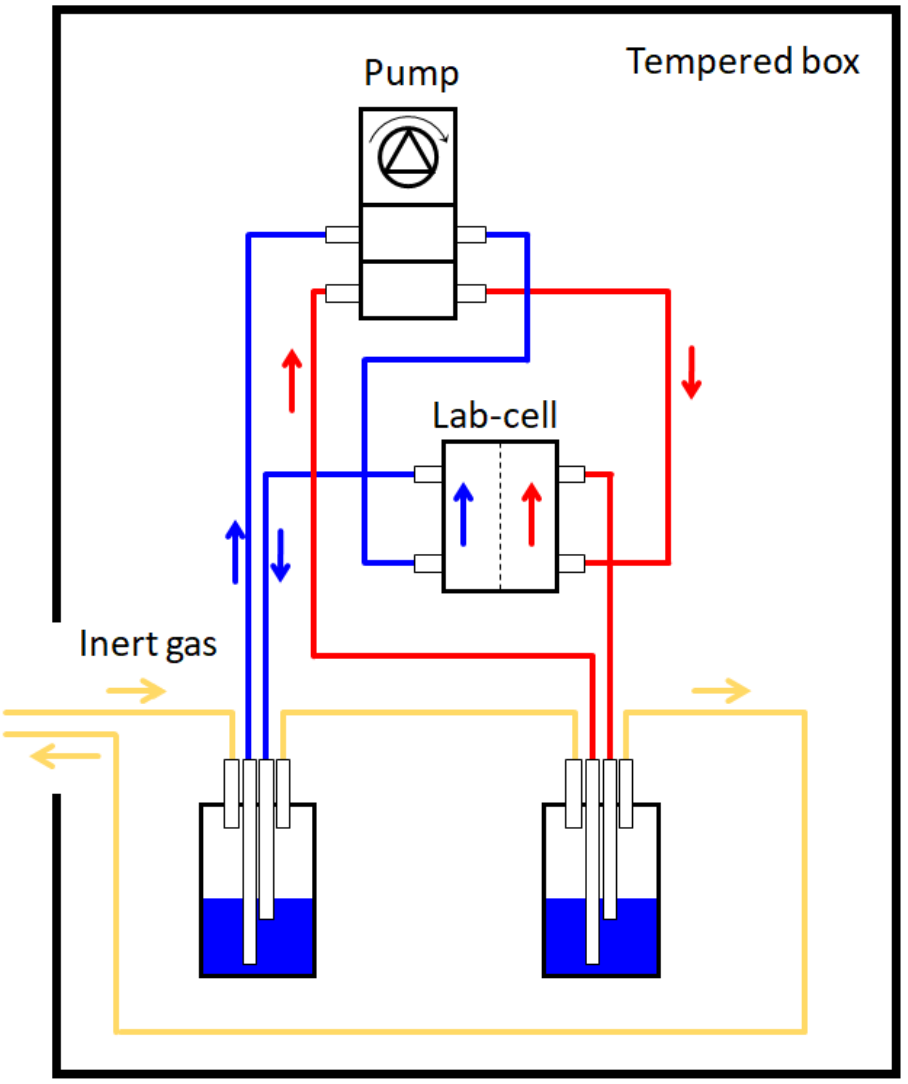
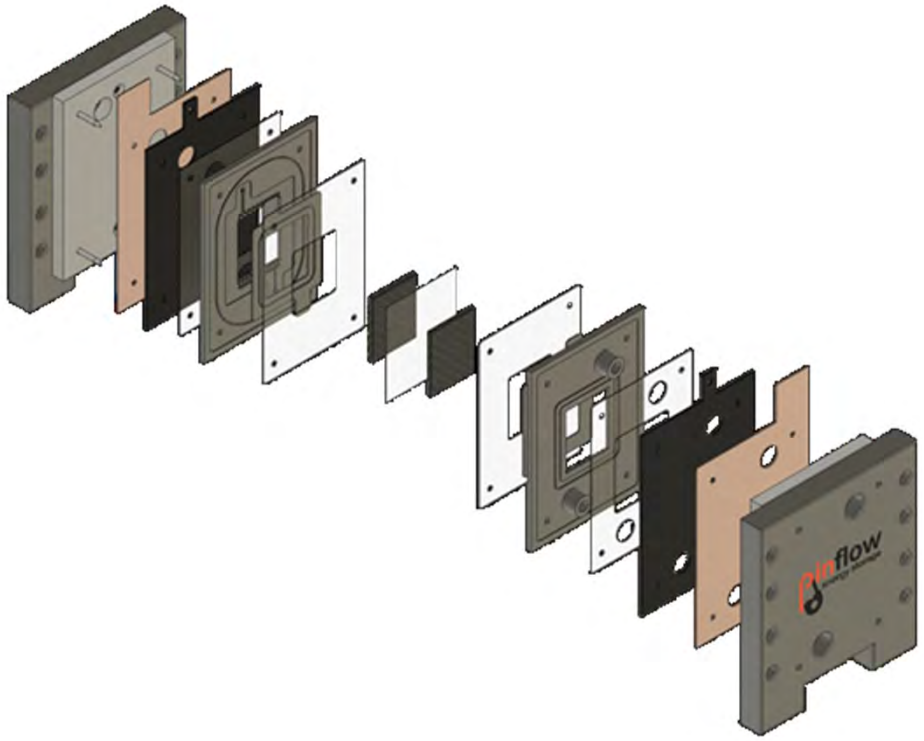


