Electrochemical Energy Storage System

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High Voltage Multiple Electrolyte Electrochemical Power Sources

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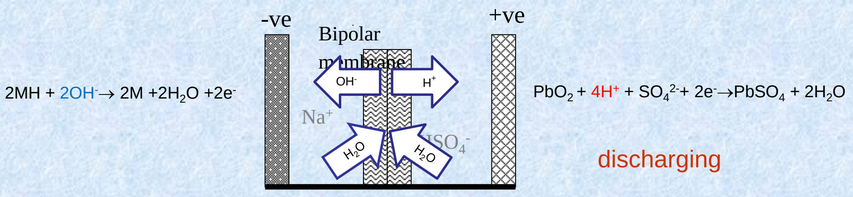
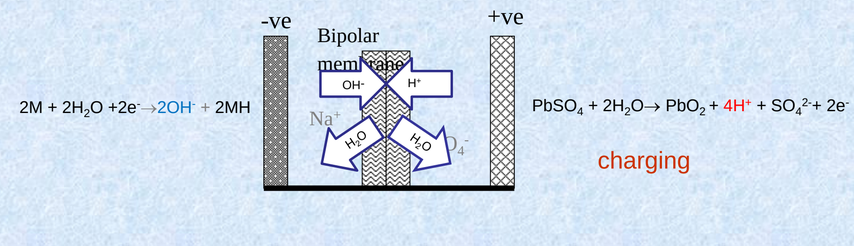
Introduction

- Cheap and efficient energy storage is essential for both power grid interfacing and the automotive industry.
- The operating voltage of aqueous power sources have been limited by the electrochemical windows of water, theoretically 1.23 V at a fixed pH solution.
- High voltage multiple electrolytes battery consists of a lead acid positive electrode and a nickel metal hydride negative electrode, which is operated in separated acid and alkaline electrolyte via a bipolar membrane or two ion membranes, is shown to have higher voltage and higher capacity than the individual lead acid or nickel metal hydride cell.

