A Comprehensive Investigation on Reducing the Area Specific Resistance of Vanadium Redox Flow Batteries

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Introduction

A few works on proposing the best time and temperature for surface modification of the graphite felt using thermal treatments.

- ❑ Two different commercial graphite felts (AvCarb G150 vs. SGL GFD 4.65 EA).
- ❑ Reducing area specific resistance (ASR)
- ❑ Proposing best treatment procedure

Experimental

- ❑ Heat up graphite felts at various temperatures and times within the furnace in the presence of air: High ramp rate to the target temperature
- ❑ Cyclic Voltammetry:
  - Working electrode: graphite felts after the treatment
  - Three electrode system, CE: platinum wire, RE: Ag/AgCl
  - Solution: V^{3+}/V^{4+} concentration: 25 mM/ 25 mM, 2M sulfuric Acid
- ❑ Polarization Techniques:
  - Single cell VRFB: symmetric configuration
  - Bipolar plate: SGL BPP (0.7 mm in thick),
  - Membrane: FS-940 (Fumatech)
  - Electrolyte: V^{3+}/V^{4+} by Oxkem and gfe
  - Neware (BTS CT-4004, 20V, 50A) Battery Tester
  - Applying constant current for 30 seconds to find stable voltage and measuring voltage average for two time periods: 4 sec (excluding mass-transfer) and 20 sec (including mass-transfer)

Results and Discussion

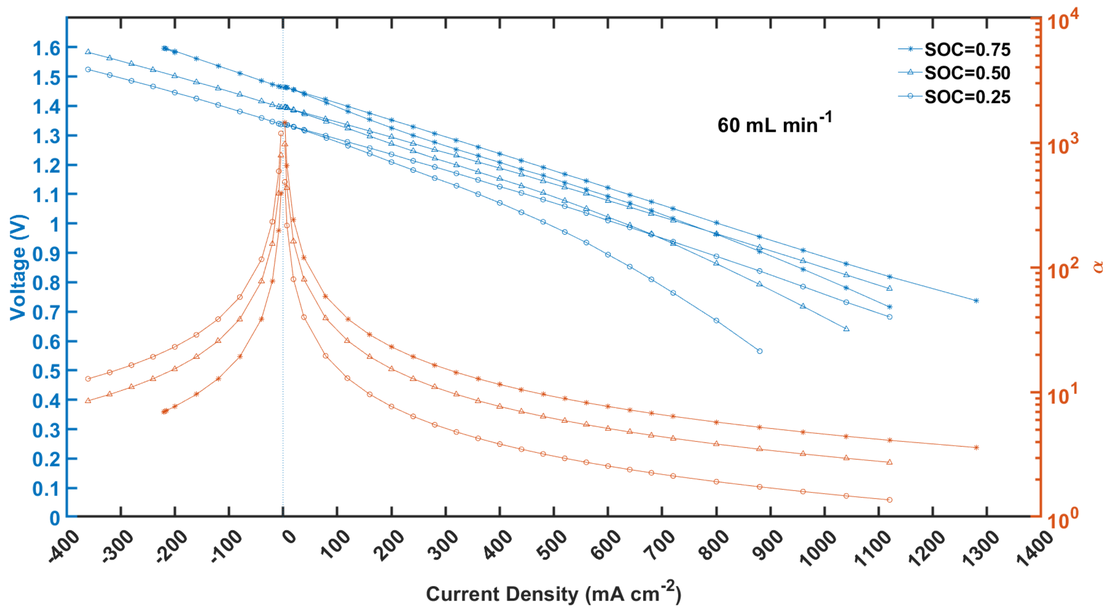
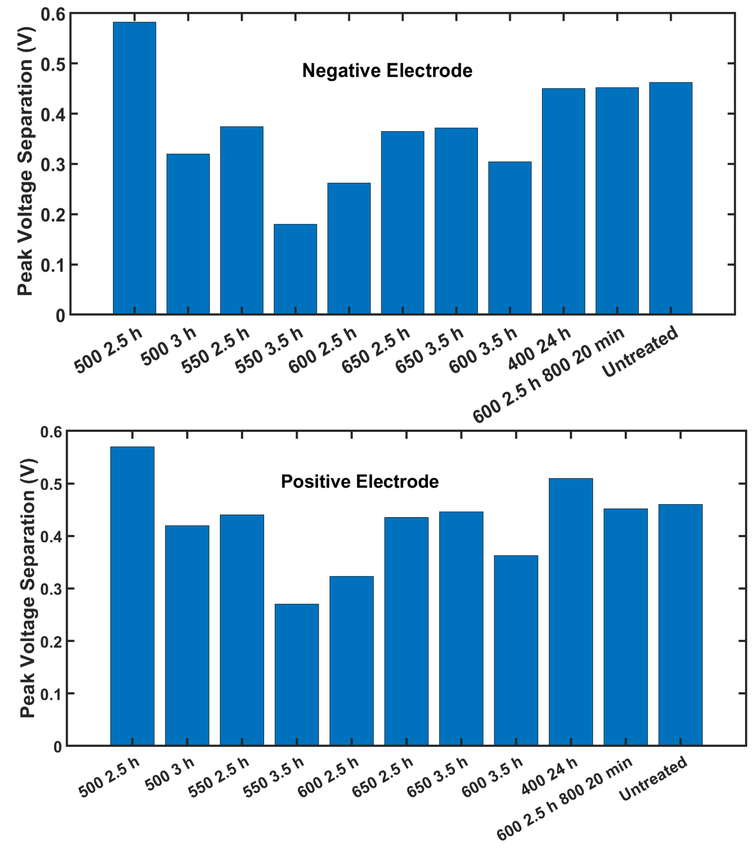