Pinflow lab cell

- Scaling cell
  - 2x2 cm^2 → 4x5 cm^2 → industry scale
- End plate →
  - cupper current collector →
    - carbon polymer composite →
      - seal → flow frame → felt →
        - seal → membrane …



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  - 0.9M $(SPr)_2V$ – 0.9M $Fe(CN)_6$
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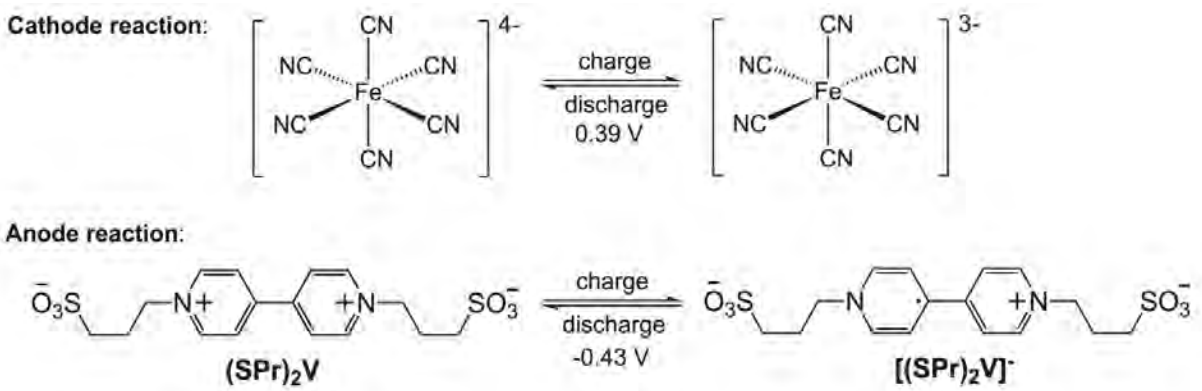
  - Membrane – Fumasep FS950
  - Felt – SGL GFD 4.6EA
  - Carbon-polymer composite – PPG86



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  - Supporting electrolyte – NH_4Cl
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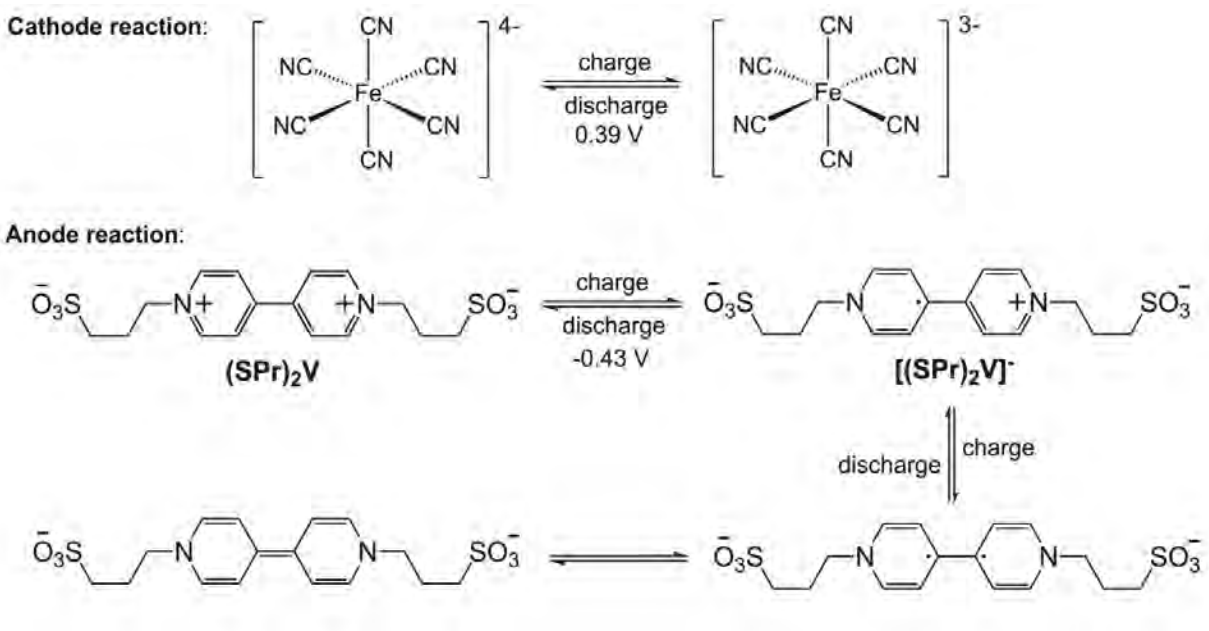
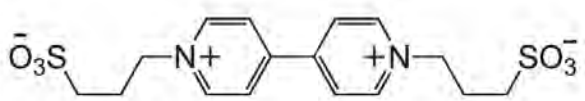
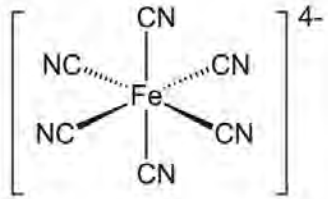
  - Carbon-polymer composite – PPG86
  - Maximum voltage – up to 1.2 V



