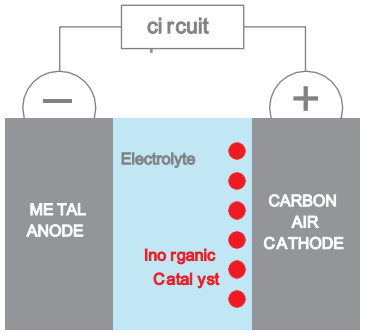
evozyne

Unlocking the potential of metal air batteries

NAATBatt Conference 2022

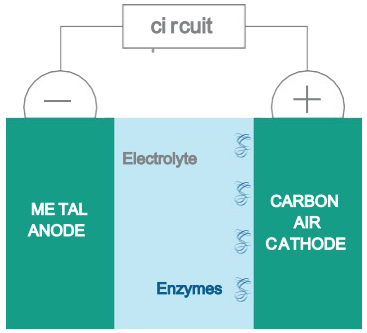
Evozyne is building the first enzymatic air cathode

Conventional Architecture



- Sluggish ORR/OER reactions
- Detrimental oxygen radicals
- Expensive catalysts

Evozyne Enzymatic Architecture



- ✓ Fast ORR/OER reactions
- ✓ Minimal oxygen radicals
- ✓ Efficient catalysts

<$25 $/kWh

>2700 Wh/kg

We are looking for **R&D partners** to help us build metal-air batteries that will unlock a more sustainable future through applications across EVs, air mobility, and grid storage with **ultra-high density batteries**

Learn more about Evozyne & our metal-air battery project

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FIND OUT MORE at

Evozyne.com

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Additional Information

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Making metal-air the gold-standard for rechargeable batteries

Context

- Rechargeable batteries are critical for enabling sustainable solutions such as large-scale energy storage, drone/air taxis and electric vehicles.
- Metal-air batteries have up to 20x energy density as lithium-ion and can be less expensive

Problem

Metal-air batteries have two main problems:

1) Sluggish reactions at the air electrode
2) Formation of damaging oxygen radicals

Solution

Evozyne is developing an enzymatic air cathode that:

- ✓ Efficiently catalyzes charging and discharging of batteries
- ✓ Eliminates the formation of oxides

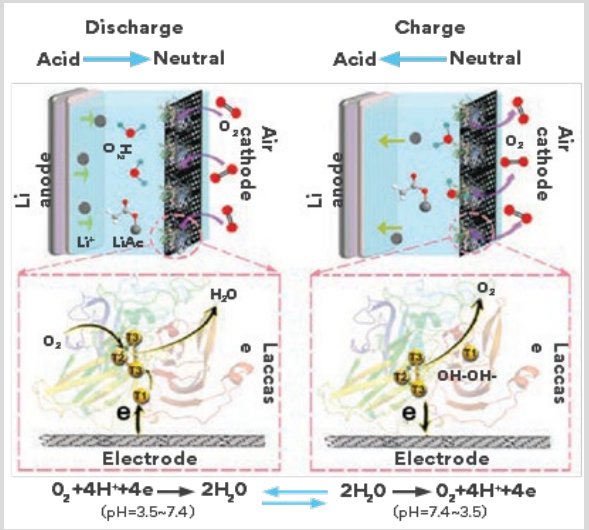
Using nature to solve challenges with metal-air batteries

In nature, there are **fungal enzymes called laccases** that have copper atoms embedded within them that help with electron transfer and redox reactions, making them **efficient electrochemical catalysts**

- Laccase were first studied in the sap of a Japanese lacquer tree
- They are typically found in bacteria and fungi to help with degradation of lignin (wood derivatives) to extract energy from plants
- Laccases have also been found to catalyze oxidation reduction reactions
- Natural laccases are not active or stable enough for use in metal air batteries – a large amount of enzyme would be required with frequent replacement

We are **engineering a more active and stable laccase enzyme** to bring breakthrough technology to the market

How do Evozyne's enzymes work?



Schematic representation of the configuration and working principle of the LacTv catalytic rechargeable Li-air battery

Image source: Energy Environ. Sci., 12/17/19, 144-151.

