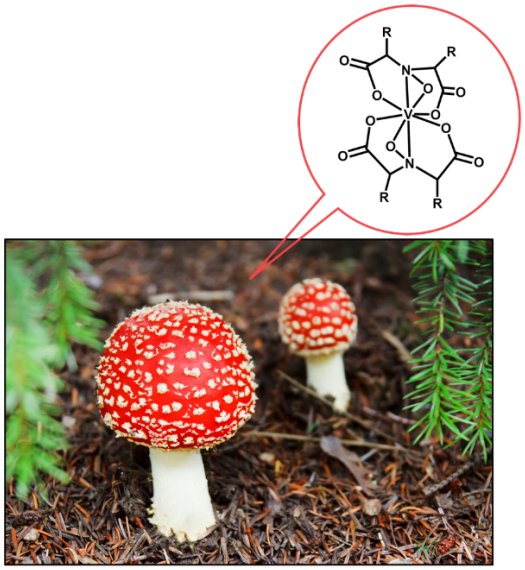
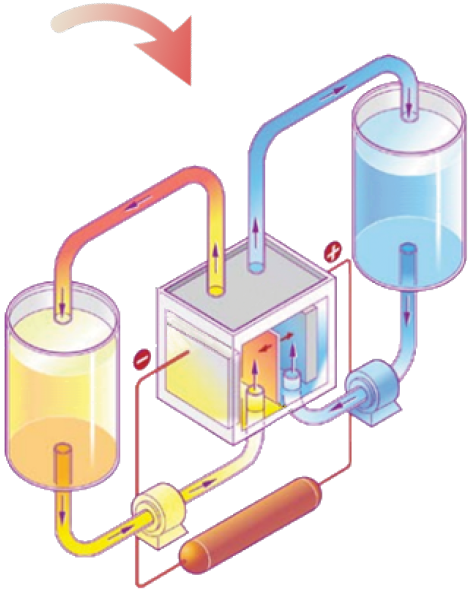
High-Stability Bio-Derived Redox Flow Batteries for Grid-Scale Energy Storage





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Energy Innovation Forum
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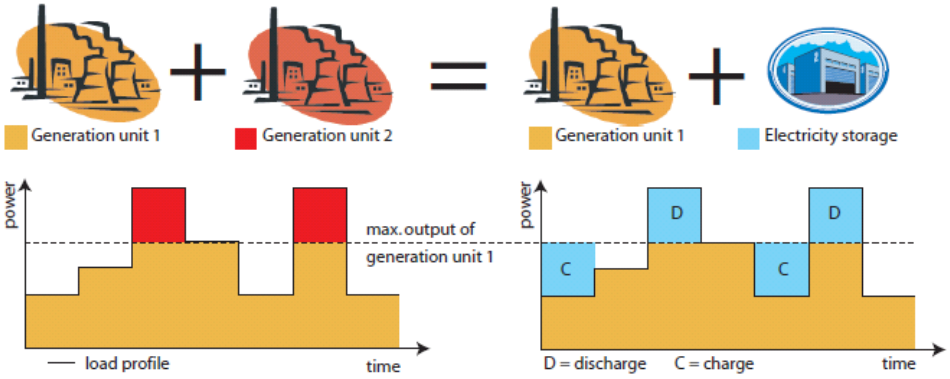
The Need: Grid-Scale Energy Storage