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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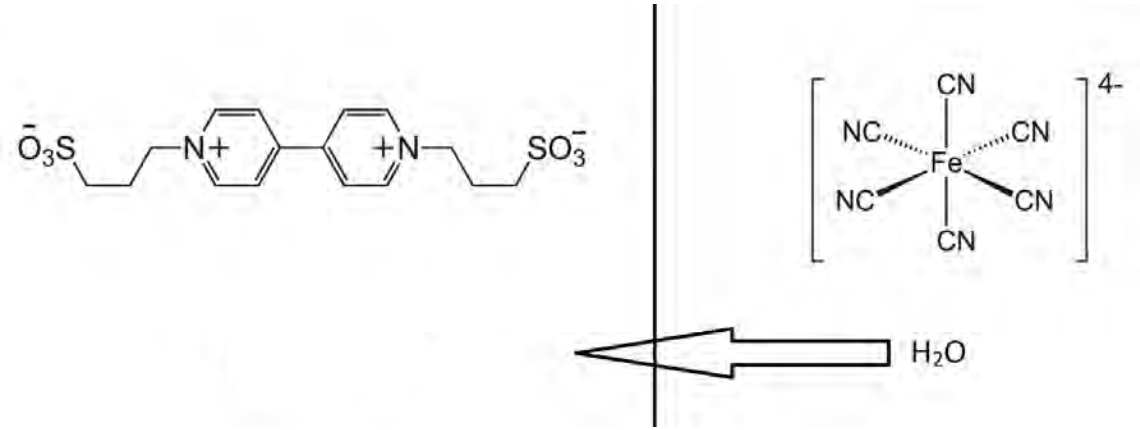

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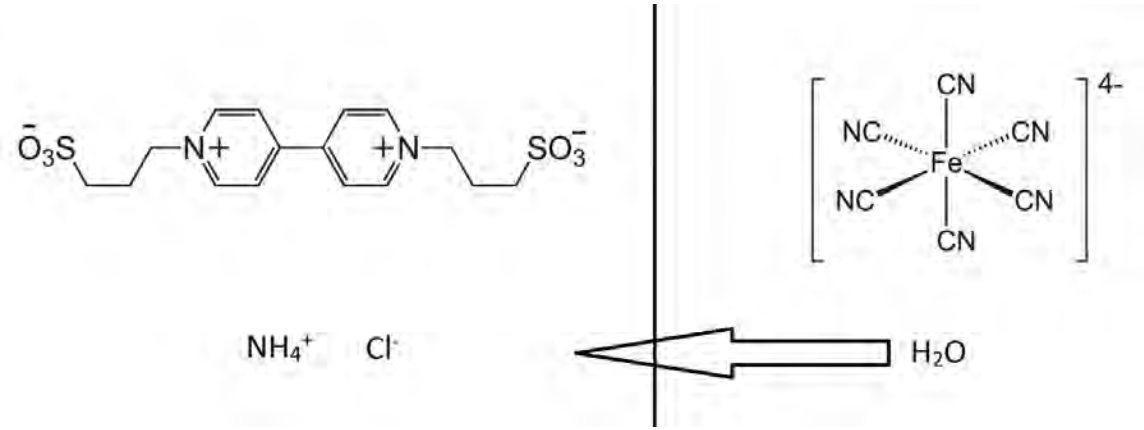
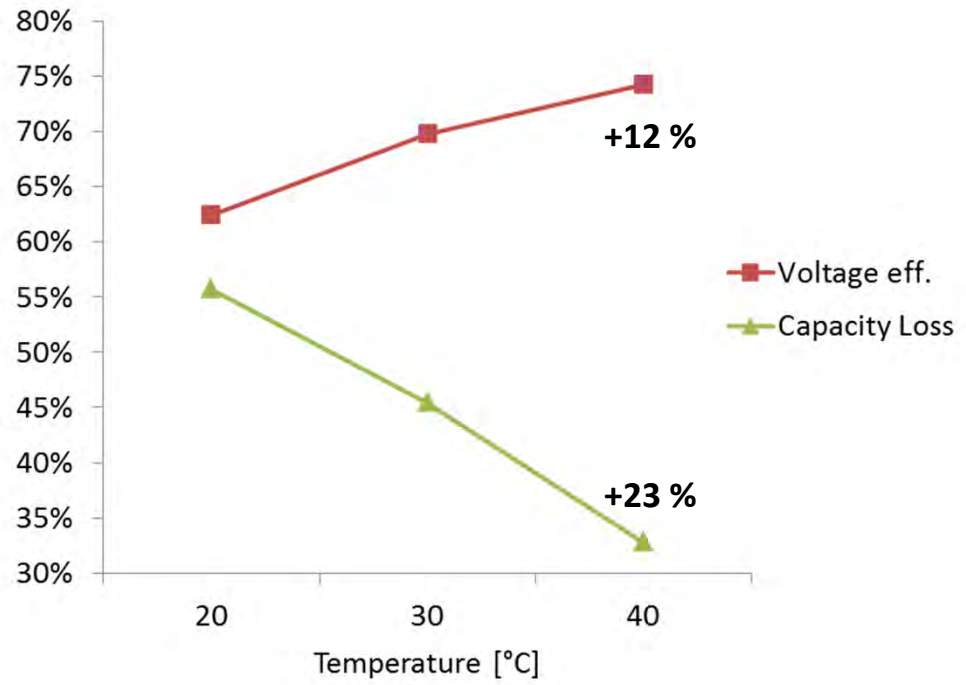


