BATTERY 2030+

Contributing to
The European Batteries
R&I Community

New Chemistries

The B2030+ roadmap workshop

M. Casas Cabanas, CIC energiGUNE

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BATTERY 2030+

Setting the scene

Emerging chemistries in energy storage promise disruptive benefits (i.e. safety, sustainability, circularity, cycle lifetime, performance, and reduced costs), and can potentially unlock new applications.

Extensive R&D is needed to overcome fundamental challenges and demonstrate their feasibility (TRL<4)

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New chemistries → Gen5

TABLE 1: BATTERY GENERATIONS CATEGORISATION

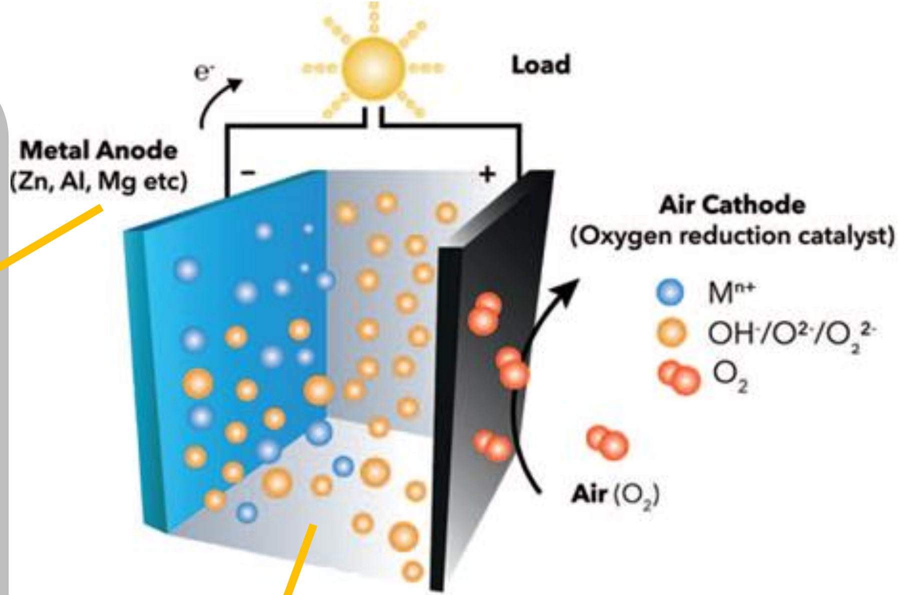
Battery Generation	Electrodes active materials	Cell Chemistry / Type	Forecast market deployment
Gen 1	• Cathode: LFP, NCA • Anode: 100% carbon	Li-ion Cell	current
Gen 2a	• Cathode: NMC111 • Anode: 100% carbon	Li-ion Cell	current
Gen 2b	• Cathode: NMC523 to NMC 622 • Anode: 100% carbon	Li-ion Cell	current
Gen 3a	• Cathode: NMC622 to NMC 811 • Anode: carbon (graphite) + silicon content (5-10%)	Optimised Li-ion	2020
Gen 3b	• Cathode: HE-NMC, HVS (high-voltage spinel) • Anode: silicon/carbon	Optimised Li-ion	2025
Gen 4a	• Cathode NMC • Anode Si/C • Solid electrolyte	Solid state Li-ion	2025
Gen 4b	• Cathode NMC • Anode: lithium metal • Solid electrolyte	Solid state Li metal	>2025
Gen 4c	• Cathode: HE-NMC, HVS (high-voltage spinel) • Anode: lithium metal • Solid electrolyte	Advanced solid state	2030
Gen 5	• Li|O_2 – lithium air / metal air • Conversion materials (primarily Li|S) • new ion-based systems (Na, Mg or Al)	New cell gen: metal-air/ conversion chemistries / new ion-based insertion chemistries	>2030

Gen 5 chemistries: M-air

dissolution
shape changes
dendrite growth

passivation
MO deposition

corrosion
Hydrogen evolution
Shelf-life



Vulnerability to CO_2
Hydrogen evolution (HER)
Evaporation and leakage problems
Cycling stability