Clean Energy Integration

An average **1.5 MW** turbine = **300 homes**

Peak Shaving / Load-Leveling



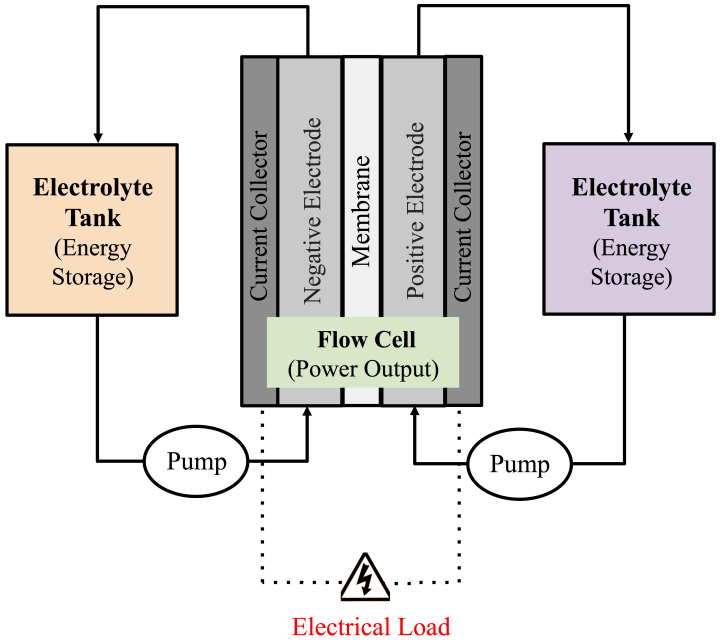
Christian Blanc, Ph.D. Thesis, EPFL, 2009

Avoid premium charges: purchasing electricity at off-peak prices for use during peaks

Grid-scale battery storage market is projected to reach ***~ $4.0 billion in 2025 with 18.7% growth rate between 2015-2025***

Grid-scale electricity storage technologies: Global markets, BCC Research, Jan. 2016.

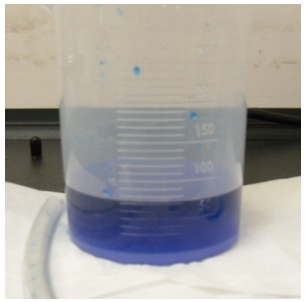
The Solution: Redox Flow Batteries



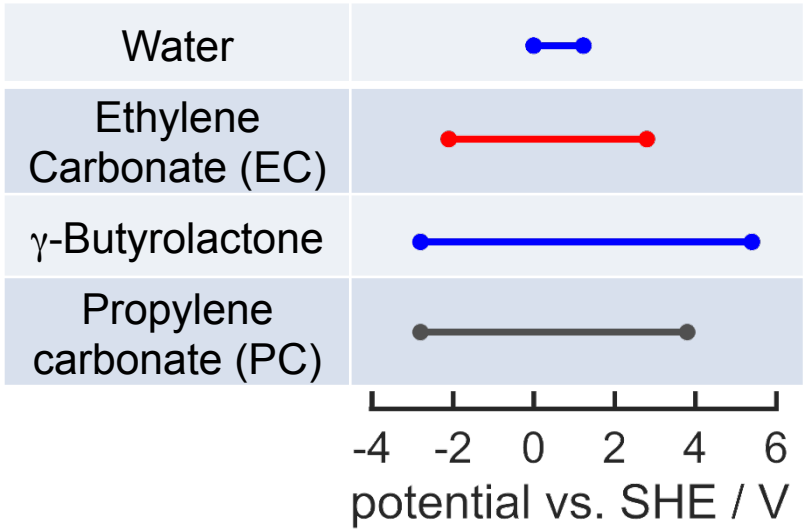
Advantages:

- Decoupled power output and energy storage - scalability
- Flexibility, modular design
- Ease of Manufacturing
- Long lifetimes

Cost is a major challenge (**DOE Target < $150 /kWh**)



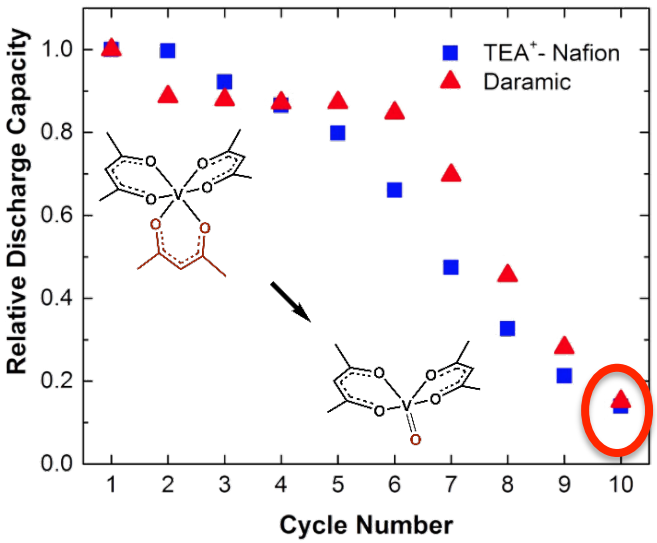
The Problem: Electrolyte Instability Issue