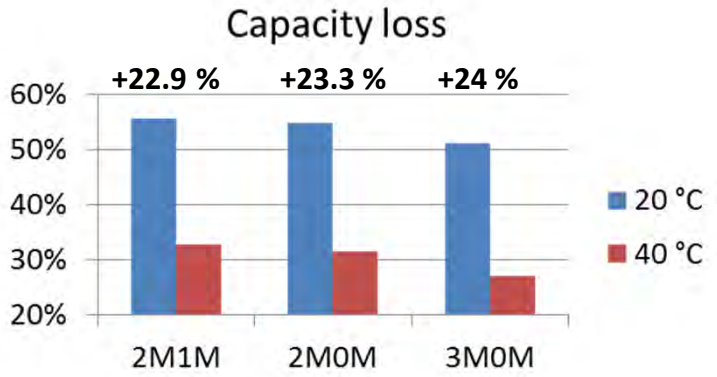
Temperature – cell 2x2 cm^2

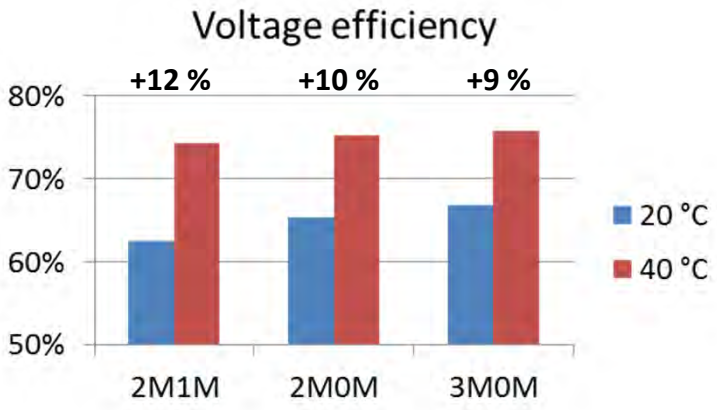
- Amount of supporting electrolyte
  - 2 M NH_4Cl in $(SPr)_2V$, 1M NH_4Cl in $Fe(CN)_6$
- Flow, Voltage
  - 20 ml/min; 0.6 – 1.15 V
- Tested temperature
  - 20, 30 and 40 °C
- Result
  - **20 and 40 °C** → cell 4x5 cm^2



Best performance – cell 2x2 cm^2

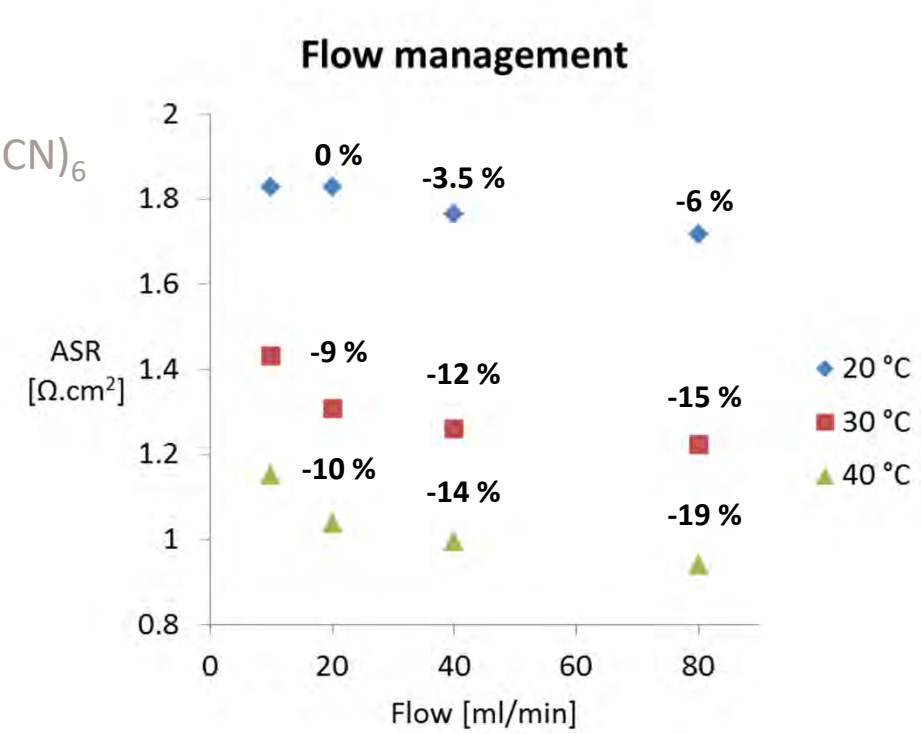
- Amount of supporting electrolyte
  - 2 M or 3M NH_4Cl in $(SPr)_2V$, 1M or 0M NH_4Cl in $Fe(CN)_6$
- Flow, Voltage
  - 20 ml/min; 0.6 – 1.15 V
- Tested temperature
  - 20 and 40 °C
- Result
  - **40 °C**
    - More than 20 % initial capacity from theoretical maximum
      - + 10 % Voltage efficiency
      - Ideal concentration of NH_4Cl – which one is the best ??