Sluggish oxygen reactions
ORR & OER

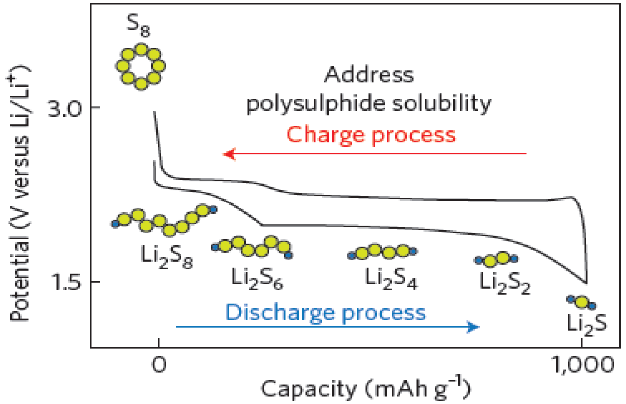
Carbon corrosion
during OER

Electrolyte/Cathode interphase
Wettability, porosity, conductivity

Gen 5 chemistries: M-S

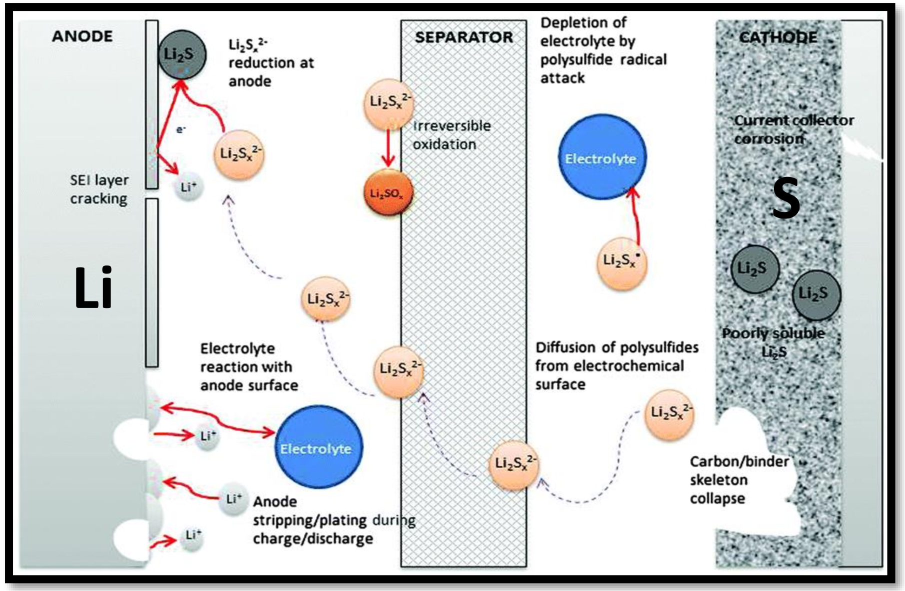
Chung, W.J. , et al. (2013), *Nat. Chem.*, **5** (6), 518–524.

Open-air sulfur storage in oil-refineries



ANODE

- *Li dentrite formation*
- *Li_2S block Li anode*
- *Short curcuit*
- *Short cycle life*



