A submillimetre bundled microtubular flow battery cell with ultrahigh volumetric power density

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Introduction

- Cell stack significant part of the capital cost of flow batteries.
- Bipolar plates, felt electrodes, frame and other contributing almost 31%.

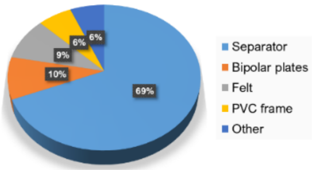


Figure 1.Cell stack capital cost components. [1]

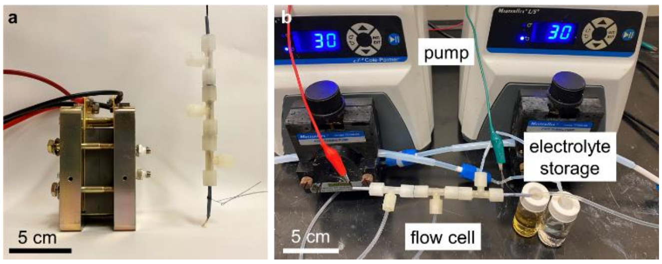
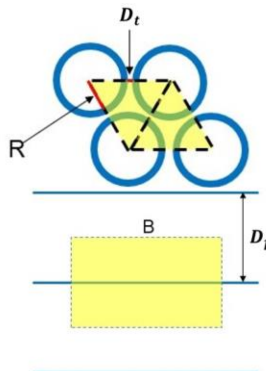


Figure 2. (a) The submillimetre bundled microtubular cell module and a conventional lab-scale planar flow battery module. (b) Experimental setup of the microtubular flow battery.[2]

Approach

The multi-tubular configuration can achieve higher membrane surface area per unit volume.



$$Multitubular = \frac{Surface\ area}{Volume\ x\ Length} = \frac{1}{D} \times \frac{2\pi}{\frac{4R}{D} + 4 + \frac{D}{R}} = \frac{f}{D_t}$$

$$Planar = \frac{Surface\ area}{Volume\ x\ Length} = \frac{1}{D_p}$$

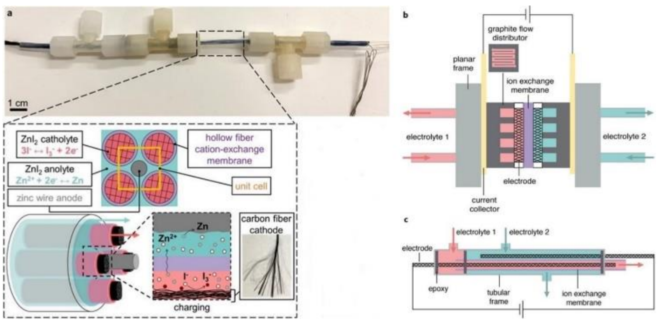


Figure 3. (a) On the top is a picture of a zinc-iodide microtubular module with four positive electrodes and one negative electrode; on the bottom is an illustration of its unit cell, detailed structure, and the electrochemical reactions during charging. (b) Conventional planar cell design. (c) Microtubular cell design.

Comparison with the planar cell

The maximum charge and discharge power volumetric power density (W/L$_{cell}$) of a ZnI_2 was measured and compared to the previous literature for planar and tubular cells.

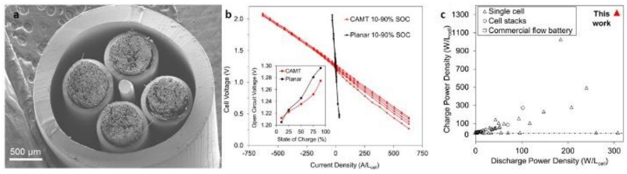


Figure 4.(a) A cross-sectional SEM image of a microtubular flow battery cell with four carbon-fiber-filled Nafion microtubes surrounding a zinc wire. (b) Experimental microtubular cell voltage vs. volumetric current density at five different SOCs. The inset shows the open circuit voltages at different states of charge. (c) Comparison of maximum charge power density vs. maximum discharge power density found in the literature.[2]

Other redox couples

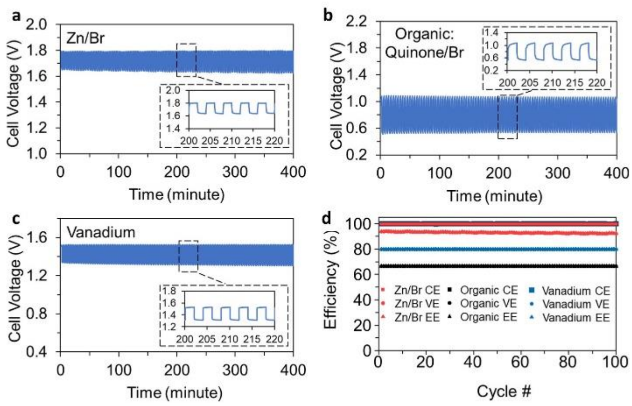


Figure 5. (a) Cycling of the $ZnBr_2$ redox couple. (b) Cycling of the vanadium redox couple. (c) Cycling of organic quinone electrolyte vs. Br_2 . (d) The Coulombic efficiency, voltage efficiency and energy efficiency of the batteries in a-c.[2]

Conclusions

- A co-axial microtubular flow battery cell with sub-millimeter tubular membranes was designed.
- The hypothesis that the co-axial microtubular cell increases the volumetric power density compared to the planar cell is confirmed.

Acknowledgements

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References

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