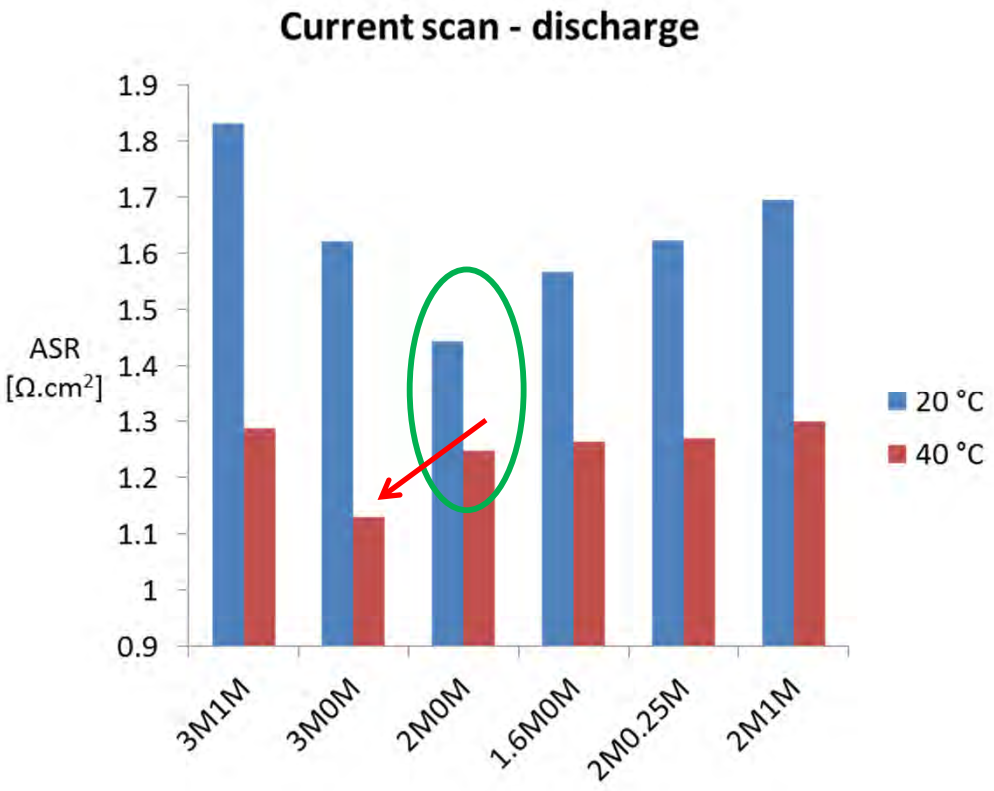


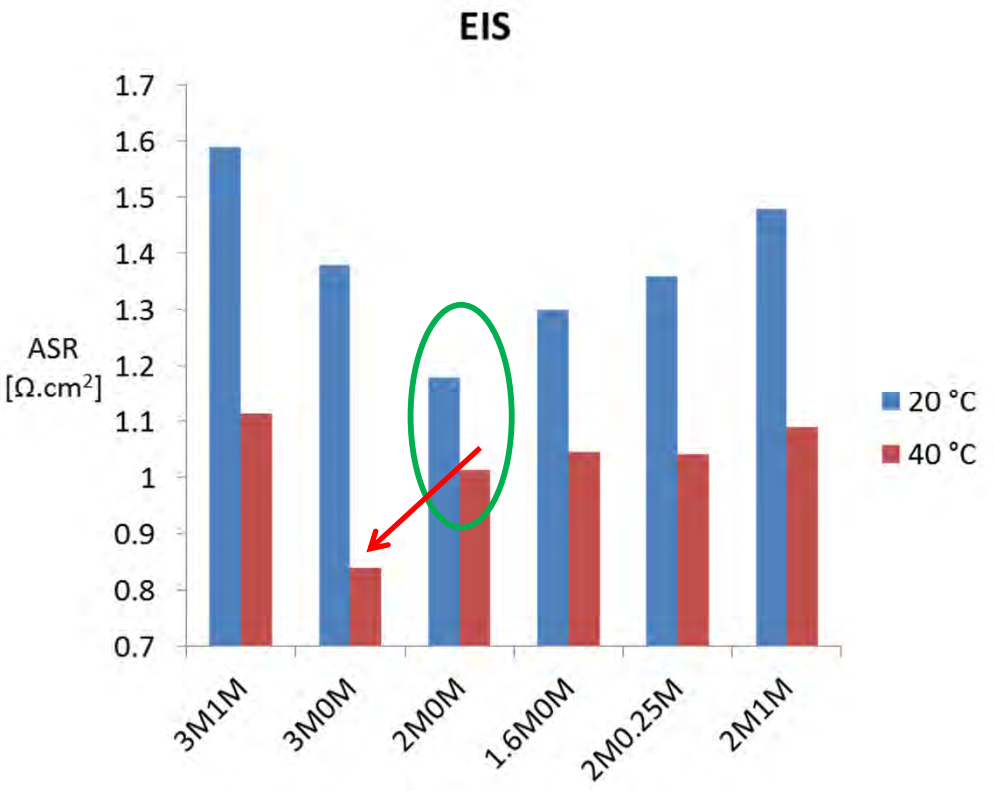
Flow management – cell 2x2 cm^2 – SoC 50 %