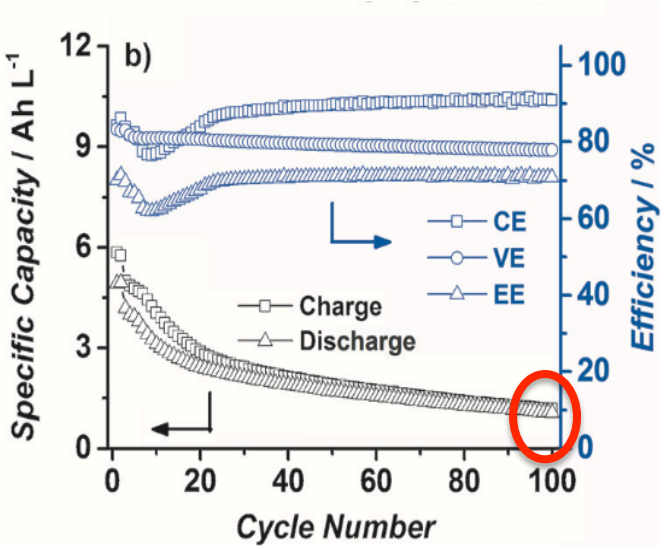
Non-aqueous solvents

=

Larger potential window



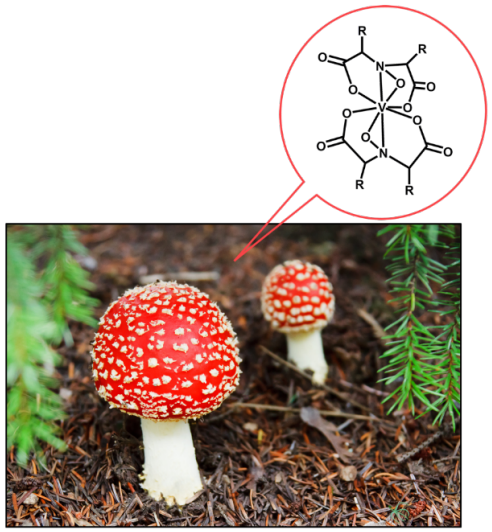
Escalante-Garcia *et al.*,. *J. Electrochem. Soc.* **2015**, 162 (3), A363-A372.