Thermodynamics

MH (Alkaline) – PbO_2PbSO_4 (Acid) Battery

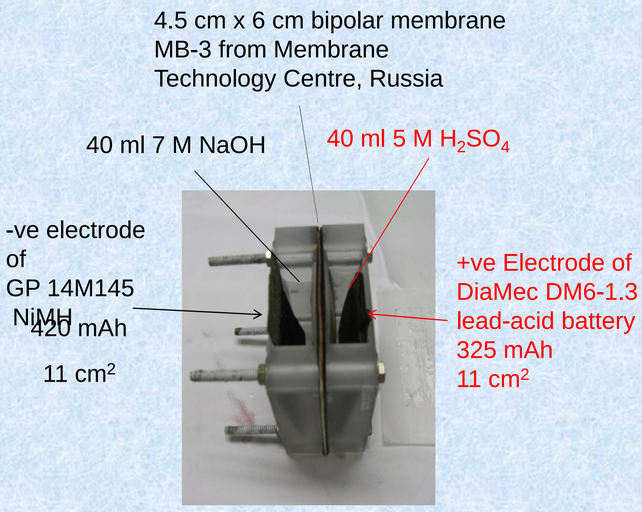




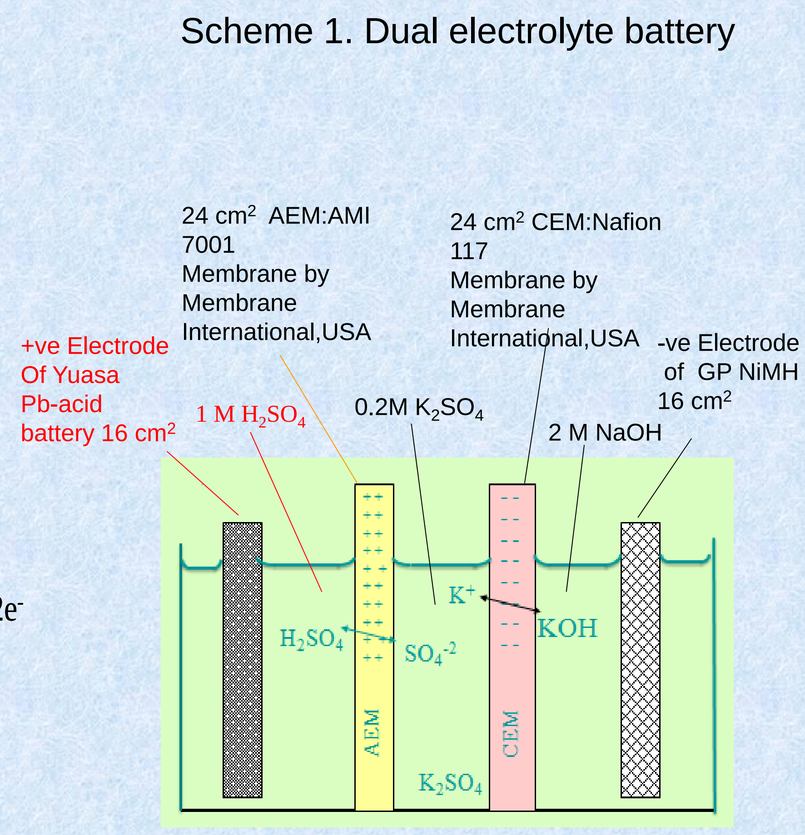
$$PbO_2 + HSO_4^- + 2MH + 2OH^- + 3H^+ + 2e^- \underset{\text{Charge}}{\overset{\text{Discharge}}{\rightleftharpoons}} PbSO_4 + 2M + 4H_2O + 2e^-$$

Experimental and Results

The electrochemical tests were performed by Autolab at room temperature.
(Charge and discharge at 100 mA)



