Electrochemistry
A science with many potentials

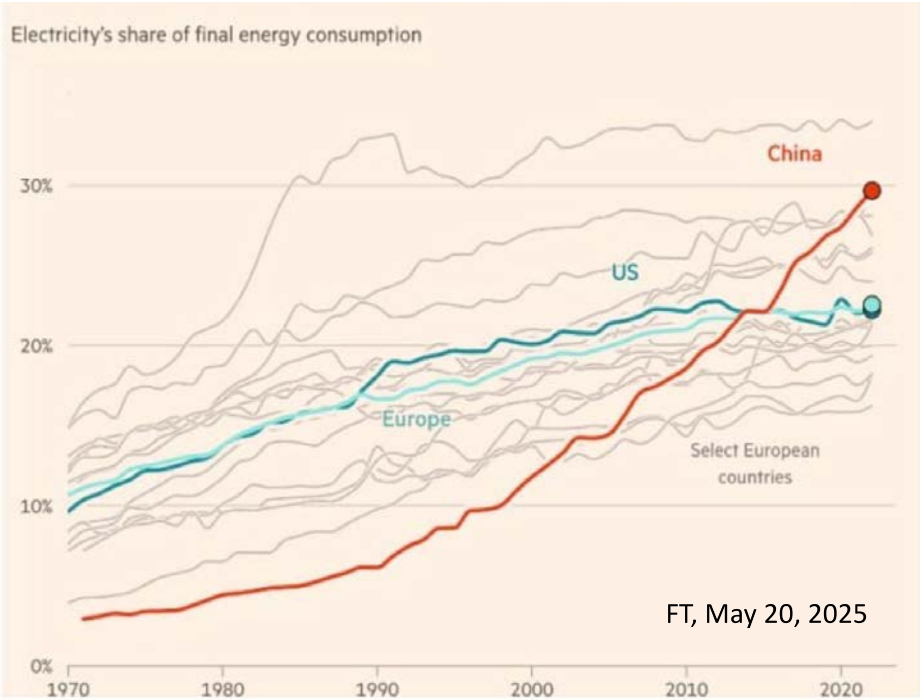
Prof. Hubert Girault

11.09.2025

EPFL

Electrification : The major challenge of the 21st century

Electrochemistry is a core science of electrification



Challenges:

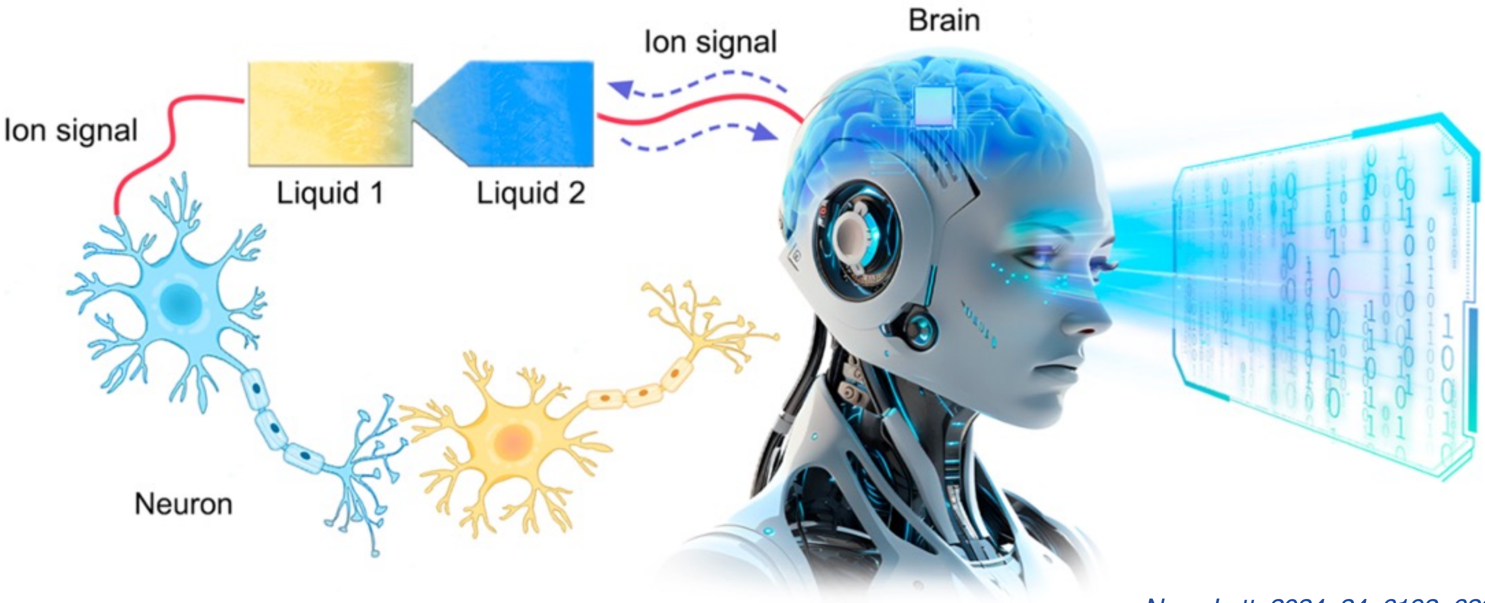
Renewable energy storage

Green hydrogen production

Powering AI

•China leads the world in electrification, with a 30% electrification rate—far ahead of the U.S. and EU at ~22%—dominating sectors like transport and industry.

Iontronics

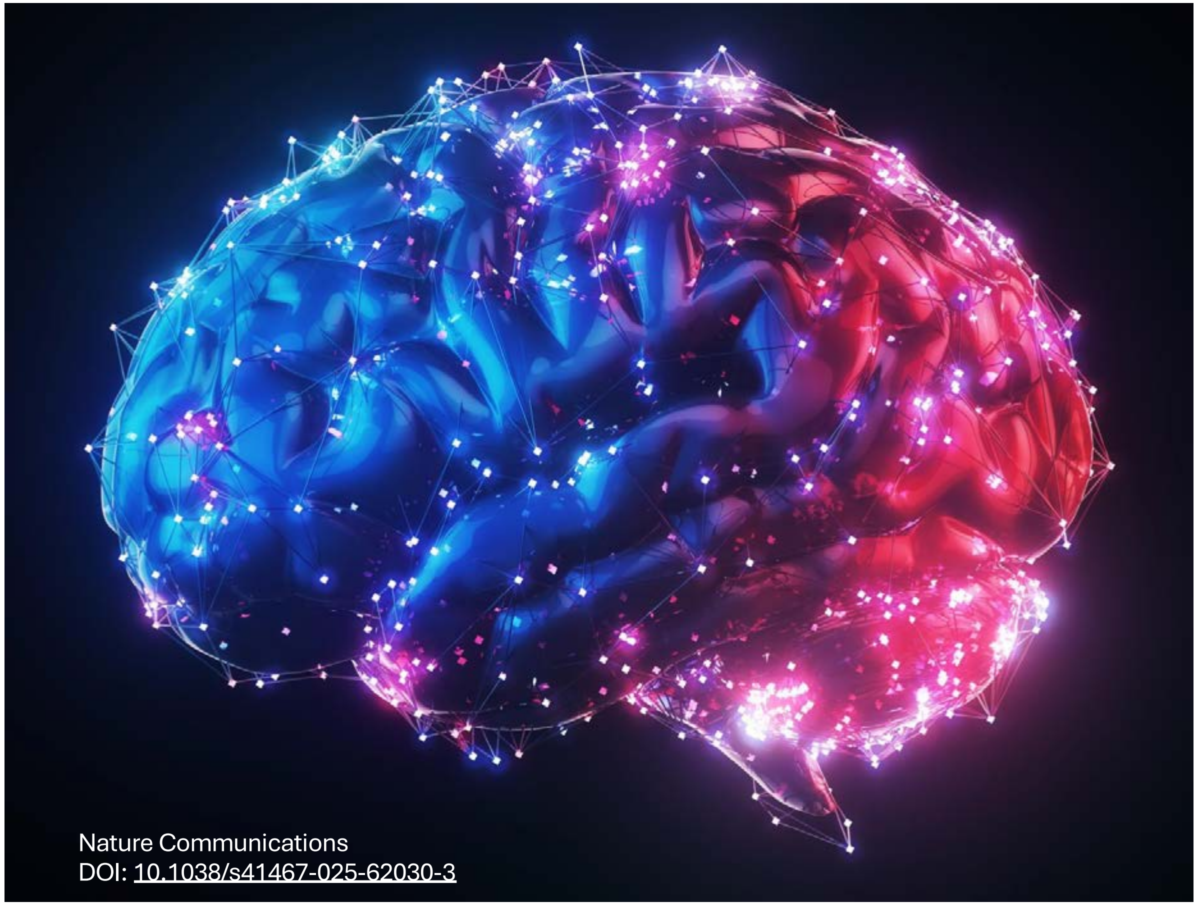


Nano Lett. 2024, 24, 6192–6200

When electrochemistry at liquid-liquid interfaces meets ion transport in nanofluidics, the ionic computer becomes feasible.

The human brain consumes about **20 W** of power on average… as a dim light bulb.

- **Energy source**: The brain gets its energy from glucose, delivered via the bloodstream.
- **Oxygen consumption**: It uses about **20% of the body's oxygen supply**, despite being only about 2% of the body’s mass.



One Graphic Processing Unit , e.g. NVIDIA A100 s consumes 300 to 400 W

A neuron consumes about 10 picowatts during active firing. With ~86 billion neurons, the brain’s total power usage (~20 watts) makes sense.

Plan

- Potentials and redox reactions
- Li-ion battery
- Water electrolysis

Potentials in electrochemistry

Electrostatic

- Inner potential
- Outer potential
- Surface potential (difference)
- Volta potential (difference)
- Galvani potential (difference)
- Contact potential (difference)
- Potential of zero charge (vs ref.)

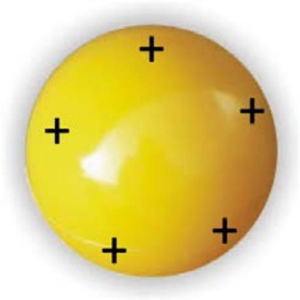
Electrokinetic

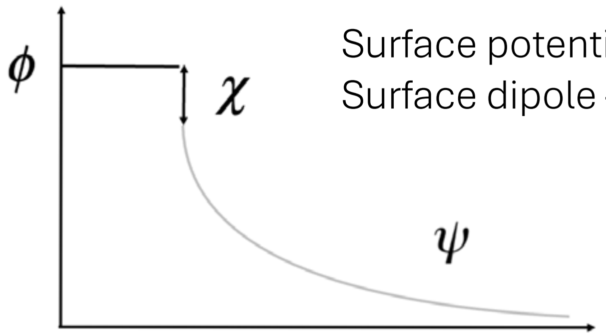
- Donnan potential
- Diffusion potential
- Streaming potential
- Zeta potential
- Liquid junction potential

Thermodynamic

- Chemical potential
- Electrochemical potential
- Real chemical potential
- Redox potential (vs ref.)
- Nernst potential (vs ref.)
- Formal potential (vs ref.)
- Transfer potential (vs ref.)
- Half-wave potential (vs ref.)

Inner Potential





Surface potential
Surface dipole – Jellium – Molecular Orientation

Outer potential
$\propto$ charge

The inner potential is constant for a given phase, neutral by definition $\phi = \chi + \psi$

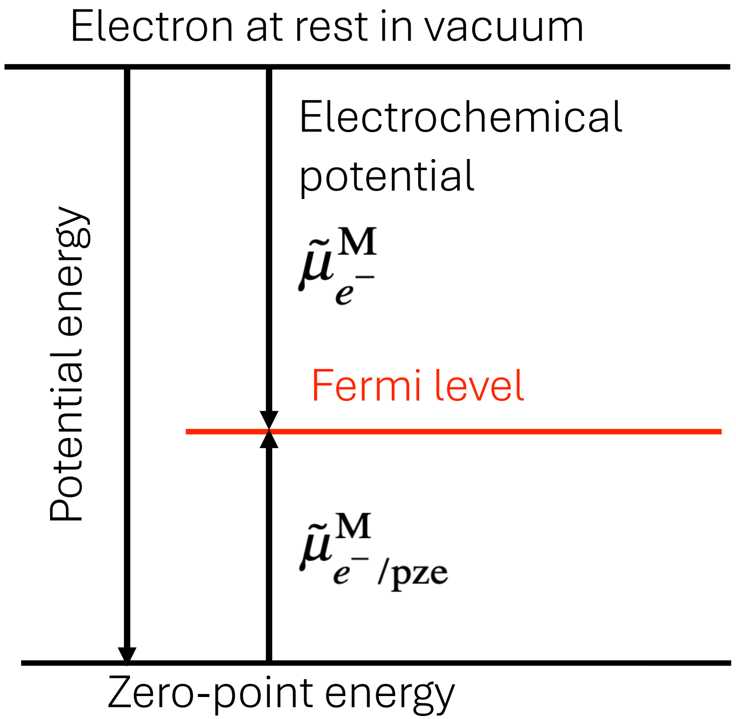
Electrochemical Potential

$$\tilde{\mu}_i = \mu_i^{\ominus} + RT \ln a_i + z_i F \phi$$

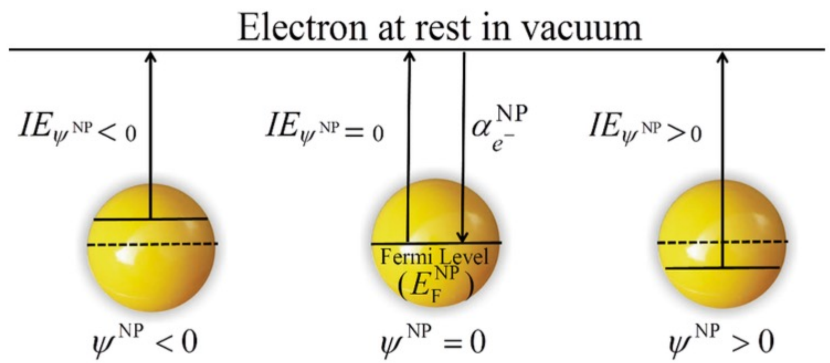
Work to transfer a charged species from vacuum to a phase

Electrochemical potential of an electron in a metal

$$\tilde{\mu}_{e^-}^{M} = \mu_{e^-}^{M} - F\phi^{M} = (\mu_{e^-}^{M} - F\chi^{M}) - F\psi^{M} = \alpha_{e^-}^{M} - F\psi^{M}$$

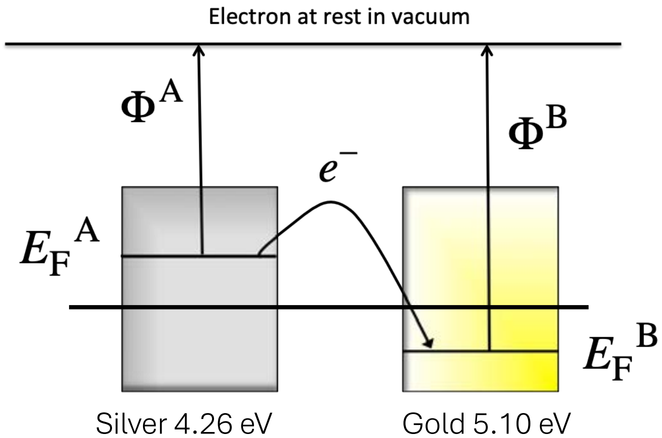


Work function $\Phi^{M} = -\alpha_{e^-}^{M}$



The Fermi level varies with the charge

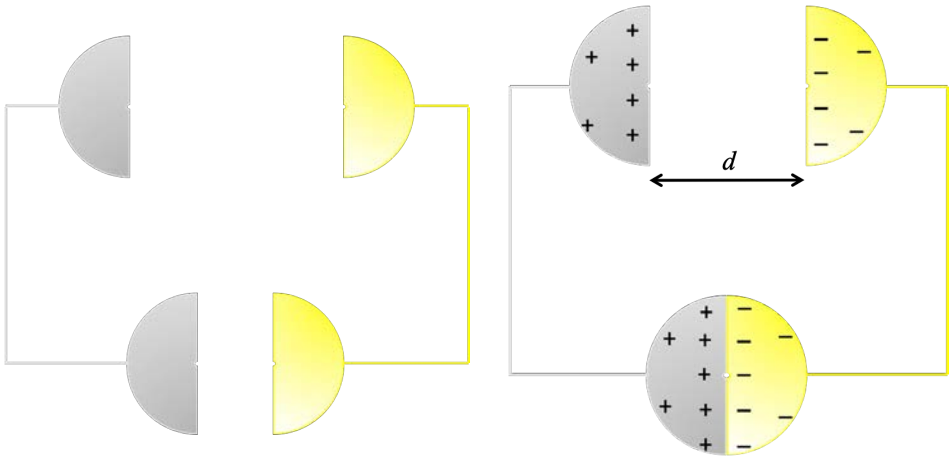
Contact potential (difference)