- Amount of supporting electrolyte
  - 2M1M == 2 M NH_4Cl in $(SPr)_2V$, 1M NH_4Cl 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 cm^2



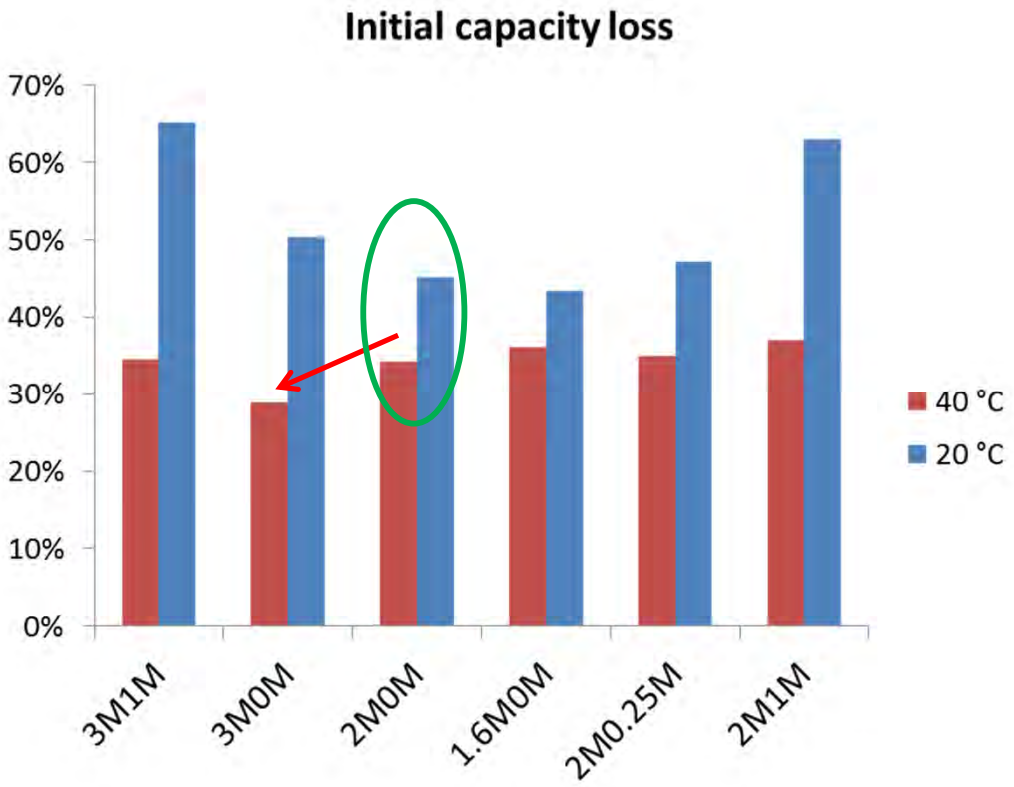
Impedance – cell 4x5 cm^2 – State of charge 50 %