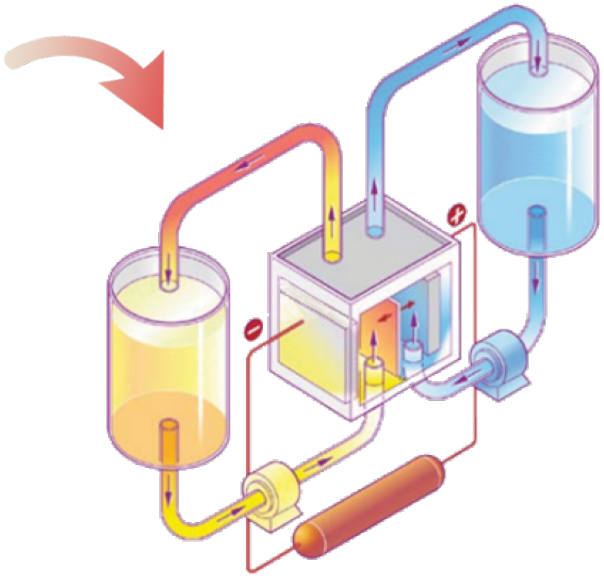


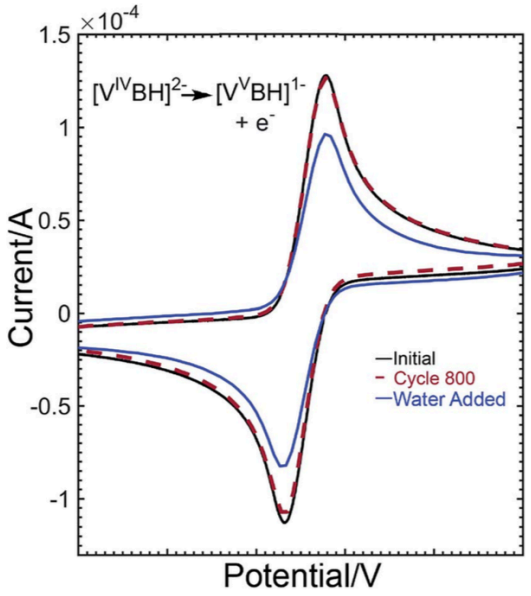
Xioliang Wei *et al.*, *Angew. Chem. Int. Ed.* **2015**, 54, 8684-8687.

Stability is paramount… and difficult to predict

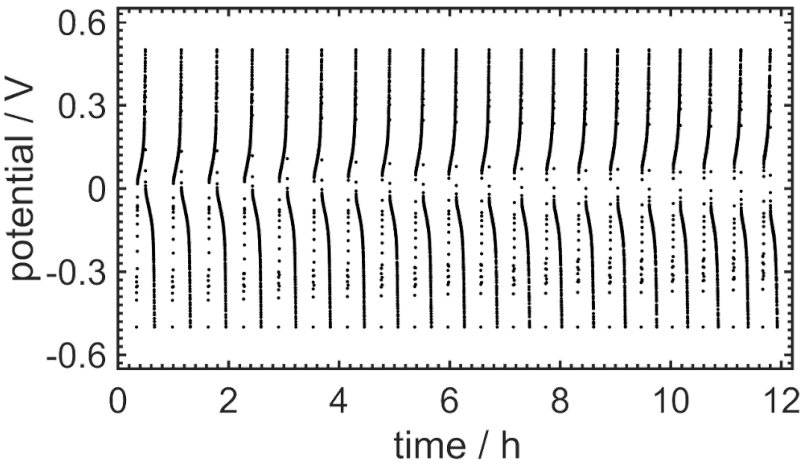
Amavadin: Our Bio-Inspired Approach







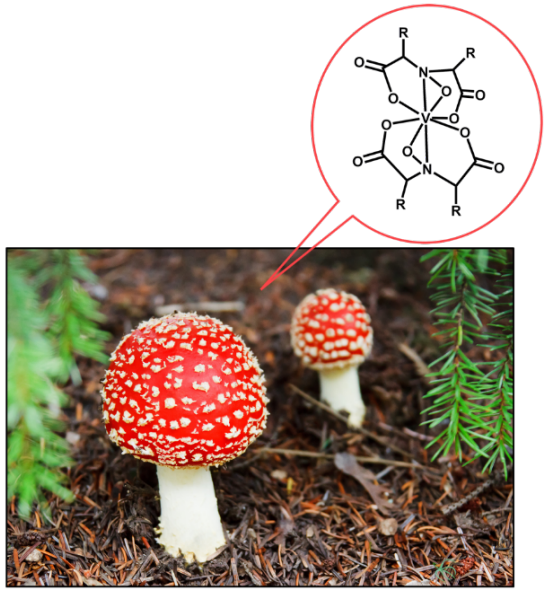
Charge/Discharge Cycling:



- No change in the shape of the voltammogram after 800 cycles
- No change even with the addition of 20% water in the presence of O_2
- Virtually unchanged after 40 cycles

Agar, Cappillino, et al., *Journal of Materials Chemistry A*, **2017,** 5, 11586-11591
"Flow Battery and Components Thereof" U.S. Provisional Pat. Application, March 7, 2017

Summary, Next Steps and Needs



Advantages of the proposed technology

- High stability NRFB active materials
- High current density/Low capacity fade
- Robust in presence of air and water

1) Stability ☑

2) Improved Solubility: *Approaching 1M in various solvents, including DMSO, GBL, and water*

Looking for funding and partnership

3) Improved Cell Voltage: Fluorine-substituted CVBH analog (VBF4H)

4) Cell Optimization: 250 cycles with < 3% capacity fade at 150 mA cm^{-2}

MASSACHUSETTS CLEAN ENERGY CENTER

OTC&V Office of Technology Commercialization and Ventures