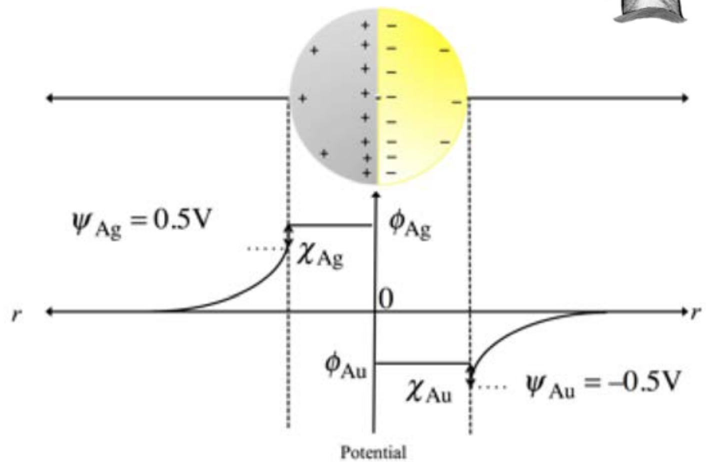
Electronic equilibrium

Volta potential difference

$$\psi^B - \psi^A = \left[\alpha^B_{e^-} - \alpha^A_{e^-}\right]/e = \left[\Phi^A - \Phi^B\right]/e$$

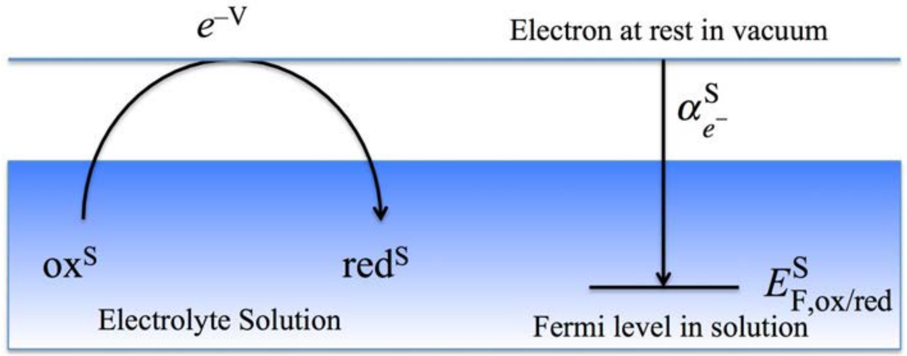


Janus particle



Fermi level for a redox couple in solution

$$\mathrm{Ox}^{\mathrm{S}} + ne^{-\mathrm{V}} \rightleftarrows \mathrm{Red}^{\mathrm{S}}$$

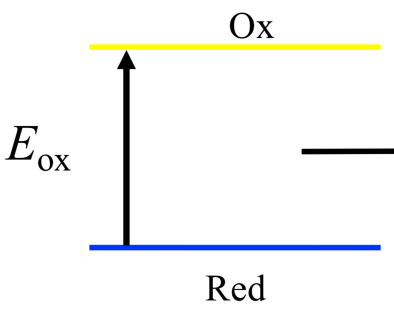


$$\left[E^{\ominus}_{\mathrm{ox/red}}\right]_{\mathrm{abs}} = -\frac{\Delta \tilde{G}^{\ominus}_{\mathrm{r}}}{nF} = \frac{\tilde{\mu}^{\ominus,\mathrm{S}}_{\mathrm{ox}} - \tilde{\mu}^{\ominus,\mathrm{S}}_{\mathrm{red}}}{nF}$$

$$= \frac{\alpha^{\ominus,\mathrm{S}}_{\mathrm{ox}} - \alpha^{\ominus,\mathrm{S}}_{\mathrm{red}}}{nF} + \psi^{\mathrm{S}}$$

$$-\alpha^{\mathrm{S}}_{e^-} = e\left[E_{\mathrm{ox/red}}\right]^{\mathrm{S}}_{\mathrm{AVS},\psi^{\mathrm{S}}=0} = \alpha^{\mathrm{S}}_{\mathrm{ox}} - \alpha^{\mathrm{S}}_{\mathrm{red}}$$

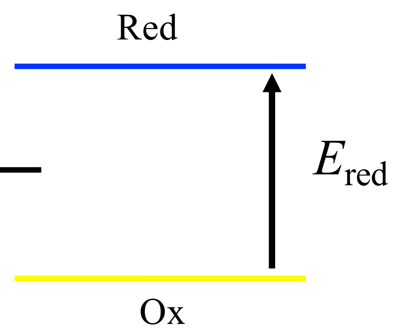
Two state Fermi-Dirac statistics



$$n_1 = \frac{1}{1+e^{(E-E_f)/kT}}$$

$$E_f = E/2$$

$$n_0 = \frac{1}{1+e^{-E_f/kT}}$$



Zeitschrift für Physikalische Chemie Neue Folge, Bd. 26, S. 223—247 (1960)

Über den Ablauf von Redoxreaktionen an Metallen und an Halbleitern

I. Allgemeines zum Elektronenübergang zwischen einem Festkörper und einem Redoxelektrolyten

Von

H. Gerischer

Max-Planck-Institut für Metallforschung, Stuttgart

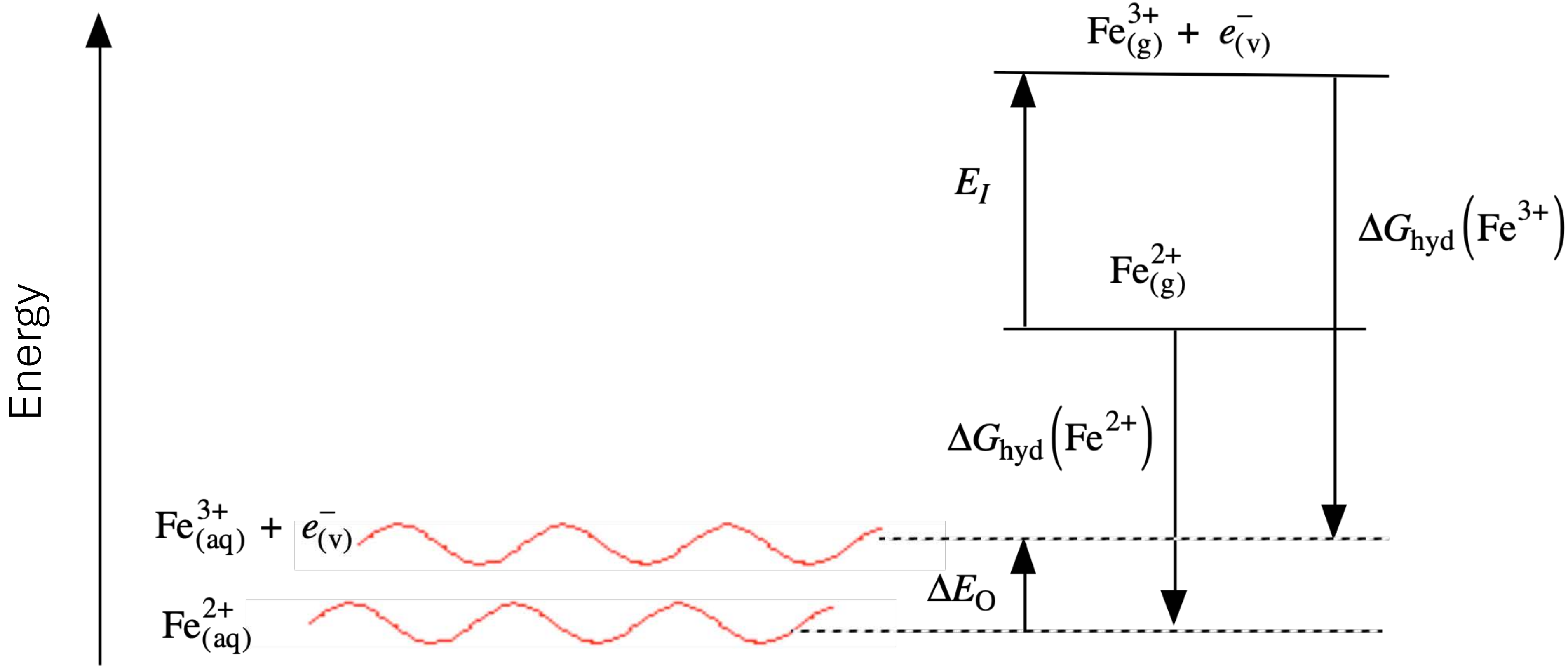
Mit 7 Abbildungen im Text

(Eingegangen am 10. Mai 1960)

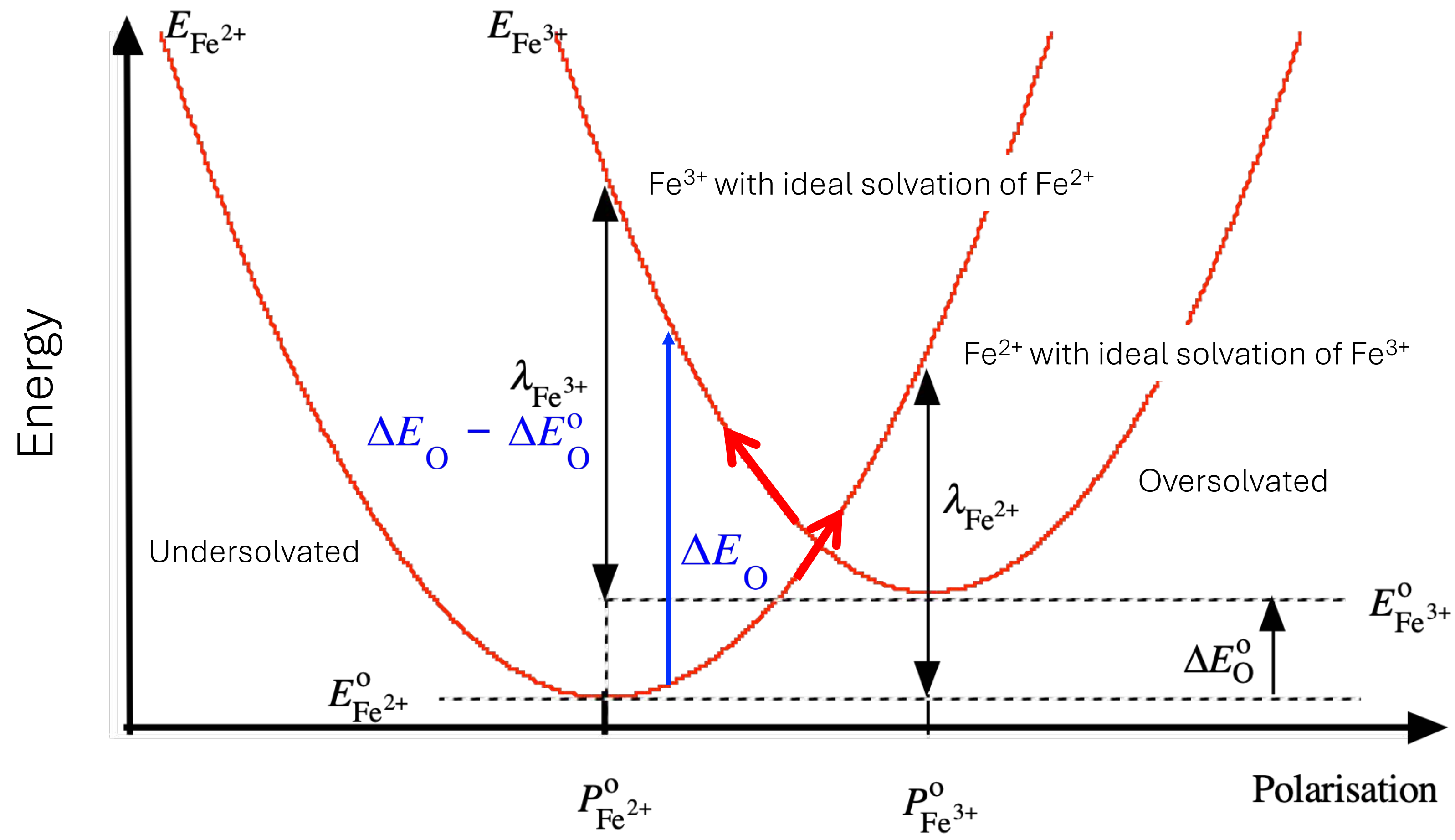
Redox reactions at metals and semiconductors