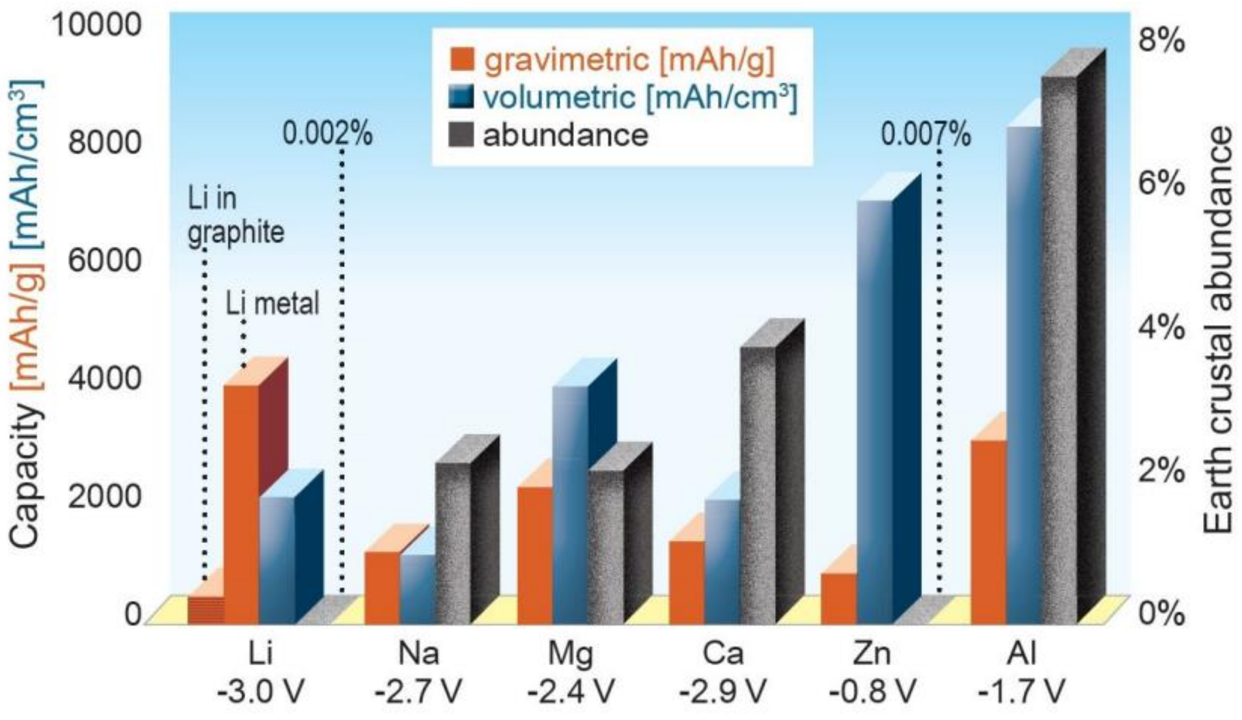
CATHODE

- *Insulating S*
- *Low S utlization*
- *Capacity fading*
- *Loss of active materia*

ELECTROLYTE

- *Flamable liquid electrolyte*
- ***PS solubility***
- *Shuttle effect (overcharging)*

Gen 5 chemistries: new ion based (K, Mg, Ca, Zn, Al, etc)