Figure 1. Typical polarization curves including/excluding mass-transfer effects in charge (− current) and discharge mode (+ current) at different SOCs for 20% electrode compression ratio and the flow rate of 60 mL min^{-1} for heat treatment at 550˚ C for 3.5 h

- ❑ SGL GFD 4.6EA shows facile kinetic compared to the AvCarb G150 .
- ❑ SGL GFD 4.6EA shows also lower ASR in all treatment cases compared to the AvCarb G150.



- Lower peak separation at 550˚ C for 3.5 h means improved electrode kinetics
- Improvement with thermal treatment for the negative electrode reaction is higher than the positive electrode reaction

Figure 2. Peak voltage separation of the VRFB negative and positive electrode reaction on the SGL GFD 4.6 EA

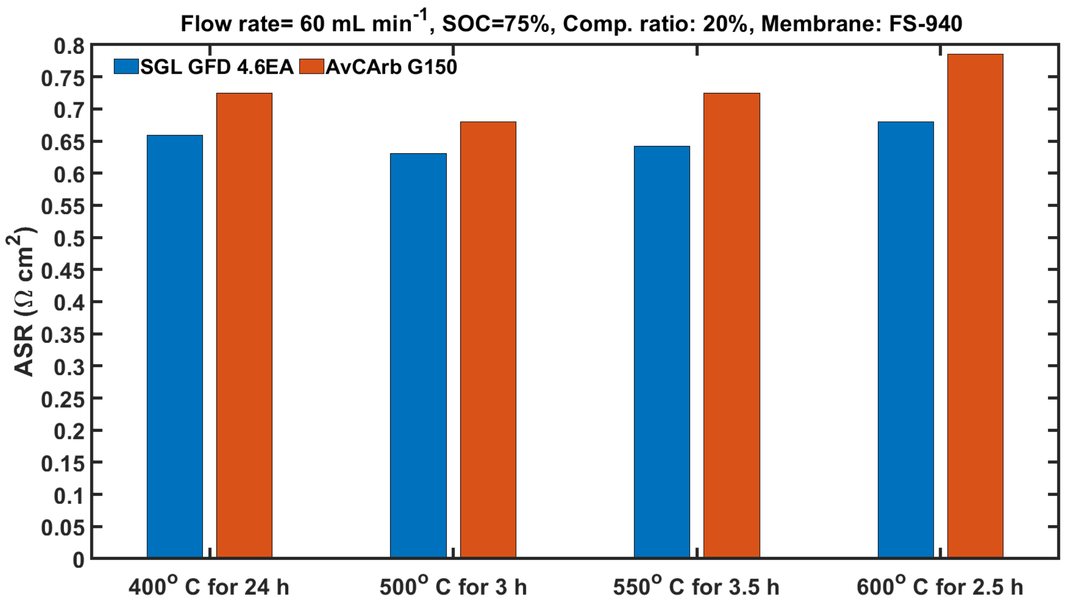


Figure3. Single cell ASR at different thermal treatment procedure for both SGL GFD 4.6 EA and AvCarb G150

- ❑ ASR is reduced significantly by conducting thermal treatment close to the optimized kinetics point.
- ❑ Single cell ASR for SGL GFD 4.6EA can be reduced to 0.63 Ω cm^2 using the thermal treatment at the temperature range of 500-550˚C for 3 to 3.5 h.
- ❑ Single cell ASR for AvCarb G150 at 500˚C for 3h was obtained around 0.68 Ω cm^2.
- ❑ Using the thermal treatment at lower temperature is suggested because although treating at 400˚C for 24h shows weak electrode kinetics compared to those of higher temperatures, the cell ASR is close to them due to the higher surface area and lower mass transfer resistance.

Conclusion

The thermal treatment method can be used as a simple way to improve the VRFB performance considerably. Moreover, optimizing the compression ratio of electrode and the flow rate are of importance to enhance the VRFB performance.

Acknowledgement

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References

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