General information on electron transfer between a solid and a redox electrolyte

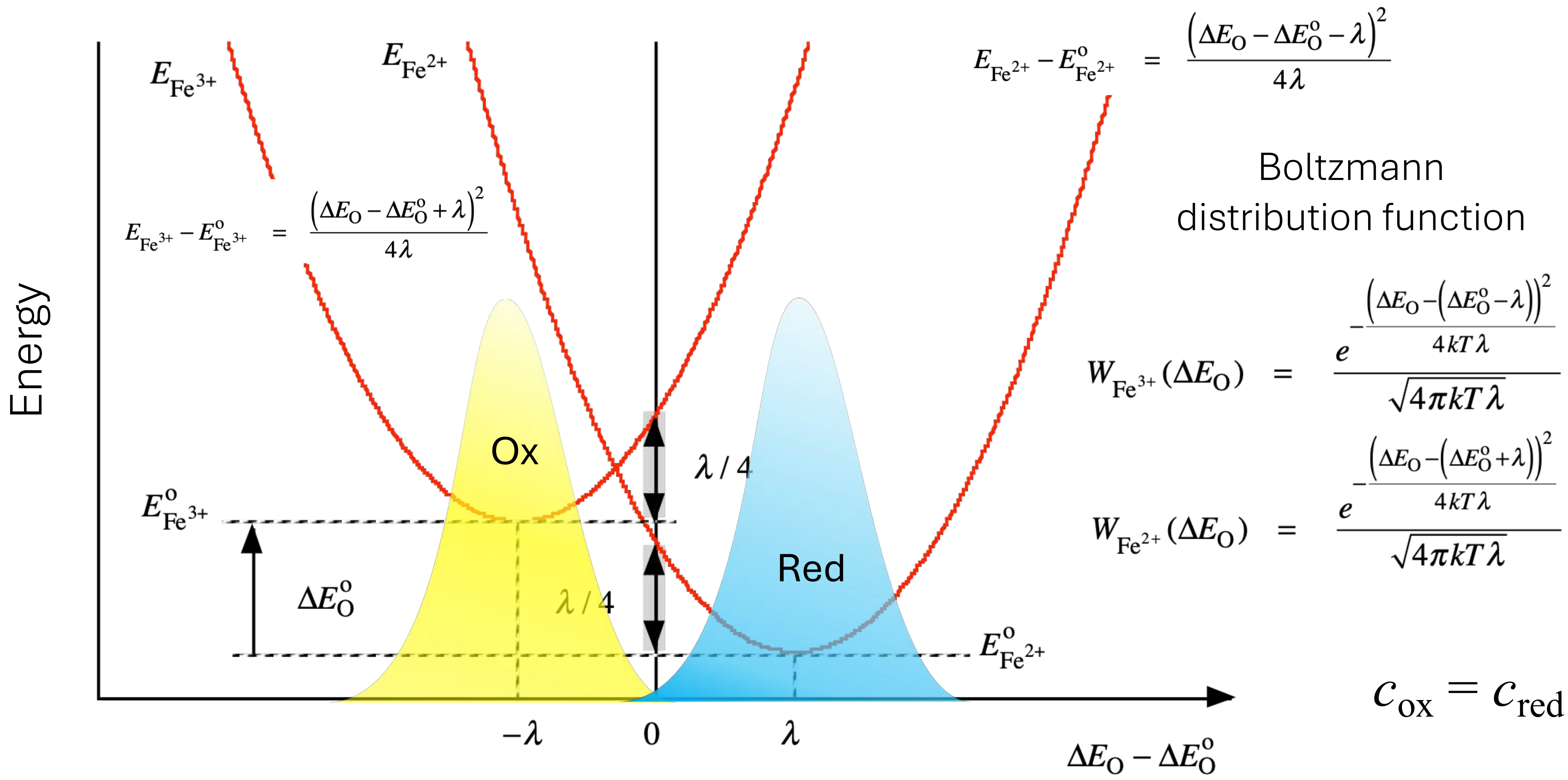
Oxidation energy in solution



Solvent re-organisation energy



Ion energy – Oxidation energy diagram



Distribution function

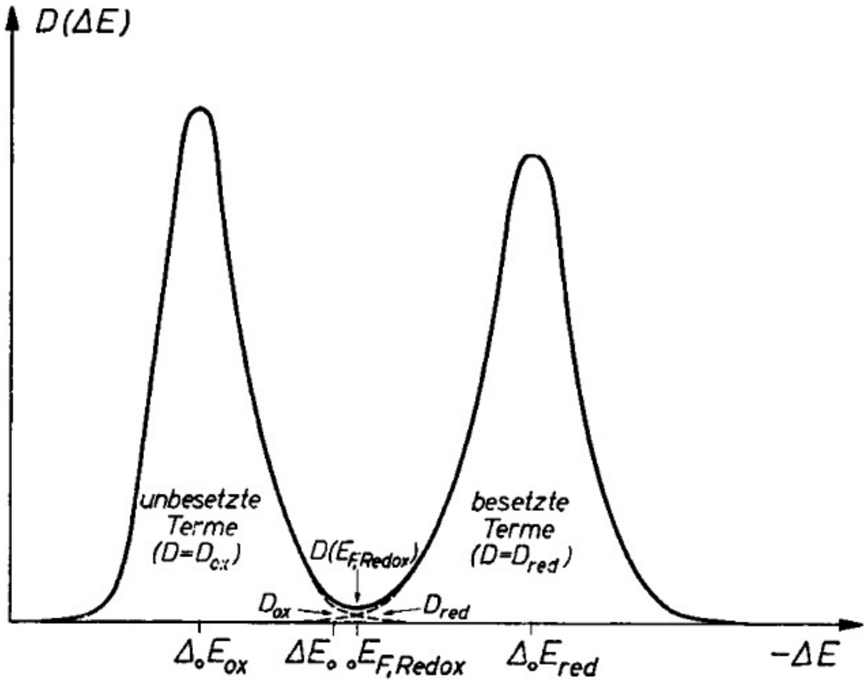
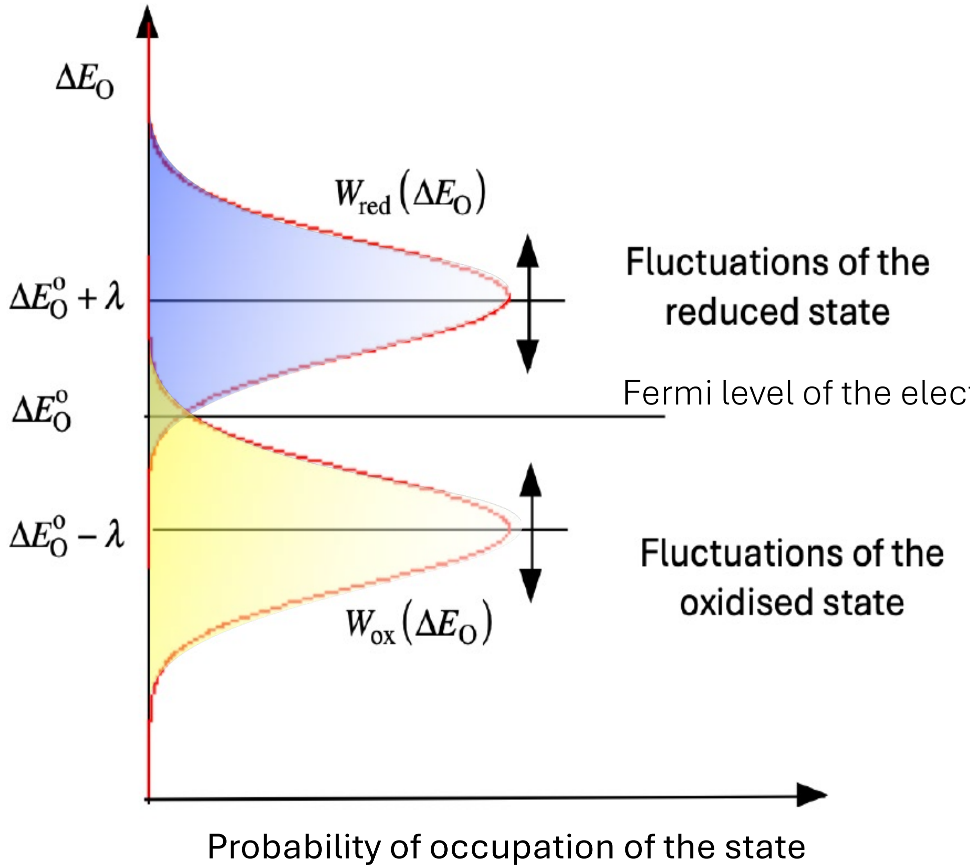


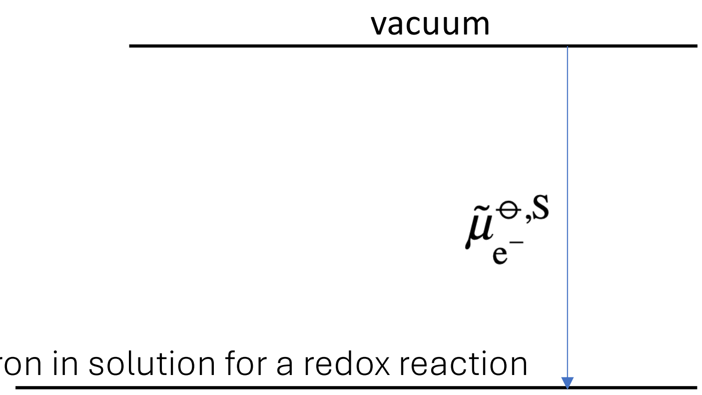
Abb. 3. Verteilungsfunktion der Energieterme für Elektronen im Redoxelektrolyten bei $c_{ox} = c_{red}$ (schematisch)

Distribution function of the energy terms for electrons in the redox electrolyte at $c_{ox} = c_{red}$ (schematic)"

Zeitschrift für Physikalische Chemie Neue Folge, Bd. 26, S. 223—247 (1960)

Gerischer diagram for oxidation



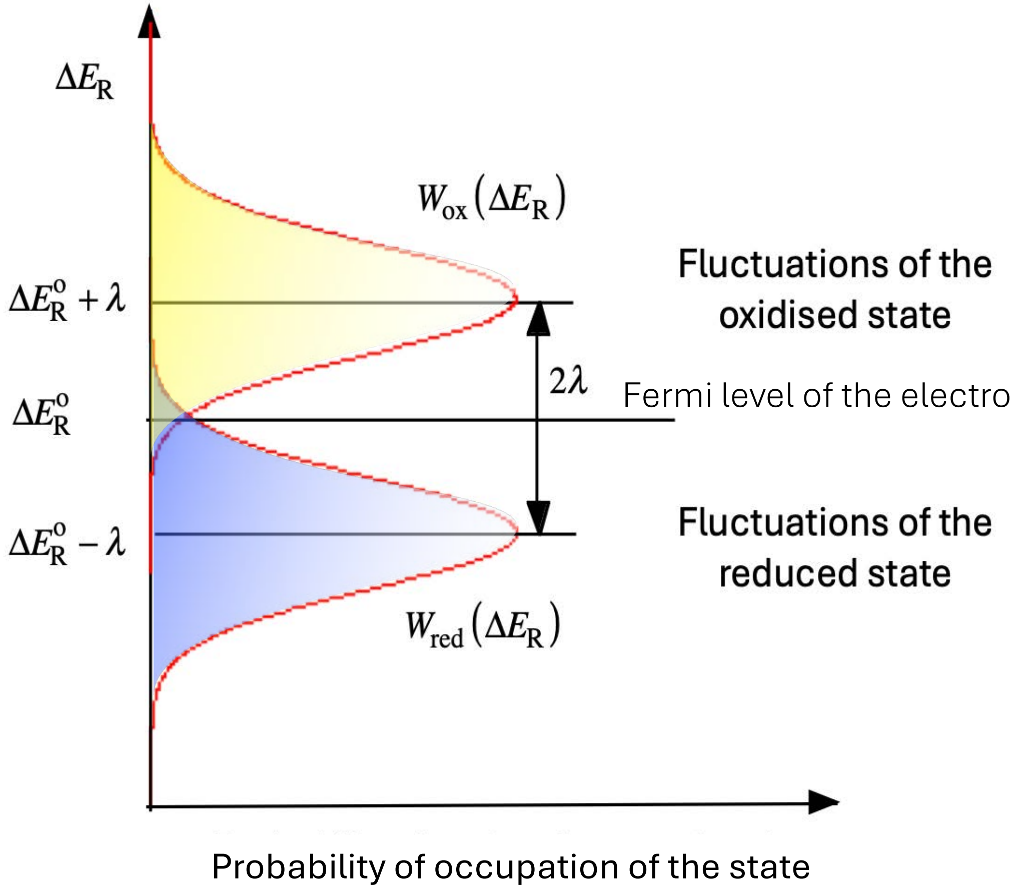


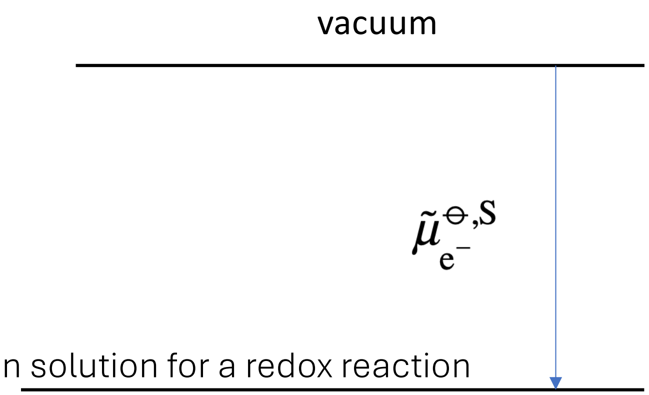
$$E_\mathrm{abs} = \left[E^{\ominus\prime}_\mathrm{ox/red}\right]_\mathrm{abs} + \frac{RT}{F}\ln\left(\frac{c_\mathrm{ox}}{c_\mathrm{red}}\right)$$

W. Nernst

1889
Habilitation
Thesis
Electromotive
force

Gerischer diagram for reduction

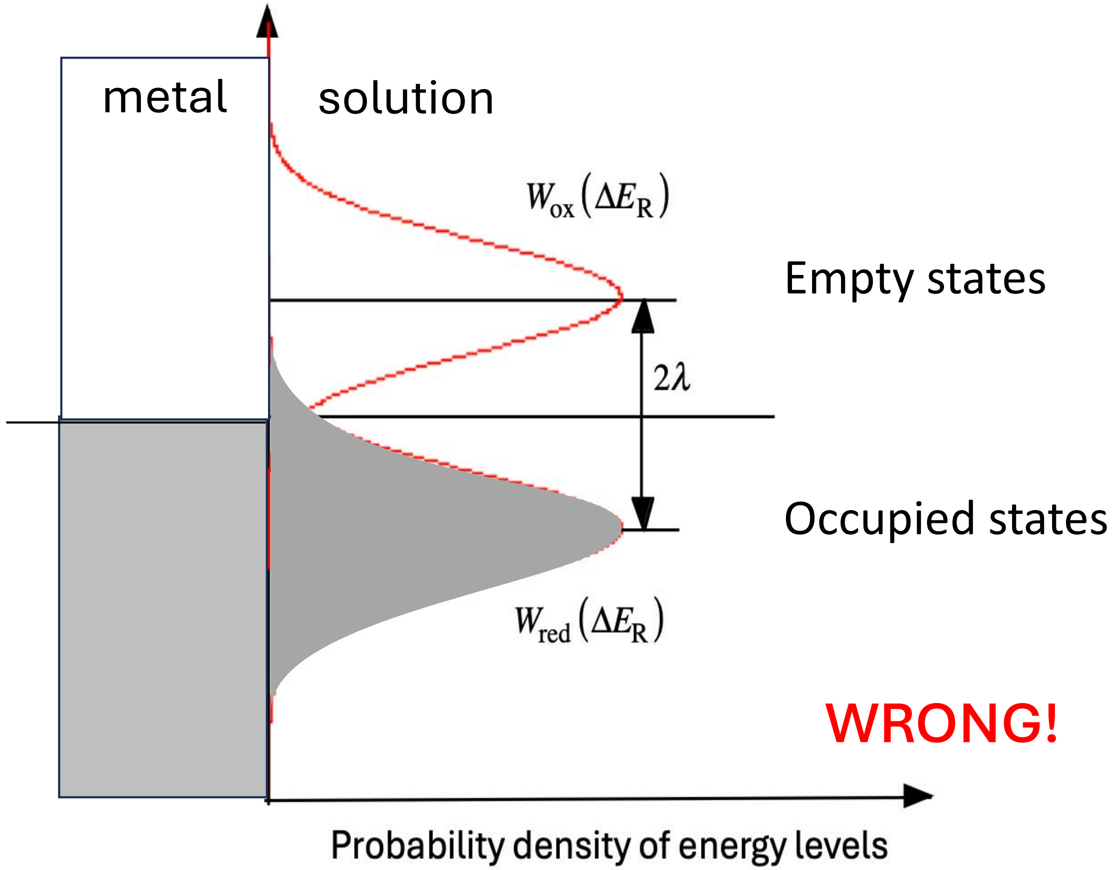


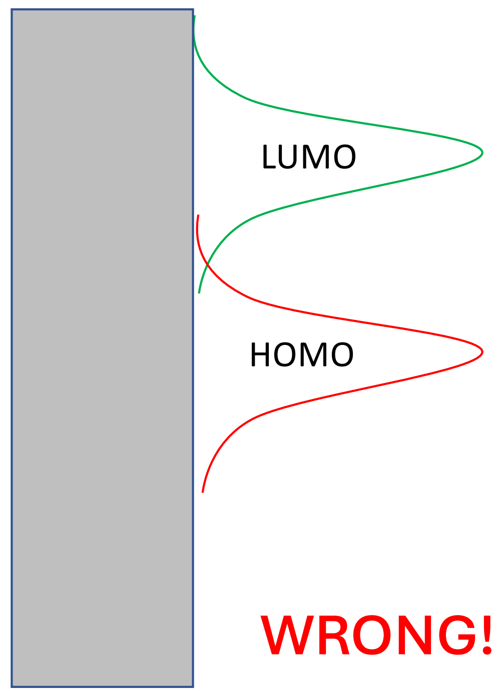


$$E_{abs} = \left[E^{\ominus\prime}_{ox/red}\right]_{abs} + \frac{RT}{F}\ln\left(\frac{c_{ox}}{c_{red}}\right)$$

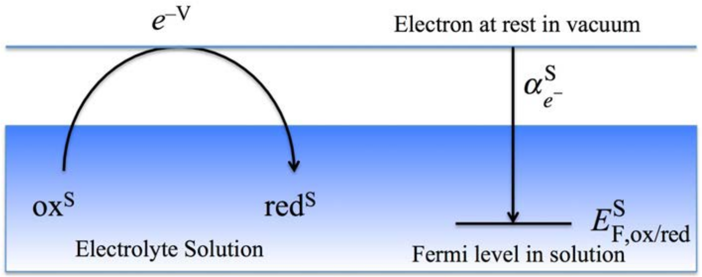
Lost in translation...