Mechanism of Action

1) Metal anode is oxidized and releases electrons to the external circuit
2) Electrons from the cathode tunnel across to the T1 copper site in laccase
3) Electrons travel to T2/T3 cluster through intramolecular electron transfer
4) O2 gets oxidized at T2/T3 cluster (ORR), creating H2O and increasing pH
5) As the pH becomes more neutral, ORR efficiency decreases due to inhibition of T1 site by OH-groups; enzyme becomes more active for OER
6) Upon application of a potential across the electrodes, OER reaction is triggered

Evozyne is solving key problems with metal-air batteries

Laccases catalyze oxidation reduction reactions through a ***one-step reaction*** *– this makes the reaction more* ***energetically favorable*** *and* ***avoids the formation of peroxides***

	Current Challenges with Metal-Air Batteries	Advantages of Evozyne's enzymatic air cathode
Reaction Efficiency	**Sluggish Reactions at the Air Electrode** The kinetics of oxygen reduction reaction (ORR) and oxygen evolution reaction (OER) are notoriously slow, necessitating large surface areas and/or slower cycles	**Optimized ORR and OER Reactions** Evozyne is engineering enzymes called laccases that are covalently attached to the cathode to efficiently and reversibly catalyze ORR and OER
Damaging By-products	**Formation of Oxygen Radicals** Oxygen electrochemistry typically results in the formation of reactive species such as peroxides which lead to catalyst and electrode corrosion	**Elimination of Oxygen Radicals** Laccases have clusters of copper atoms within the structure that can catalyze oxygen without creating harmful superoxides and peroxides
Catalyst	**Expensive Inorganic Catalysts** The use of expensive cathode catalysts is hindering commercialization of metal air batteries	**Efficient enzymatic catalyst** The bi-functionality of Evozyne's enzymatic catalyst minimizes degradation of activity and stability during charge-discharge cycling

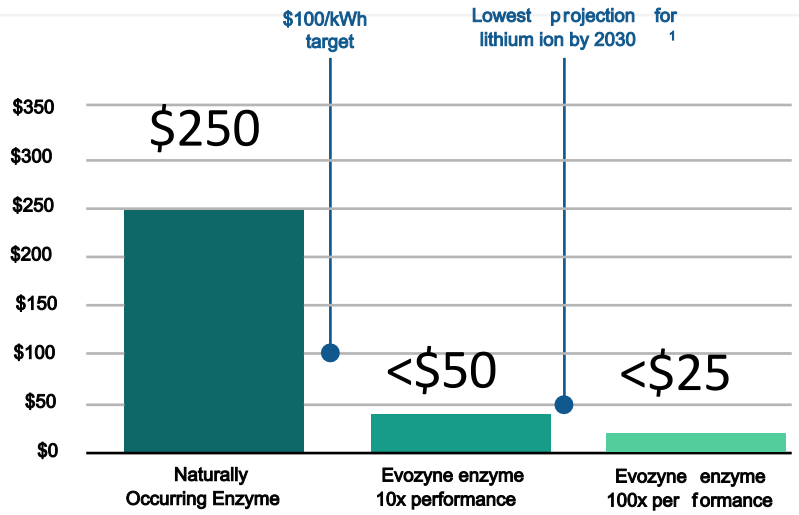
Performance Targets

Our cost model* indicates **<$50/kWh** for lithium air batteries with just **10x improvement** in enzyme performance

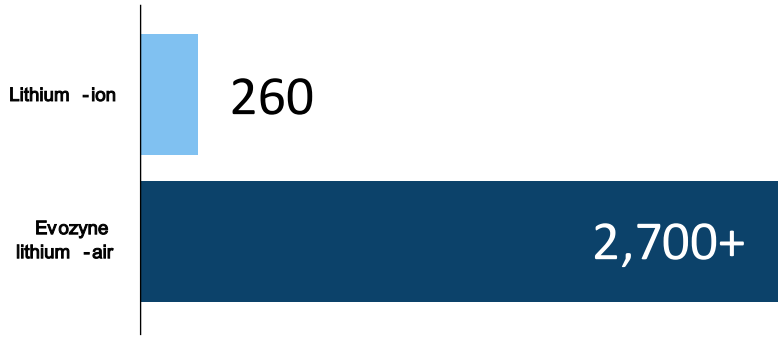
With greater improvements, we could see costs **<$25/kWh**

Evozyne's lithium-air battery would have **10X the energy density** of the best lithium-ion battery today

Projected Battery Cost, $/kWh**



Projected Energy Density, Wh/kg



*Model built based on a lithium battery but the technology can be tailored to other metals.
**Internal cost model. | [1]National Blueprint for Lithium Batteries 2021–2030, June 2021, FCAB.

More on Evozyne & the work we do

We are is embracing revolutionary science, technology, and artificial intelligence to solve some of the toughest societal challenges

Evozyne is a high-impact, biotech company with a mission of creating novel proteins that can solve complex human and societal problems.

Based on over 20 years of research, Evozyne helps customers solve their unsolvable problems with breakthrough advancements in how proteins are made and what they can do. We deliver protein designs that are high performance and adaptive, with exceptionally advanced functionality in even the most extreme conditions.

Evozyne was founded by Jeff Aronin of Paragon Biosciences and Rama Ranganathan M.D., PhD with the mission of using science and technology to find answers to critical global challenges in environmental and life sciences.

Investors Include:

Paragon BIOSCIENCES

Fidelity INVESTMENTS

VALOR EQUITY PARTNERS

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