Scheme 1. Dual electrolyte battery



Scheme 2. Three electrolyte battery

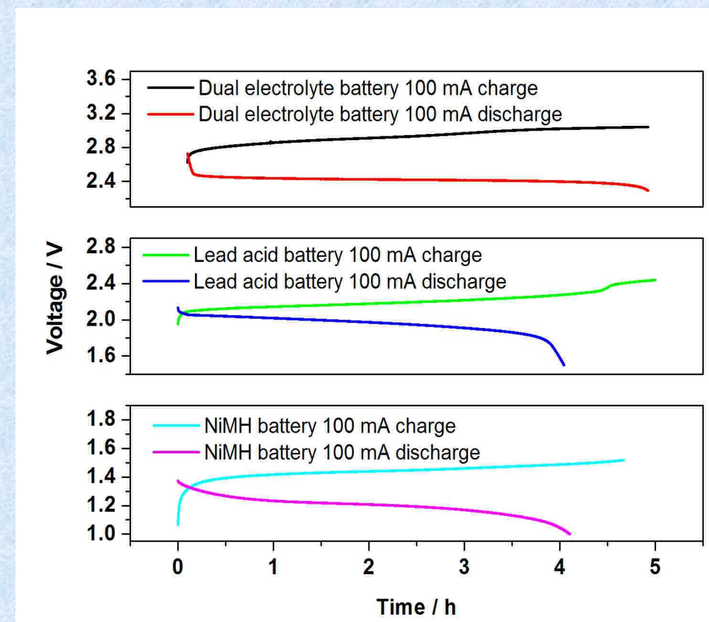


Fig 1. Comparison of Dual electrolyte battery, Lead acid & NiMH batteries

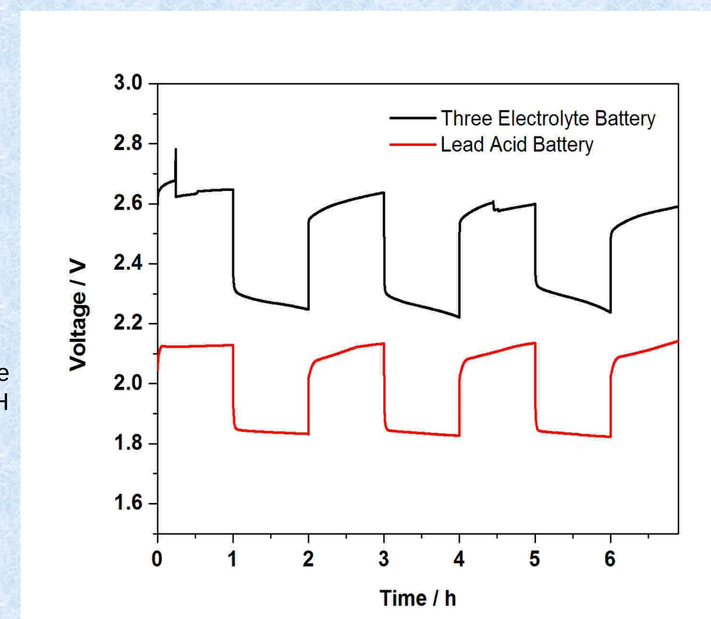


Fig 2. Cell performances of three electrolyte battery & lead acid battery

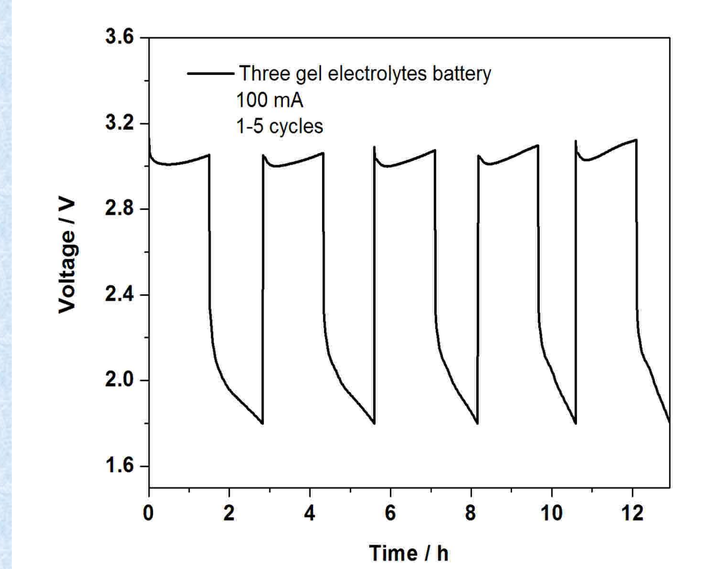


Fig 3. Cell performances of three gelled electrolyte battery

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- Initiative for Clean Energy & Environment (ICEE)
- Zentric Inc.

Conclusions

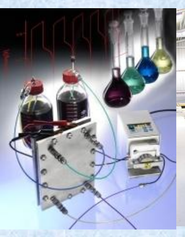
- The MH(alkaline)/PbO2 (acid) rechargeable cell has OCV 2.65 V, stable operation at 2.4 V and repeated charging-discharging cycles.
- On-going investigation on the use of gel electrolytes for hybrid battery.

References

[1] S.A. Cheng and K.Y. Chan, US Patent 7344801 B2 issued March 2008, prior publication US 2004/0121227 A1, June 2004.

[2] SA Cheng and KY Chan*, "High Voltage Dual Electrolyte Electrochemical Power source", *ECS Trans*. Jan 2010.

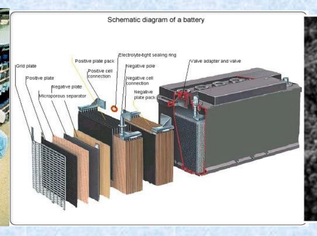
Technology Comparison	Density				Cycle life to 80% DOD	Self discharge %/month	Maturity	Cost			Range +/- 50%	Unique features
	Energy		Power					Current	Future	Environmental impact		
	Wh/kg	Wh/L	W/kg	W/L				$/kWh	$/kWh		km	
Flooded lead acid (EnerSys)	36	90	194	538	400	20	Mature	100	100	Low with recycling	96	Modest performance
Advanced lead acid	35	71	412	955	500	5	In production	150	100	Low with recycling	160	High performance
Nickel Metal Hydride	80	200	220	600	600+	15-20	In production	1000	200	Low	320	High capacity
HVDE (Lead+NiMH)	96	70	Uncertain at the moment (dependent on the current density of membrane or alternative ionic interfaces)		Similar to Ni MH or Pb acid at low current discharge		Laboratory	In between NiMH and Pb acid	In between NiMH and Pb acid	Low with recycling		Significantly higher voltage per cell
Lithium Ion	100	300	1300	920-1400	920	10	Laboratory	1000	500-1000	Low	500	High power density



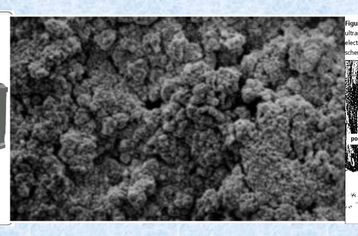
Lab.Vanadium Redox and full Scale electrolyte tanks

Sodium Sulphur Battery Stacks

Lead Acid Battery Stacks



Lead Acid Cut Away



SEM Sulphation