Misconception on the Gerischer diagram

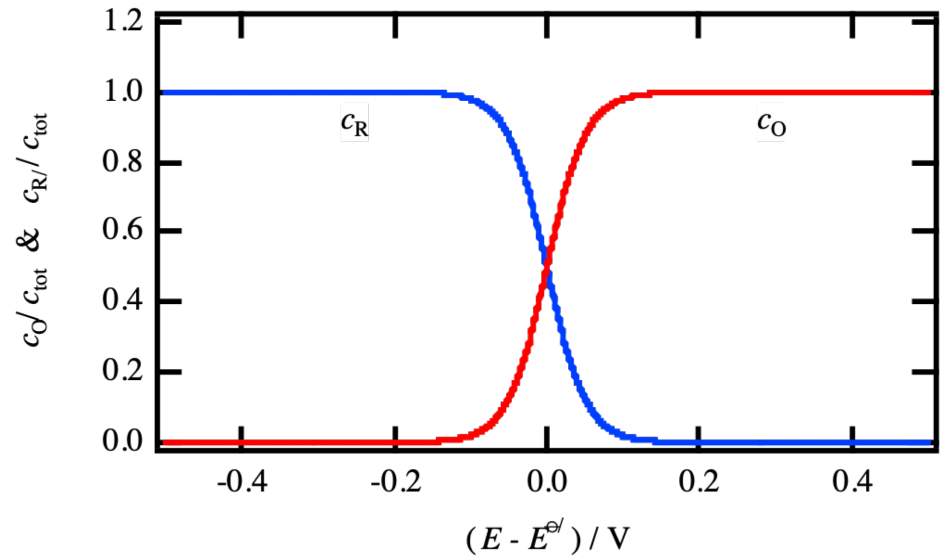




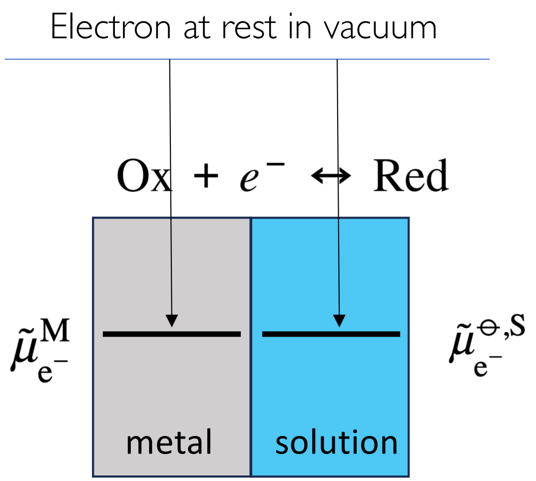
Nernst equation . Two state Fermi-Dirac statistics



$$E_{abs} = \left[E^{\ominus/}_{ox/red}\right]_{abs} + \frac{RT}{F}\ln\left(\frac{c_{ox}}{c_{red}}\right)$$

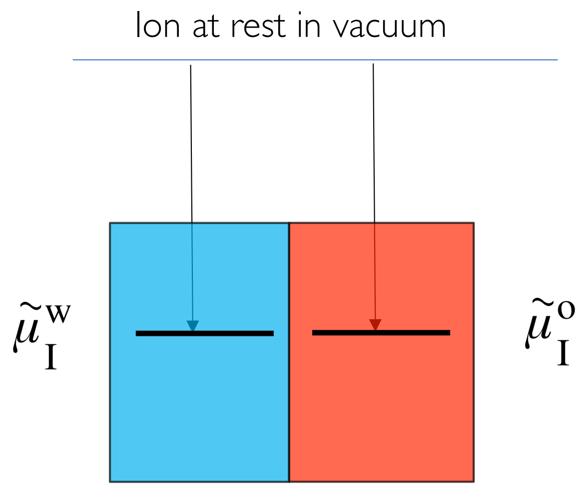


Electron transfer reactions



At equilibrium

Ion transfer reactions



with $\tilde{\mu} = \mu^{\ominus} + RT\ln a + zF\phi$

$$E_{abs} = \left[E^{\ominus\prime}_{ox/red}\right]_{abs} + \frac{RT}{F}\ln\left(\frac{c_{ox}}{c_{red}}\right)$$

Nernst equation for electron transfer

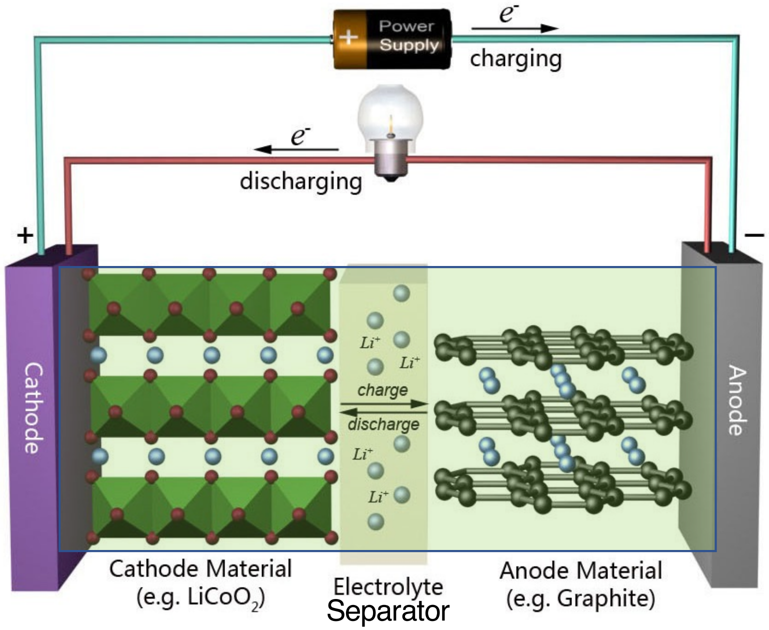
$$\Delta_o^w\phi = \phi^w - \phi^o = \Delta_o^w\phi_i^{\ominus} + \frac{RT}{z_iF}\ln\left(\frac{a_i^o}{a_i^w}\right)$$

Nernst equation for ion transfer

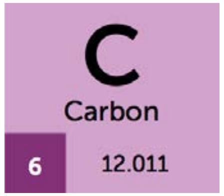
Plan

- Potentials and redox reactions
- Li-ion battery
- Water electrolysis

Intercalation reactions



http://www.scs.illinois.edu/murphy/Ran/research/energystorage.html



$E = 0.9$ V *vs* SHE

$$Li_{1-x}CoO_2 + x\,Li^+ + x\,e^- \longrightarrow LiCoO_2$$

$$Co^{IV}O_2 + Li^+_{sol} + e^-_{CB} \longrightarrow Li^+Co^{III}O_2$$

Discharging

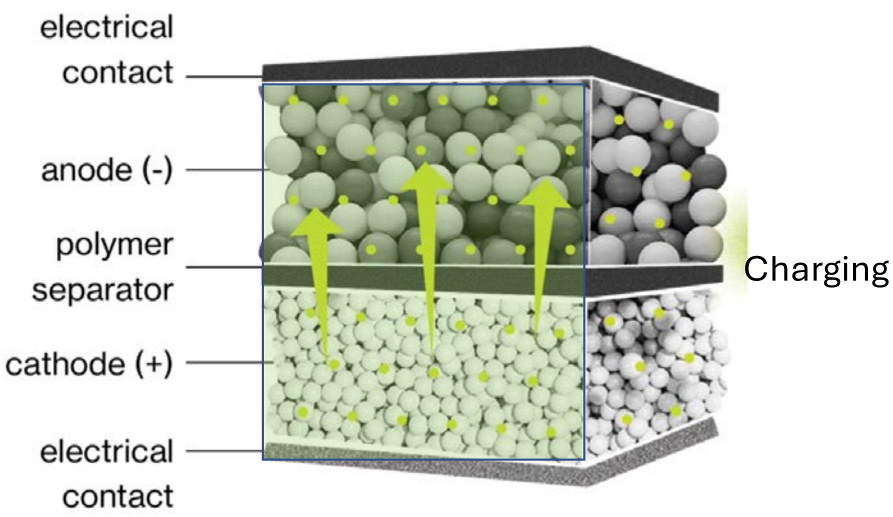
$E = -2.9$ V *vs* SHE

$$6\,C + x\,Li^+ + x\,e^- \longrightarrow C_6Li_x$$

$$nC_g + Li^+_{sol} + e^-_g \longrightarrow Li^+_g + nC^-_g$$

Charging

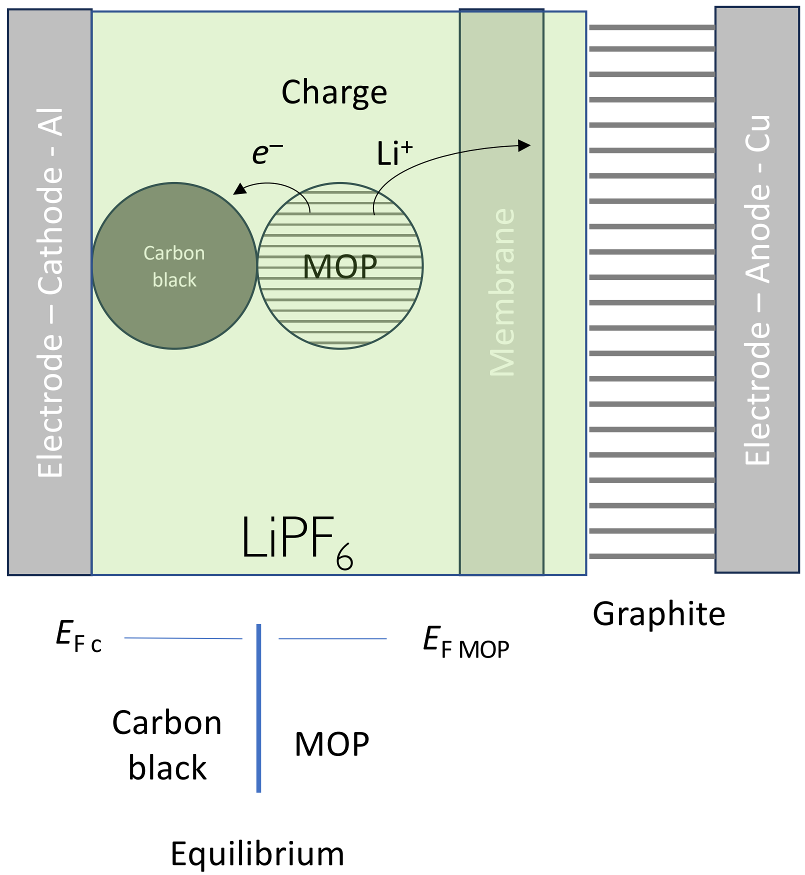
Lithium-ion battery with graphite anode



Powder and coating technologies

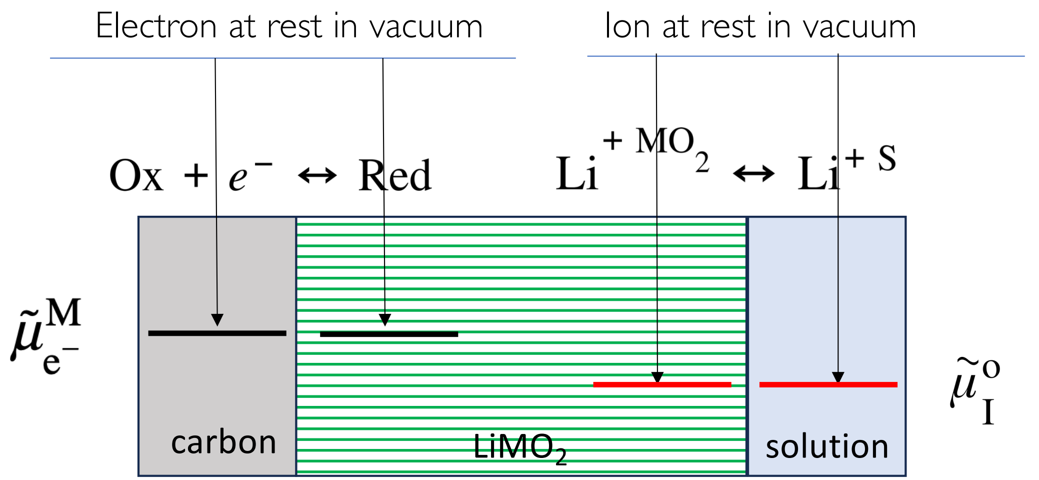
https://mineralprices.com/novel-lithium-metal-batteries-will-drive-the-switch-to-electric-cars/

MOP: Redox Metal Oxide Particle



Insertion reactions

Nernst equation
for electron transfer

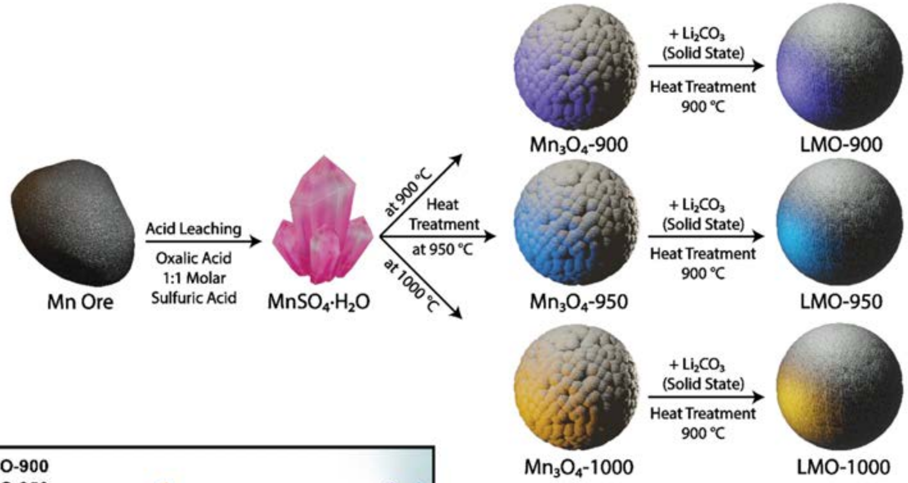


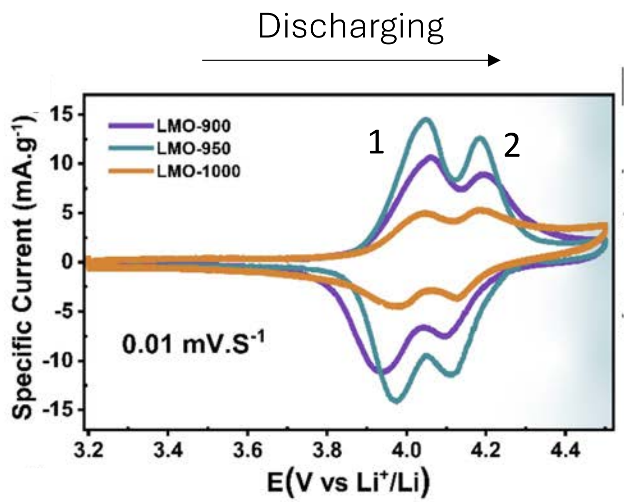
Nernst equation
for ion transfer

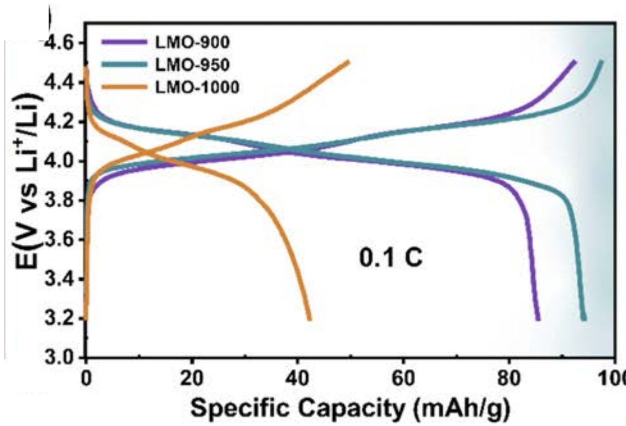
The redox solid phase should remain electroneutral inside

$LiMO_2$ reduction = Li^+ insertion

Lithium Manganese Oxide -LMO







Ox2/Red 2: $MnO_2/Li_{0.5}Mn_2O_4$

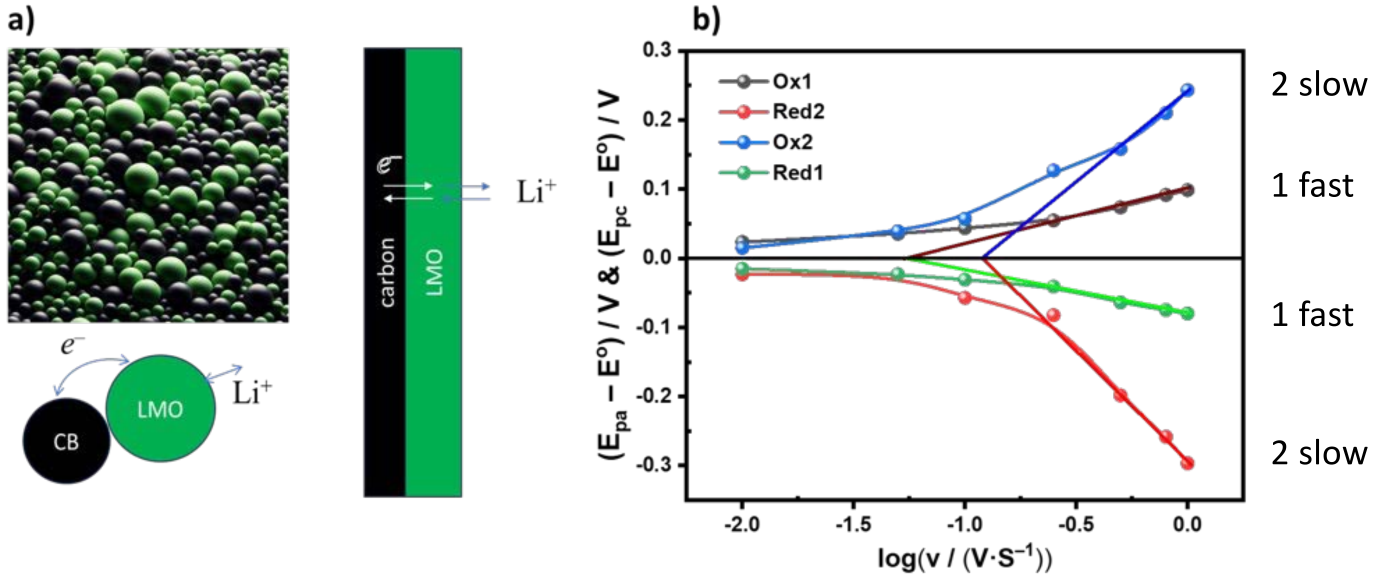
Ox1/Red 1: $Li_{0.5}Mn_2O_4/LiMn_2O_4$

Phase transition at x=0.5

From tetrahydral to octahydral sites

Electrochimica Acta 509 (2025) 145286

Thin layer voltammetry - LMO



Thin-layer constant

$$K_{cm} = \frac{RTA\,k^{\ominus}}{nF\nu V} = \frac{RTk^{\ominus}}{nF\nu\delta}$$