Need of reliable protocols

Lack of optimized components

Poor ion mobility

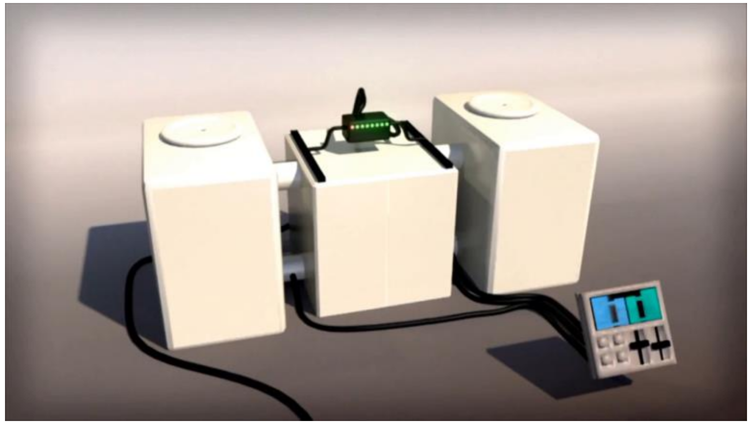
Solvent co-intercalation

Proton intercalation

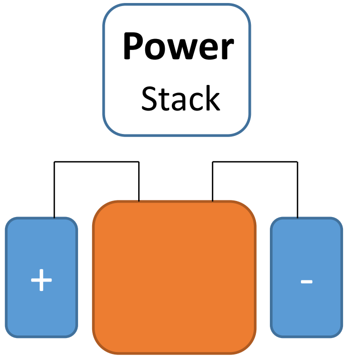
Low cycle life

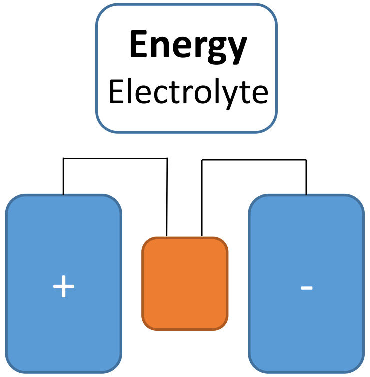
Low voltage

but also…RFB



DECOUPLED POWER AND ENERGY



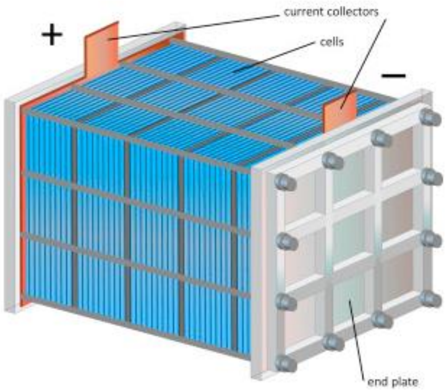


<u>Particular architecture</u> → Decoupled power and energy

- **Energy module**: tanks containing electrolyte (kWh). More volume of electrolyte, more energy
- **Power module**: stack of electrochemical cells (kW). More or bigger cells, more power
- **Flow system**: pipes and pumps

Main challenges

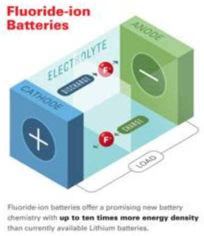
- Cost
- Side reactions /(electro)chemical-thermal stability
- Crossover (selectivity)
- Resistance (ASR)
- Concentration (energy density)
- Leakage

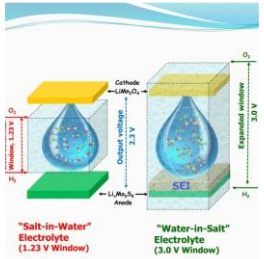


and...

anodeless

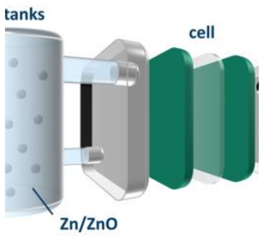
Anion shuttle





aqueous

hybrid
concepts



Food for thought…

New chemistries obviously benefit from chemistry agnostic approaches:

- Accelerated Discovery (adv. ch. methods, digitalisation,etc)
- Improved interfaces
- Smart and connected
- Sustainability…

On the other hand…

- New chemistries are VERY diverse
- Each new chemistry has its own specific challenges, risk of dilution (Gen 5)
- Often get less attention because they target distant scenarios

Can we gain focus and ambition if these technologies are discussed in a specific chapter?

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Setting objectives

Short

overcome fundamental challenges

- new materials
- stable interfaces
- fundamental understanding
- cyclability
- computational models
- disruptive concepts

Medium

advance technologial development stage

- Cell design
- Manufacturability
- System level demonstration
- Operational conditions
- Solid state concepts
- Scalability
- Safety evaluation

Long

Sustainability and growth

- end-of-life and recycling solutions
- Integration
- Large scale production
- Market penetration

Round table Q&A

How to integrate new chemistries within the other pillars of B2030+? Should they have their own chapter?

How to give visibility to the diversity of new chemistries?

Where do you see the major challenges for new chemistries?

Which aspects should be included in the roadmap?

An opportunity to update TRL definition and the battery generation categorization?