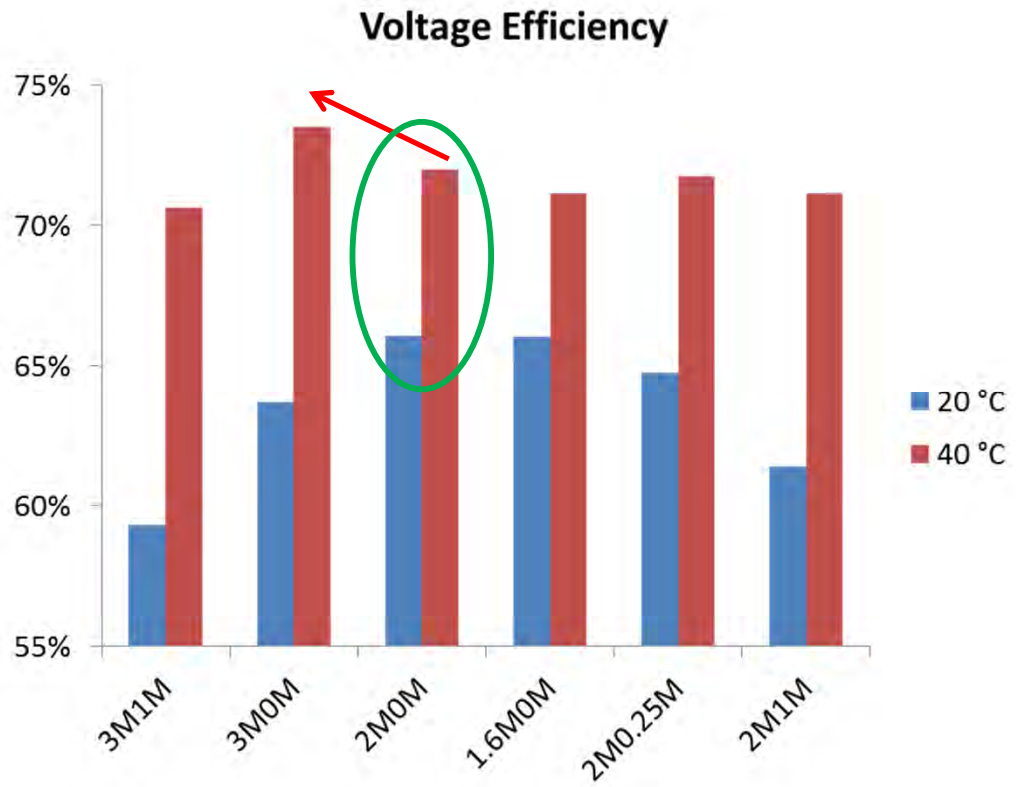




Note: 2M1M == 2 M NH_4Cl in $(SPr)_2V$, 1M NH_4Cl in $Fe(CN)_6$

Cycling performance – cell 4x5 cm^2; 40 ml/min; 50 cycles





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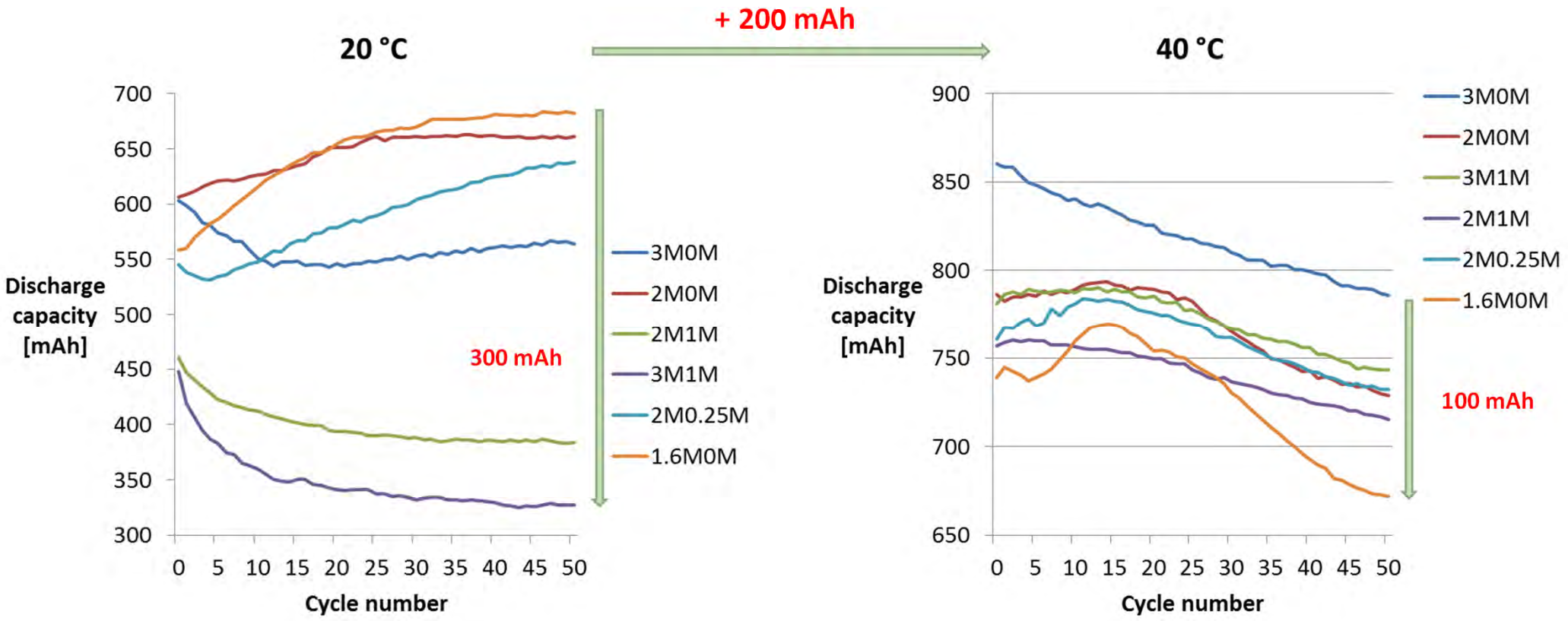
Behavior during cycling – cell 4x5 cm^2; 40 ml/min; 50 cycles