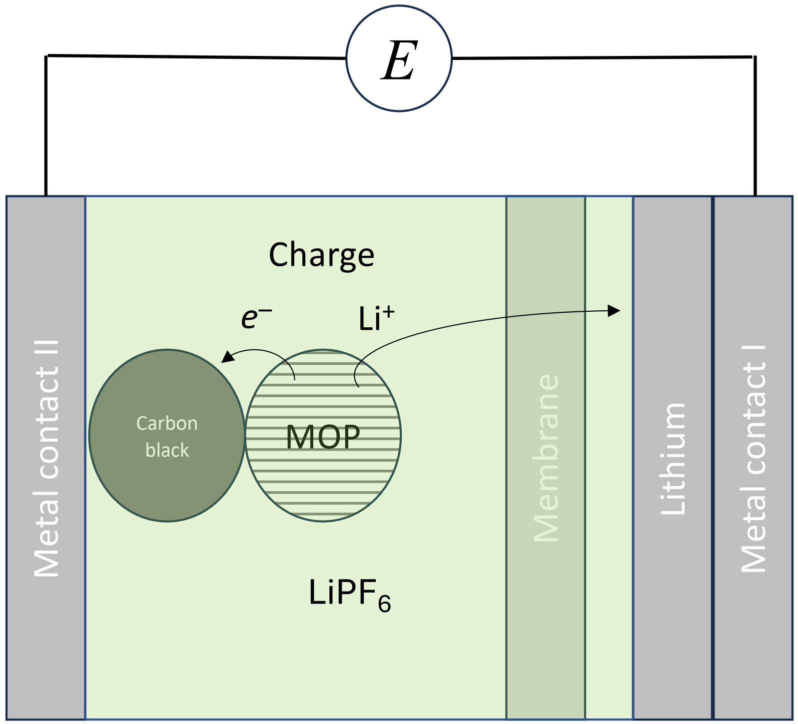
Laviron equation

$$E_{pa} = E^{\ominus\prime} + \frac{RT}{\alpha nF}\ln\left(\frac{\alpha}{K_{cm}}\right) = \left[E^{\ominus\prime} + \frac{RT}{\alpha nF}\ln\left(\frac{\alpha nF\delta}{RTk^{\ominus}}\right)\right] + \frac{RT}{\alpha nF}\ln\nu$$

$$E_{pc} = E^{\ominus\prime} - \frac{RT}{(1-\alpha)nF}\ln\left(\frac{1-\alpha}{K_{cm}}\right)$$

UM6P University Mohammed VI Polytechnic

Nersnt equation for an insertion reaction



$$\left[E_{M^{IV}/M^{III}}\right]_{Li^+/Li} = \phi^{MC^{II}} - \phi^{MC^{I}} =$$

$$\left(\phi^{MC^{II}} - \phi^{CB}\right) + \left(\phi^{CB} - \phi^{S}\right) + \left(\phi^{S} - \phi^{Li}\right) + \left(\phi^{Li} - \phi^{MC^{I}}\right)$$

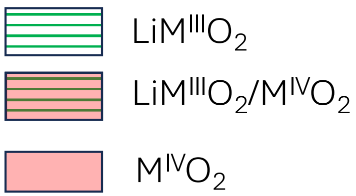
Insertion reaction equilibrium

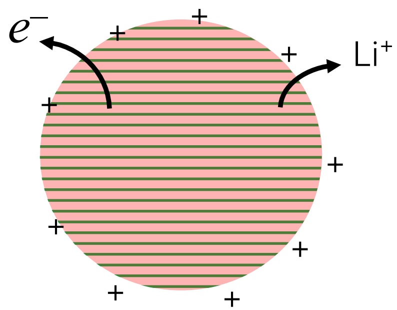
$$M^{IV}O_2 + Li^{+\,S} + e^{-\,CB} \rightleftarrows Li^+M^{III}O_2$$

$$\tilde{\mu}^{MOP}_{M^{IV}} + \tilde{\mu}^{S}_{Li^+} + \tilde{\mu}^{CB}_{e^-} = \tilde{\mu}^{MOP}_{M^{III}} + \tilde{\mu}^{MOP}_{Li^+}$$

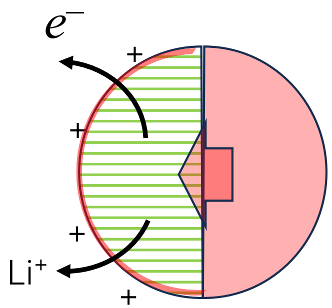
Metal Oxide Particle oxidation

Lithiated metal oxide particle





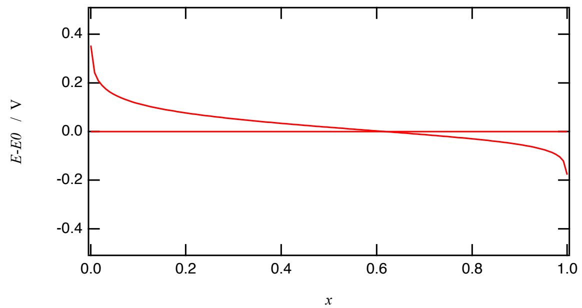
Solid solution oxidation



Biphasic oxidation

Nernst equation

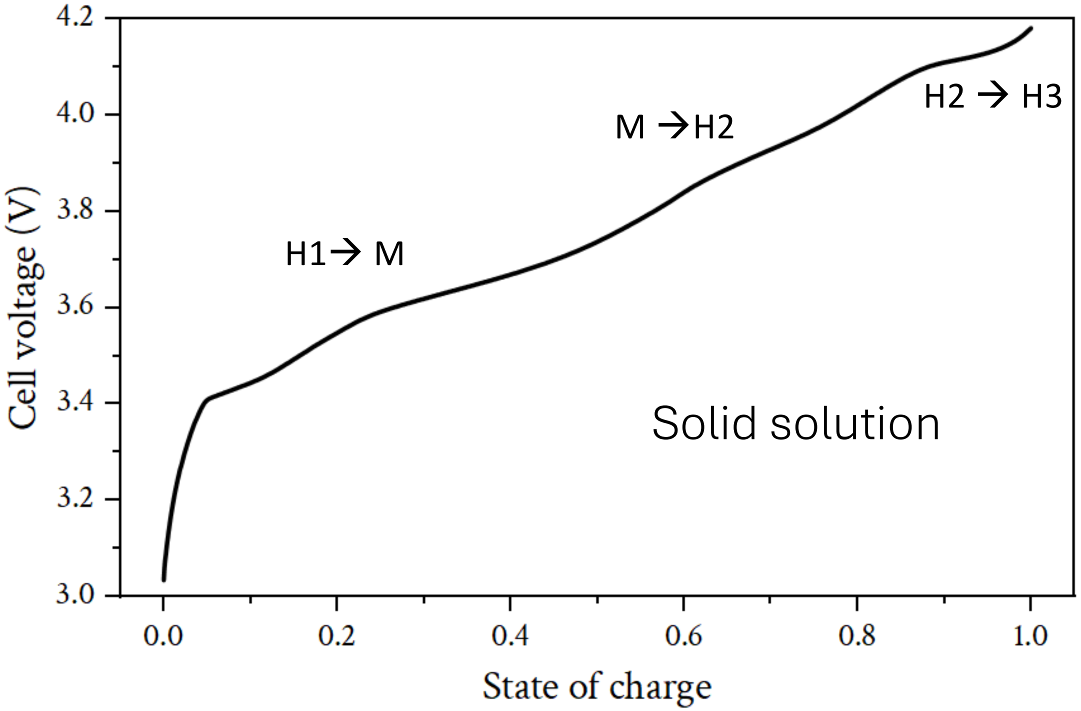
$$\left[E_{M^{IV}/M^{III}}\right]_{Li^+/Li} = \left[E^{o}_{M^{IV}/M^{III}}\right]_{Li^+/Li} + \frac{RT}{F}\ln\left[\frac{1-x}{x^2}\right]$$



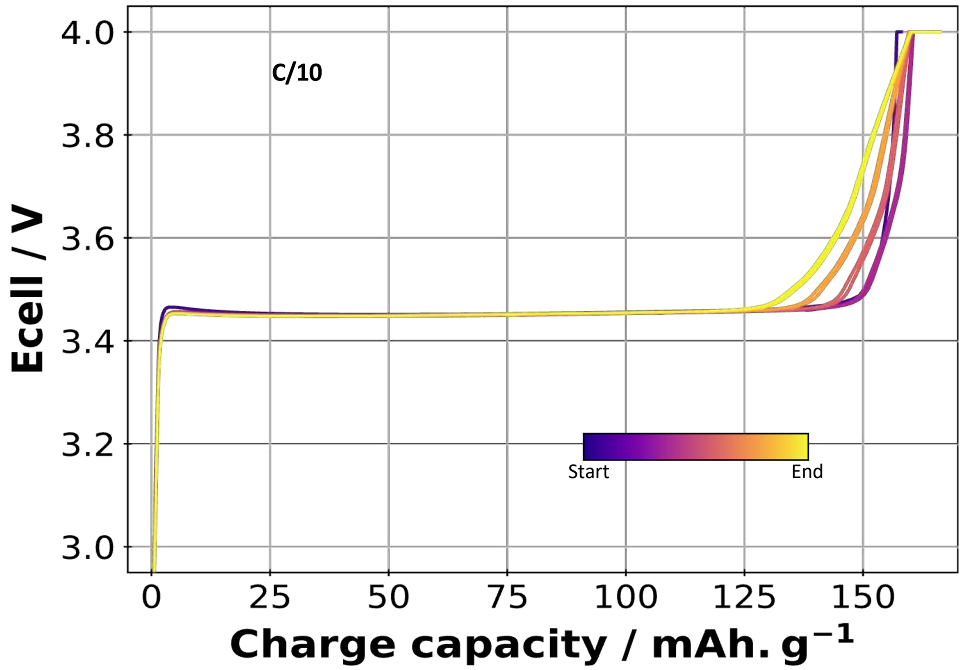
Constant potential

$$\left[E_{M^{IV}/M^{III}}\right]_{Li^+/Li} = \left[E^{o}_{M^{IV}/M^{III}}\right]_{Li^+/Li}$$

NMC811 vs Graphite



LFP vs Li

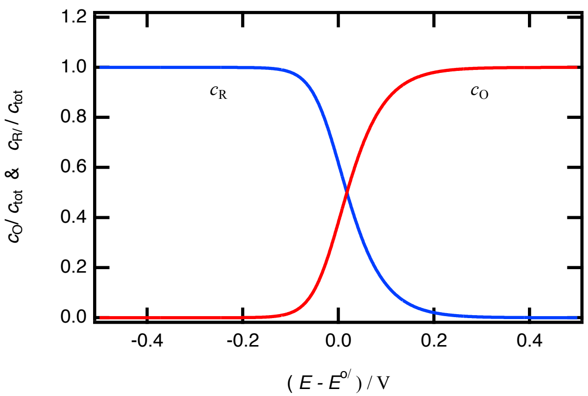


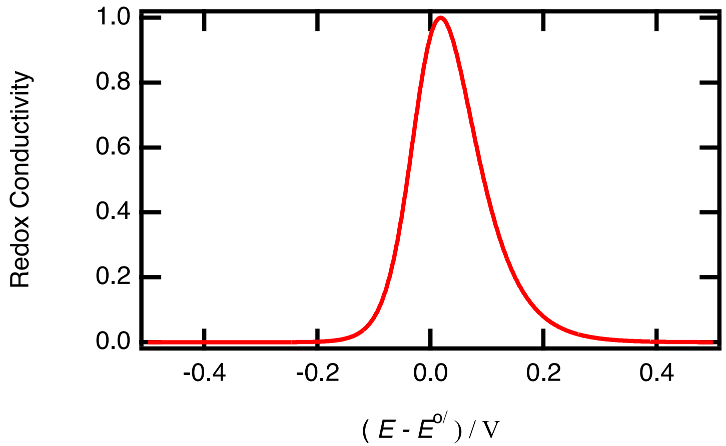
Courtesy Arno Villalbi, LEPMI

Biphasic solids

Redox conductivity in solid solutions

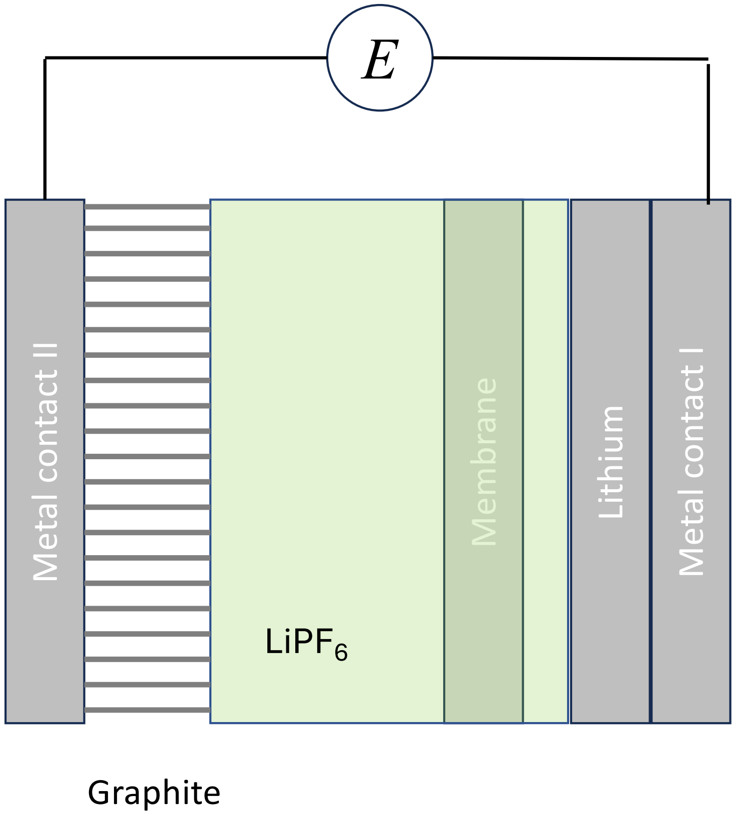
Electron hopping $$D_e = k_{ex} c_{redox}^{tot} \Delta x^2$$

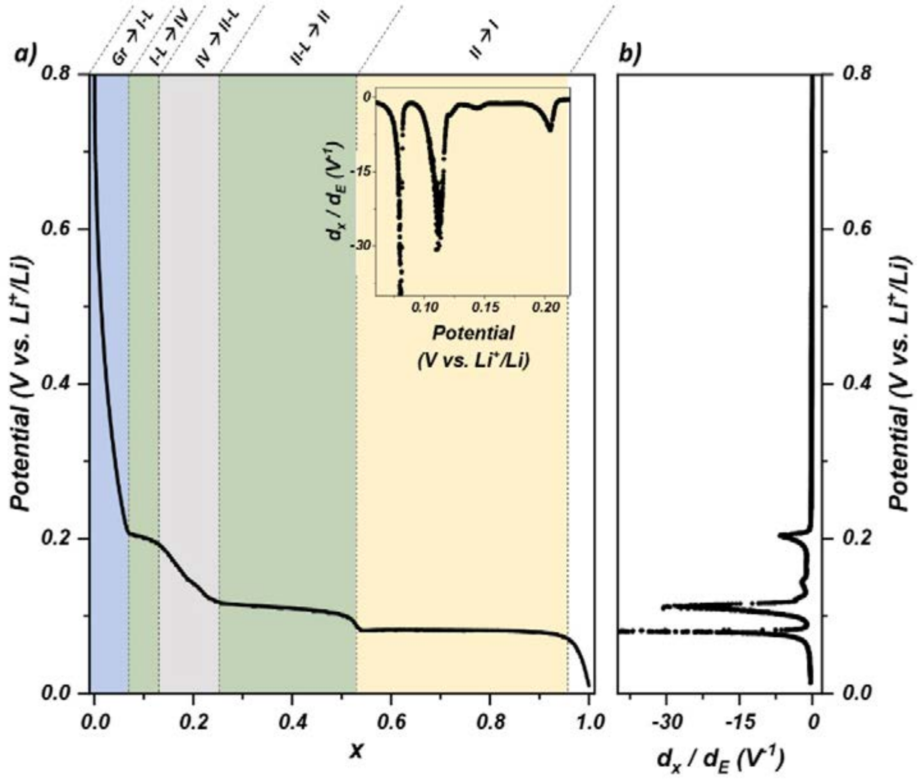




$$\sigma_{redox} = \frac{F^2 D_e}{RT} c_{red} \left(1 - \frac{c_{red}}{c_{redox}^{tot}}\right) = \frac{F^2 D_e}{RT} c_{redox}^{tot} x(1 - x)$$

"Graphite Anode"

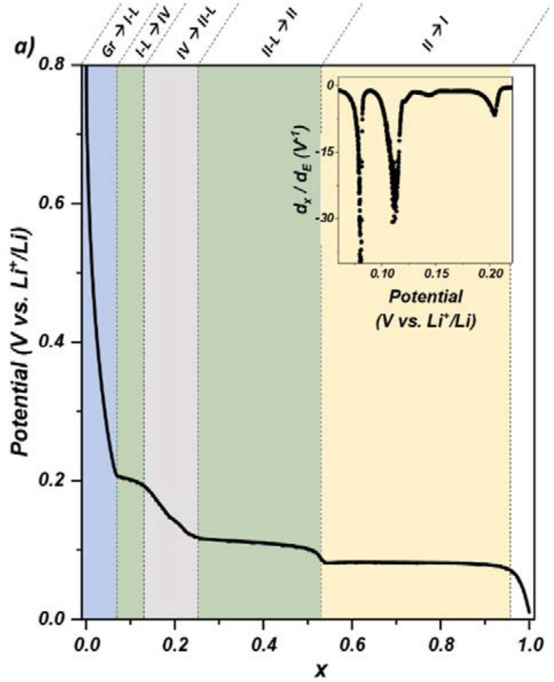


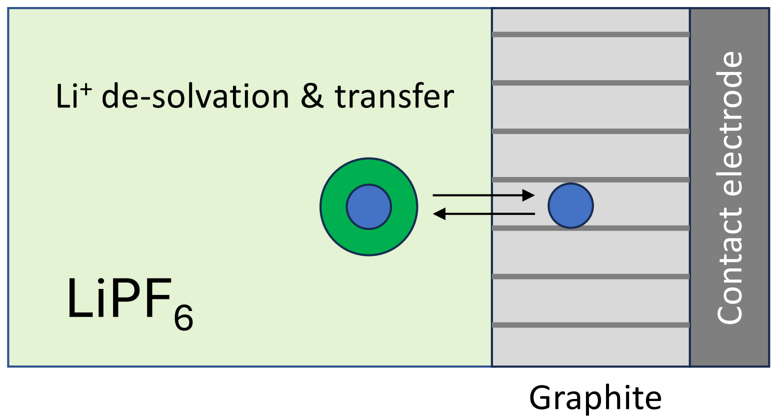


$$[E]_{\mathrm{vs\ Li^+/Li}} = \phi^{\mathrm{M^{II}}} - \phi^{\mathrm{M^{I}}} = \left(\phi^{\mathrm{G}} - \phi^{\mathrm{S}}\right) + \left(\mu_{\mathrm{Li}} - \mu^{\mathrm{o,S}}_{\mathrm{Li^+}} - \mu^{\mathrm{G}}_{e^-}\right)/F - \frac{RT}{F}\ln a^{\mathrm{S}}_{\mathrm{Li^+}}$$

First blue zone ($x < 0.08$)

Ion transfer reaction : Solid solution I-L





Nernst equation
for ion transfer reactions

$$\phi^{G} - \phi^{S} = \left(\mu^{o,S}_{Li^+} - \mu^{o,G}_{Li^+}\right)/F + \frac{RT}{F}\ln\left(\frac{a^{S}_{Li^+}}{a^{G}_{Li^+}}\right)$$

Cell potential

$$[E]_{vs\ Li^+/Li} = \left(\mu_{Li} - \mu^{o,G}_{Li^+} - \mu^{G}_{e^-}\right)/F - \frac{RT}{F}\ln a^{G}_{Li^+}$$

Potentiometric titration of silver with precipitation

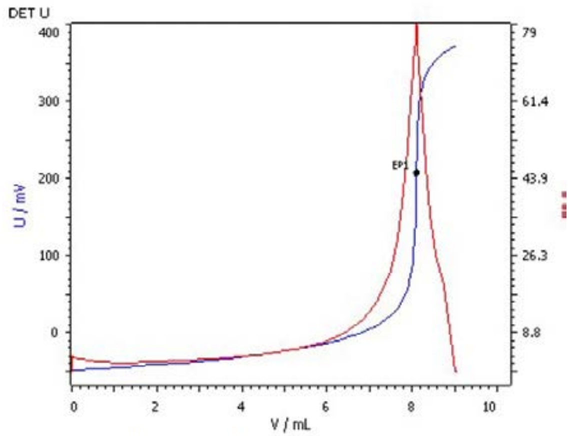


Fig. 1: Titration curve of fine silver according to EN ISO 11427

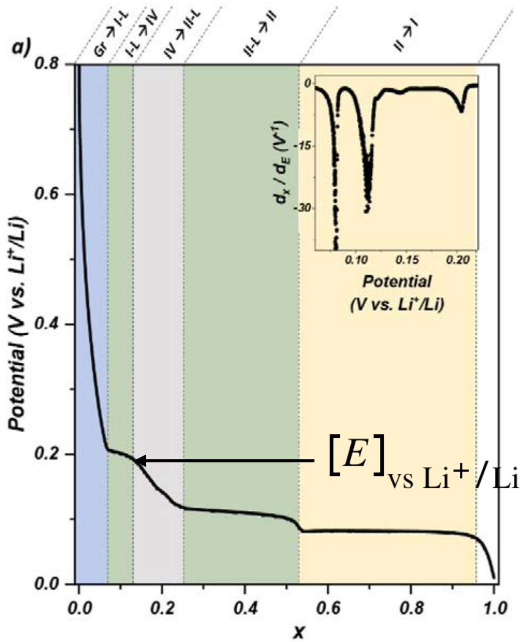
- Dissolve sample in nitric acid.
- Titrate with KCl
- AgCl precipitates
- Measure the Nernst potential of a silver electrode *vs* a reference electrode

First green zone : Precipitation of LiC_{36}

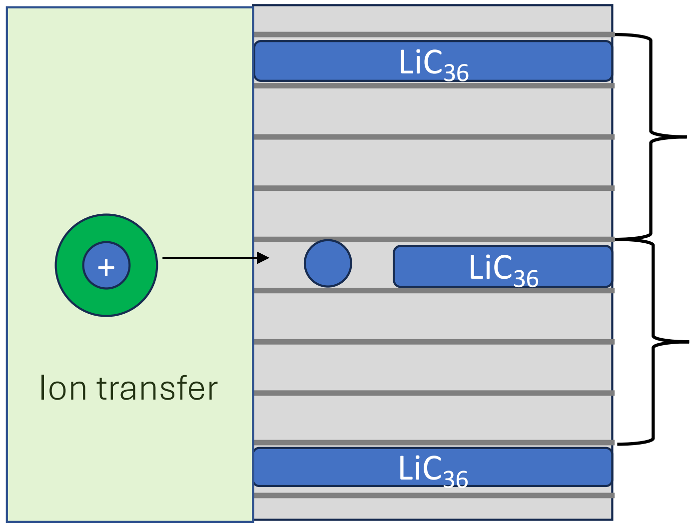
$0.08 < x < 0.16$

Titration of C_6 sites

Precipitation of LiC_{36}



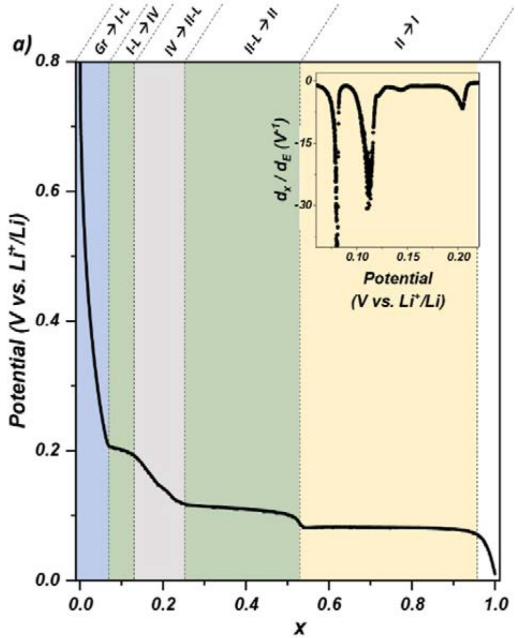
$$[E]_{\text{vs Li}^+/\text{Li}} = \left(\mu_{\text{Li}} - \mu_{\text{LiC36}} + 36\,\mu_{\text{C}}^{\text{G}}\right)/F$$



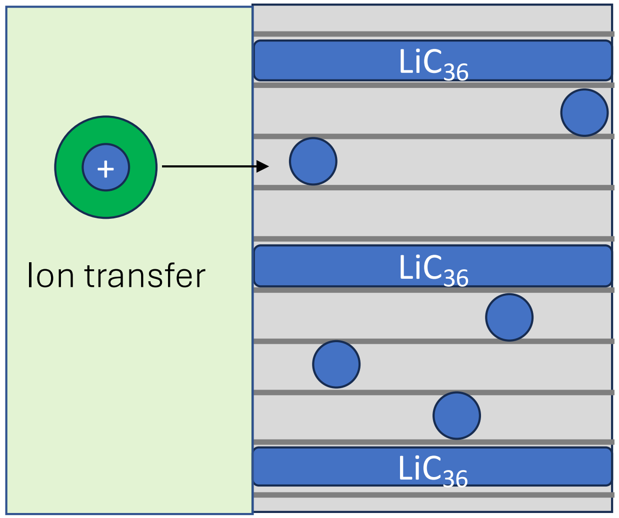
1L to Stage 4 Biphasic solid solution-solid

$$\text{Li}^{+,\text{S}} + e^{-\text{G}} + 36\,\text{C}^{\text{G}} \rightleftarrows \left[\text{Li}^{+}\text{C}_{36}^{-}\right]^{\text{LiC36}}$$

Grey zone : New solid solution 2L (0.16 < x < 0.25)



2L Solid solution formation



Stage 4 to 2L

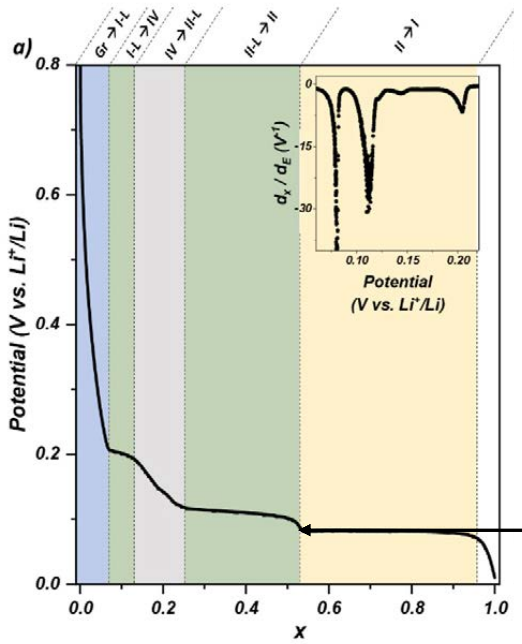
Nernst equation
for ion transfer reactions

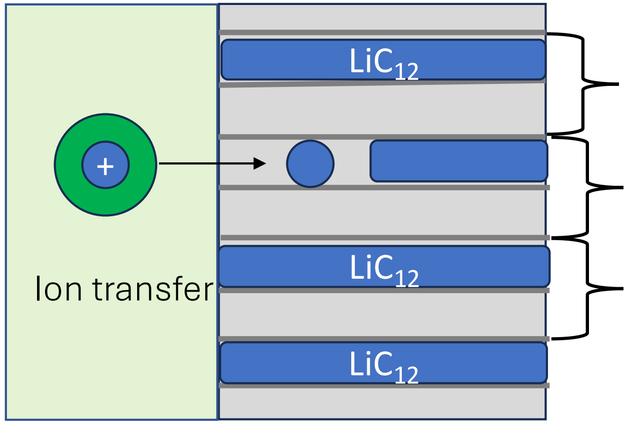
$$\phi^{G} - \phi^{S} = \left(\mu^{o,S}_{Li+} - \mu^{o,G}_{Li+}\right)/F + \frac{RT}{F}\ln\left(\frac{a^{S}_{Li+}}{a^{G}_{Li+}}\right)$$

Second green zone : Precipitation of LiC_{12}

$0.25 < x < 0.52$

Titration of C_6 sites
Precipitation of LiC_{12}





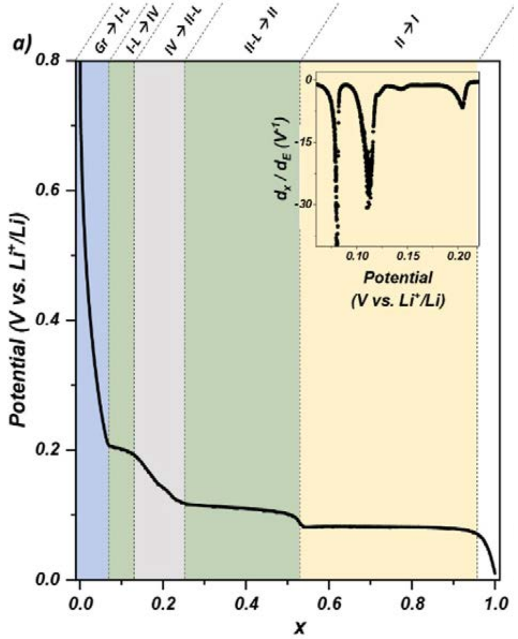
$$[E]_{\text{vs Li}^+/\text{Li}} = \left(\mu_{\text{Li}} - \mu_{\text{LiC12}} + 12\,\mu_{\text{C}}^{\text{G}}\right)/F$$

2L to Stage 2 Biphasic solid solution-solid

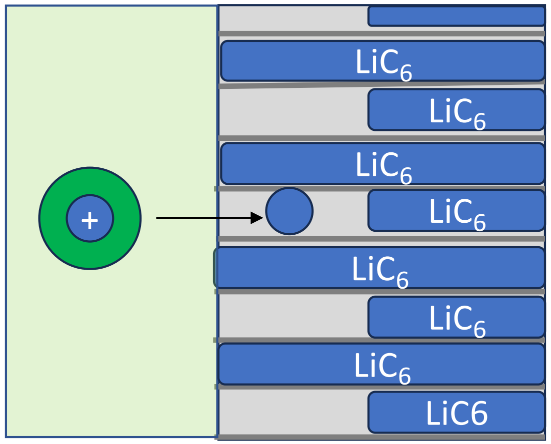
$$\text{Li}^{+,\text{S}} + e^{-\text{G}} + 12\,\text{C}^{\text{G}} \rightleftarrows \left[\text{Li}^{+\delta}\text{C}_{12}^{-\delta}\right]^{\text{LiC12}}$$

Yellow zone : Formation of LiC_6

$0.52 < x < 0.95$



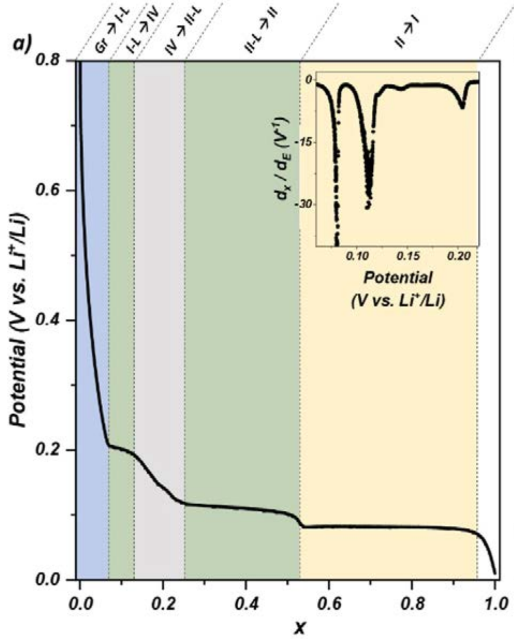
Li^+ addition on LiC_{12} to form LiC_6 domains