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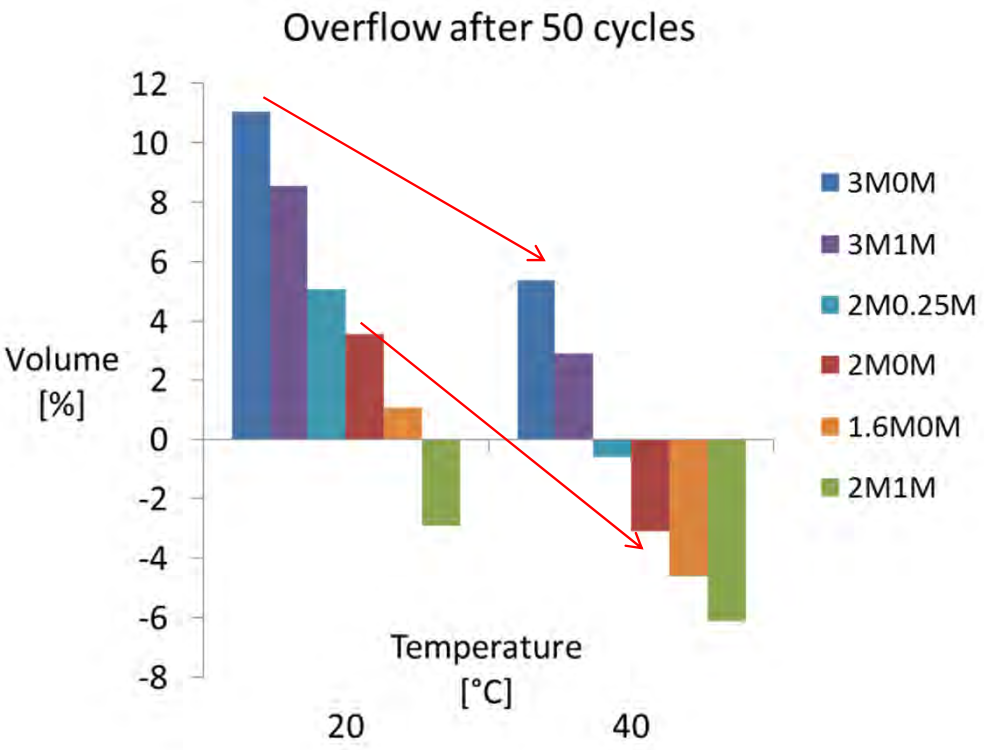
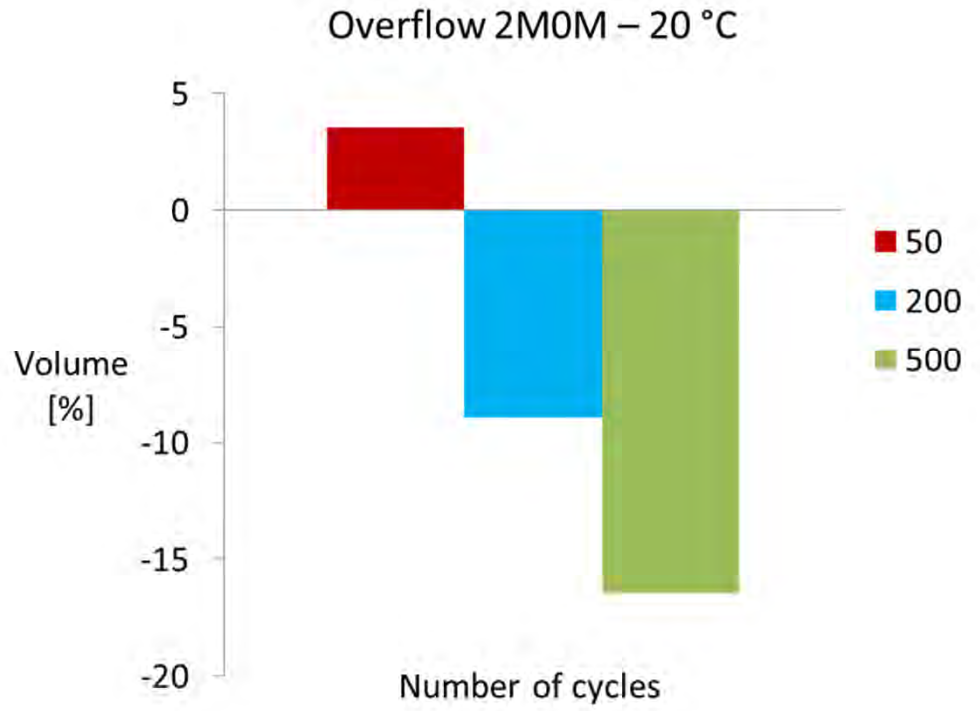
Overflow – cell 4x5 cm^2; 40 ml/min





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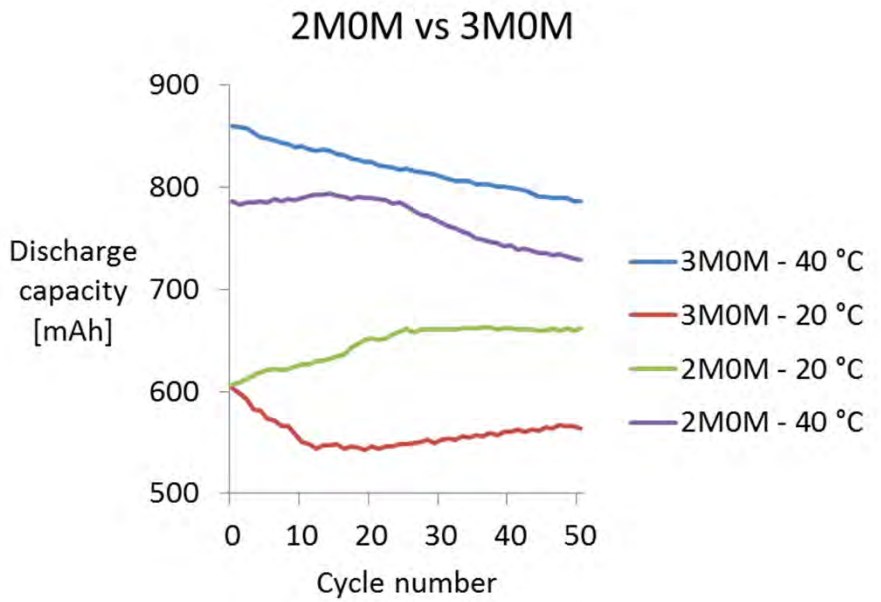
Conclusion

- 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
  - 2M0M
    - smallest difference in behavior between 20 °C and 40 °C
  - 3M0M
    - the best performance during cycling in 40 °C



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Thank you!

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