Stage 2 to Stage1: Biphasic solid-solid lithium insertion

Yellow zone : Formation of LiC_6

$0.52 < x < 0.95$

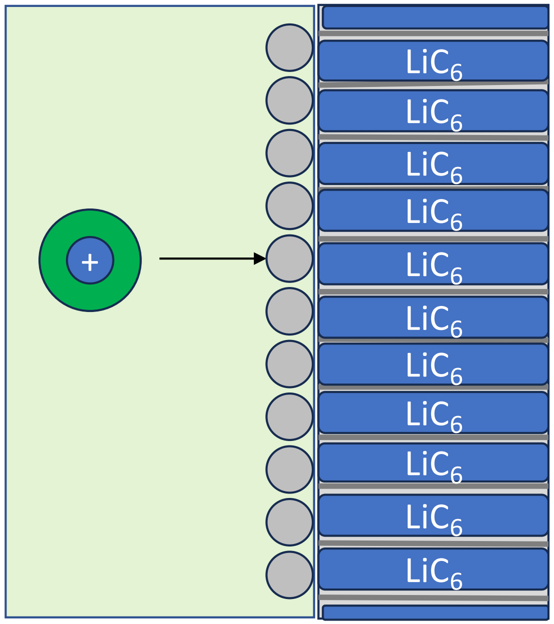


Li^+ addition on LiC_{12} to form LiC_6 domains

Stage 2 to Stage1: Biphasic solid-solid lithium insertion

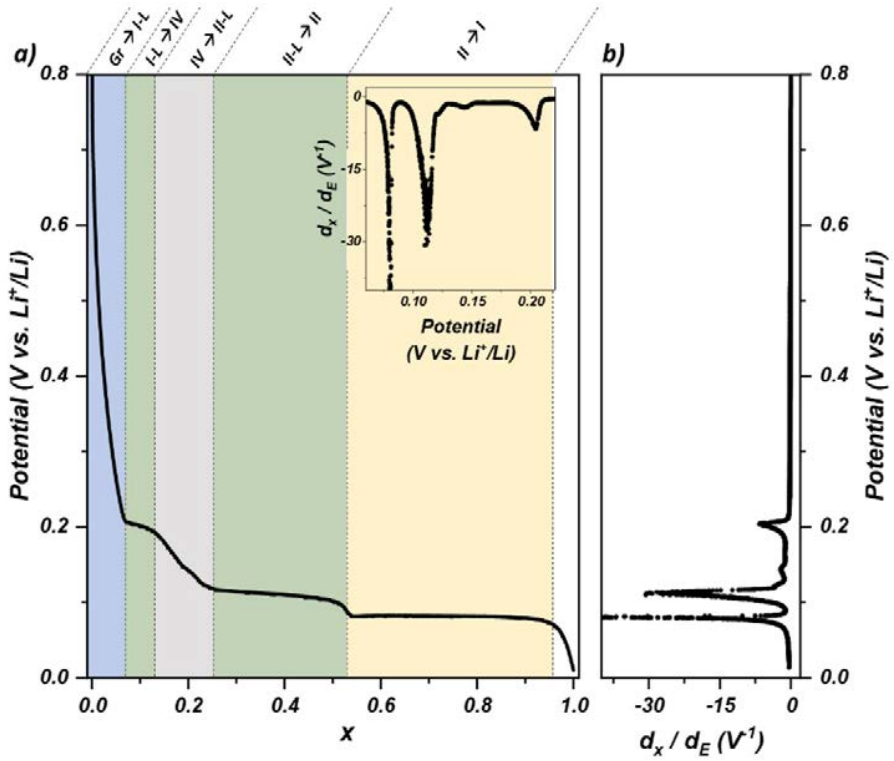
Under potential lithium metal deposition

$0.95 < x < 1.0$



Under potential deposition of Li metal on LiC_6

Potentiometric titration of graphite

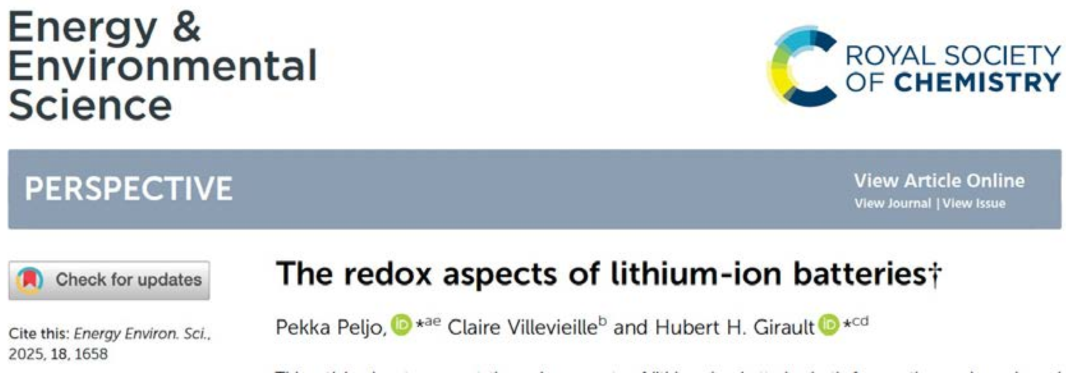


Electronic charge

1. Adsorption of solvated lithium on negatively charged graphite and intercalation of bare ions to form a solid solution I-L
2. Precipitation of LiC_{36}
3. Intercalation of bare ions to form a solid solution II-L
4. Precipitation of LiC_{12}
5. Intercalation to form LiC_6 by a solid/solid reaction
6. Electroplating of Li metal on LiC_6.

Conclusion

“Cathode material” : Redox reactions with ion insertion.
Redox conductivity in solid solutions


Energy & Environmental Science

ROYAL SOCIETY OF CHEMISTRY

PERSPECTIVE

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Cite this: *Energy Environ. Sci.*, 2025, 18, 1658

The redox aspects of lithium-ion batteries†

Pekka Peljo, [*ae] Claire Villevieille[b] and Hubert H. Girault [*cd]

Graphite : No redox reactions as neither lithium nor carbon change their degree of oxidation. “Volumic capacitor”

Definitions- IUPAC Gold book

oxidation

Online use...

https://doi.org/10.1351/goldbook.O04362

1. The complete, net removal of one or more electrons from a molecular entity (also called 'de-electronation').
2. An increase in the oxidation number of any atom within any substrate.
3. Gain of oxygen and/or loss of hydrogen of an organic substrate.

reduction

Online use...

https://doi.org/10.1351/goldbook.R05222 Copy

The complete transfer of one or more electrons to a molecular entity (also called 'electronation'), and, more generally, the reverse of the processes described under oxidation (2) and (3).

Conclusion : *Stricto sensu* graphite is not an anode as long as lithium plating does not occur

INTERNATIONAL UNION OF PURE AND APPLIED CHEMISTRY

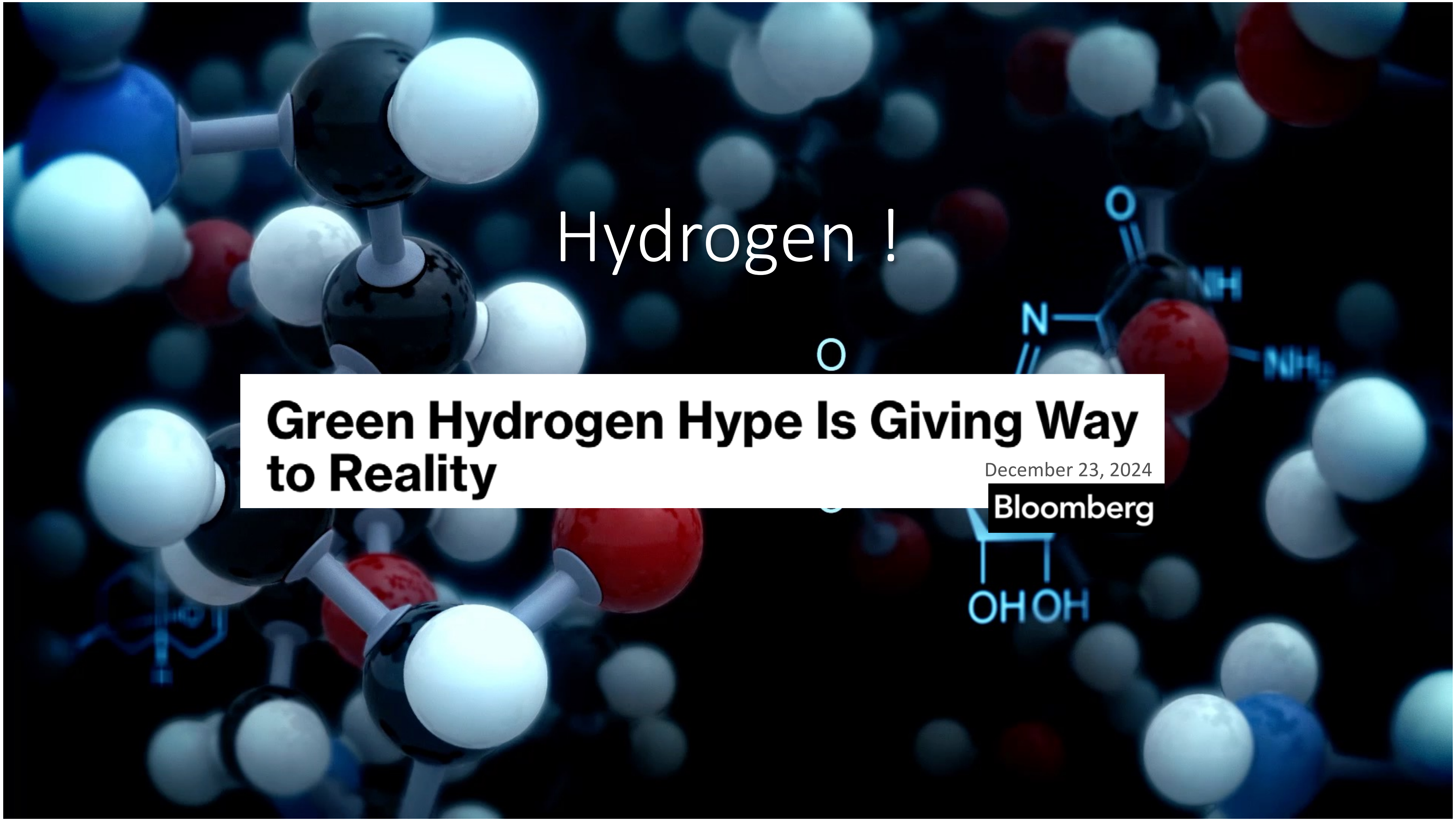
Battery Definition

Batteries are devices that store energy to later be converted into electricity using chemical reactions. During discharge of a battery, the anode undergoes an oxidation reaction, which produces electrons, and the cathode undergoes a reduction reaction, which absorbs electrons.

In 1746–1748, Benjamin Franklin experimented with charging Leyden jars in series and developed a system involving 11 panes of glass with thin lead plates glued on each side and then connected together. He used the term "**electrical battery**" to describe his electrostatic battery in a 1749 letter about his electrical research in 1748. It is possible that Franklin's choice of the word battery was inspired by the humorous wordplay at the conclusion of his letter, where he wrote, among other things, about a salute to electrical researchers from a battery of guns. This is the first recorded use of the term electrical battery. Wikipedia

Plan

- Potentials and redox reactions
- Li-ion battery
- Water electrolysis


Hydrogen !
Green Hydrogen Hype Is Giving Way to Reality
December 23, 2024
Bloomberg

Hydrogen : Electron storage molecule !

Base Chemical → Green Ammonia → Green Methanol → Green Steel → SAF

Fuel for → Aerospace → Aviation → Heavy mobility → Storage

Can play a major role in electric grid regulation.

Being paid to produce hydrogen and remove electrons from the grid !

Different electrolysis technologies for different markets

Hydrogen production in 1899

Schmidt, O. (1899)
Apparat zur Elektrolysevon Wasser. Patent DE 111,131, Jun.13, 1899.

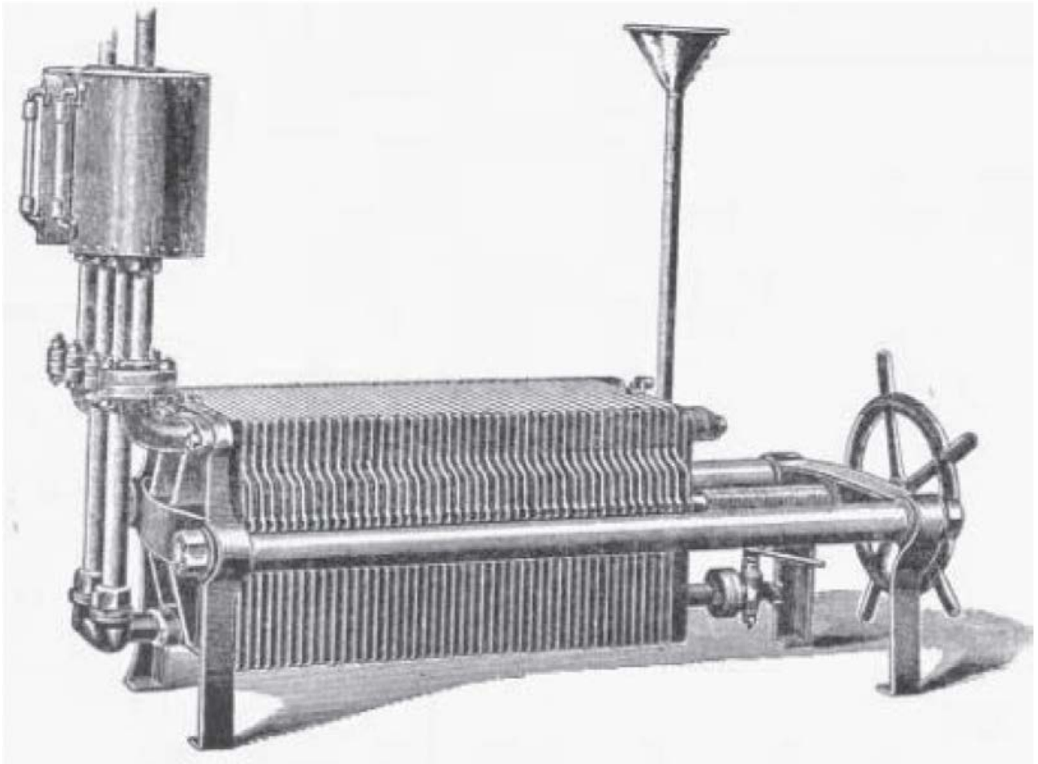
Bipolar filter-press electrolyser with asbestos cloth diaphragm

2.5 V per cell

Current ranging from 15 A to 150 A

Oerlikon, Zurich, Switzerland

Voltage control (no thyristors yet...)
Dynamos

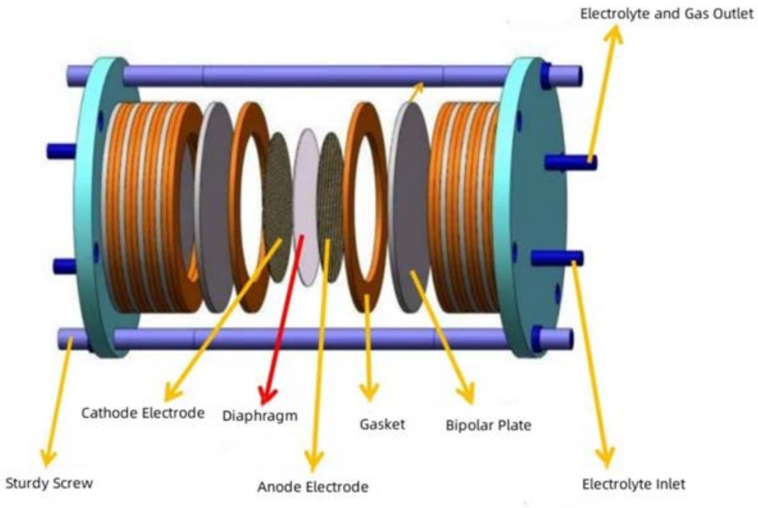


Nicolas Guillet and Pierre Millet in Hydrogen Production: by Electrolysis, First Edition. Edited by Agata Godula-Jopek.

Hydrogen production in 1905: Norsk Hydro

The Vemork power plant, had six floors housing more than 300 Pechkranz electrolyzers. The stacks consisted of 140 cells operated at 2.5 kA with approx. 2.5V/cell (262.5 MW). The plant could produce 43500 Nm^3 of hydrogen in one hour (3.9 tons H_2/h compared to 5.2 today).

Alkaline electrolysers today



Alkaline Electrolyzer structure

Incremental progresses

Still mainly bipolar electrodes
Still circular electrodes (mostly..)
Still operating at up to 30 bars and 80°C
Membranes :

- PPS with inorganic fillers
- Ion solvating membrane

Catalysts :

- Nickel based
- PGM

Key drawbacks:

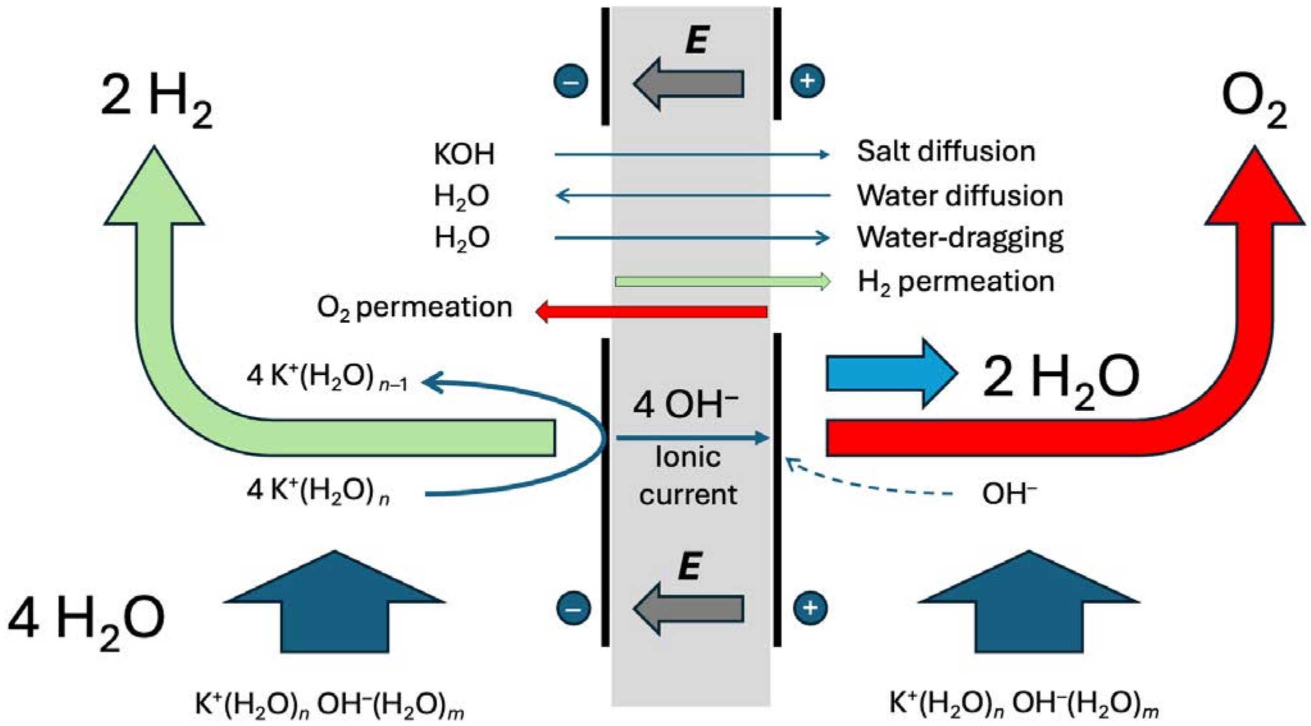
- Bubbles
- Plant corrosion

Key advantages:

- Robust and proven

All in all, a chemical plant...
to operate at steady-state

Alkaline water electrolysis: Where is the water?

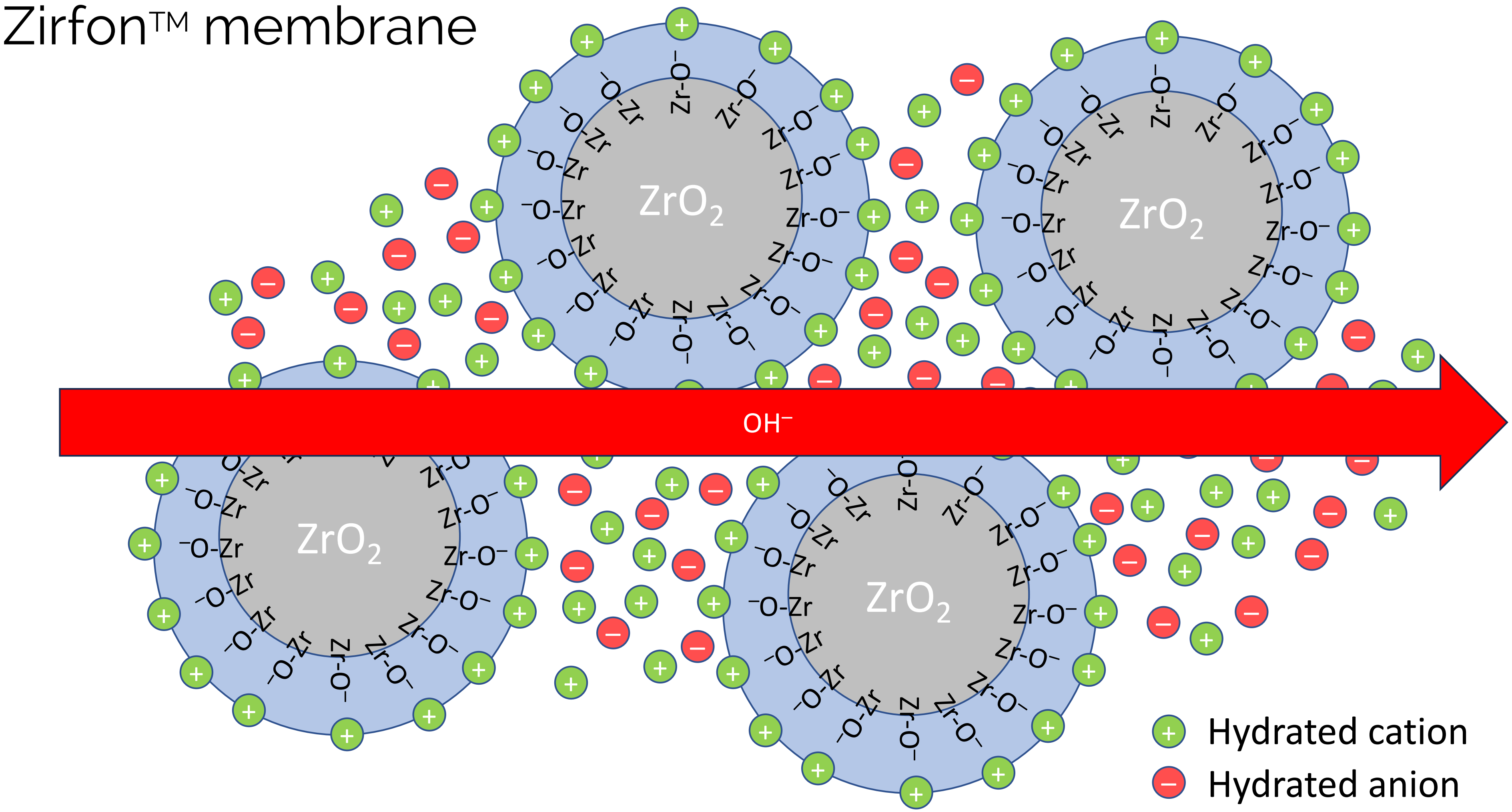


Research
A SCIENCE PARTNER JOURNAL

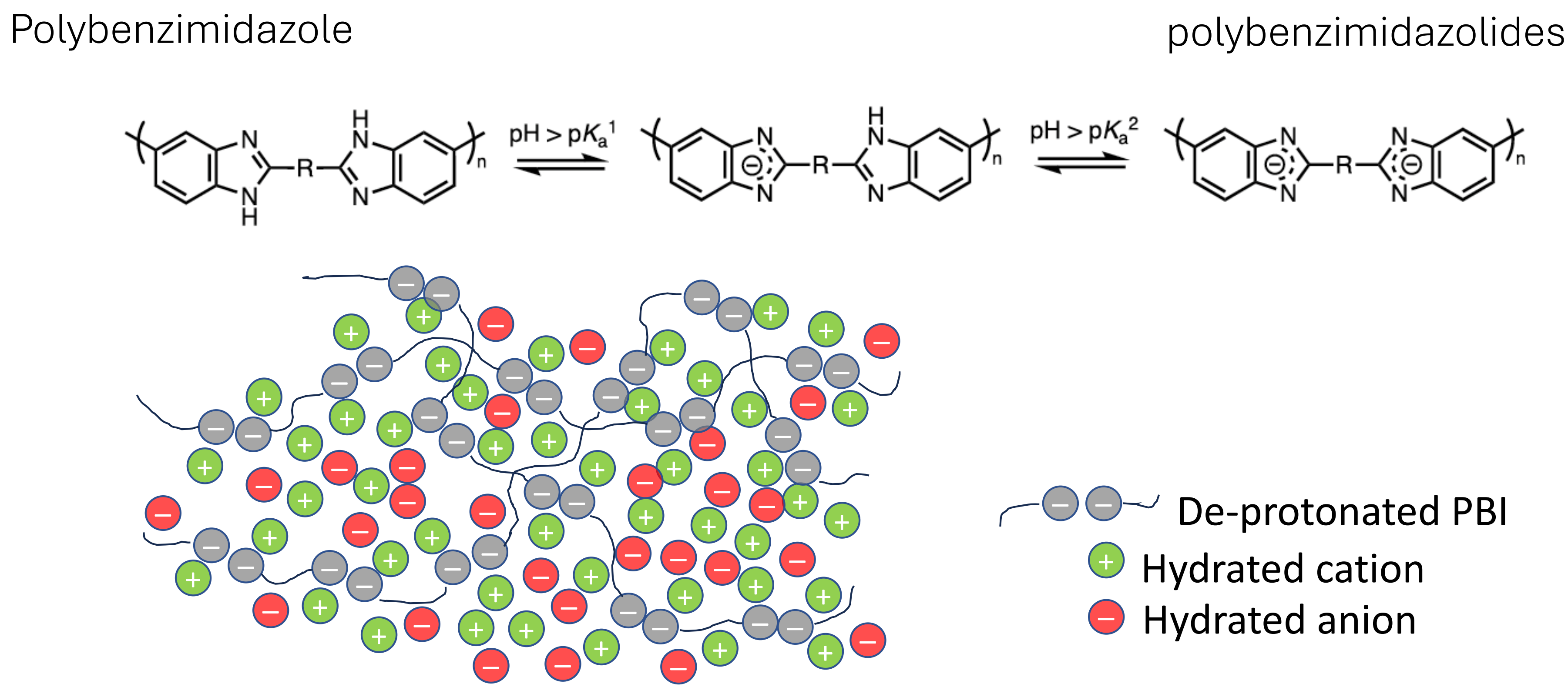
Ionic Transport Aspects of Water Electrolysis in Alkaline Media.

F. El Bachraoui, D. Aymé-Perrot and H.H. Girault

AAAS


Zirfon™ membrane
ZrO2
OH⁻
Hydrated cation
Hydrated anion

Ion solvating membrane



Sinopec
Solar to Hydrogen

300 MW solar
618 GWh/year
2000 hours/year

20'000
tonnes H_2/year

52 electrolysers
13 from :
Cockerill JingLi
Longi
PERIC

By Global Times
Published: Aug 08, 2023 09:27 PM

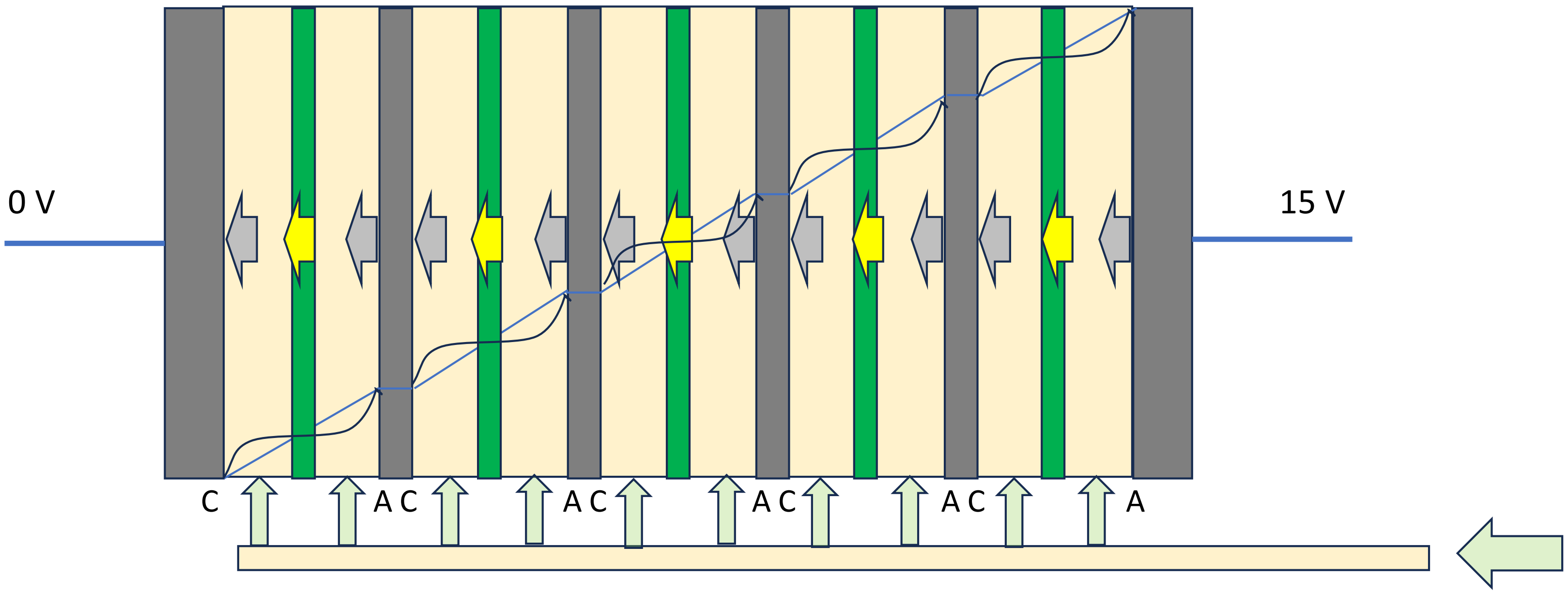
The photo shows the green hydrogen demonstration project in Kuqa city, Northwest China's Xinjiang Uygur Autonomous Region on July 11, 2023. The project marks the first one in China utilizing photovoltaic power to directly generate hydrogen on a large scale with a total investment of 3 billion yuan ($416.66 million) and can help reduce carbon dioxide emissions by 485,000 tons annually. Photo: VCG https://www.hydrogeninsight.com/production/exclusive-worlds-largest-green-hydrogen-project-has-major-problems-due-to-its-chinese-electrolysers-bnef/2-1-1566679

EXCLUSIVE | World's largest green hydrogen project 'has major problems due to its Chinese electrolysers': BNEF

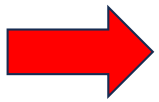
All the electrolysers at Sinopec's 260MW Kuqa facility in China — made by three prominent manufacturers — have safety issues related to renewable-energy fluctuations, says analyst

11 December 2023 8:57 GMT *UPDATED 12 December 2023 13:35 GMT*

Bipolar stack

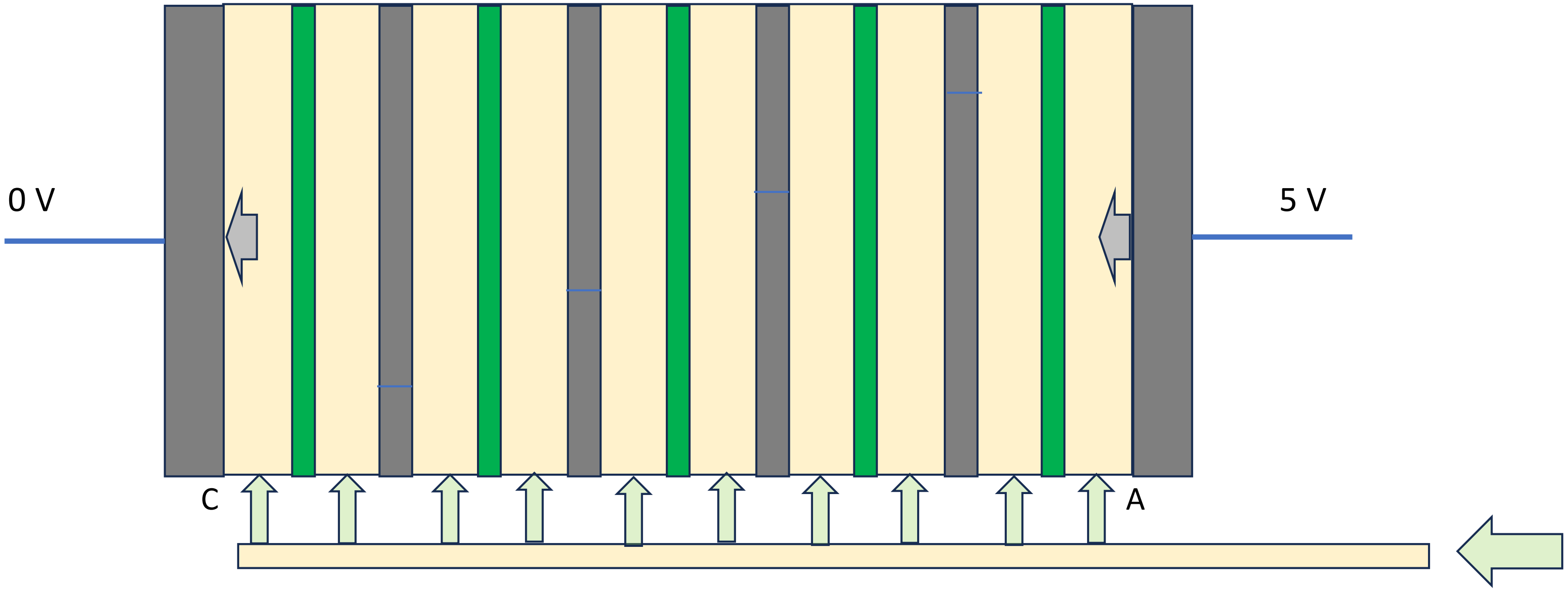


Continuity of current
Electroneutrality



- No control of individual cell voltage
- Inhomogeneous membrane resistance
- Inhomogeneous current distribution on a single bipolar plate

Bipolar stack – Shunt current



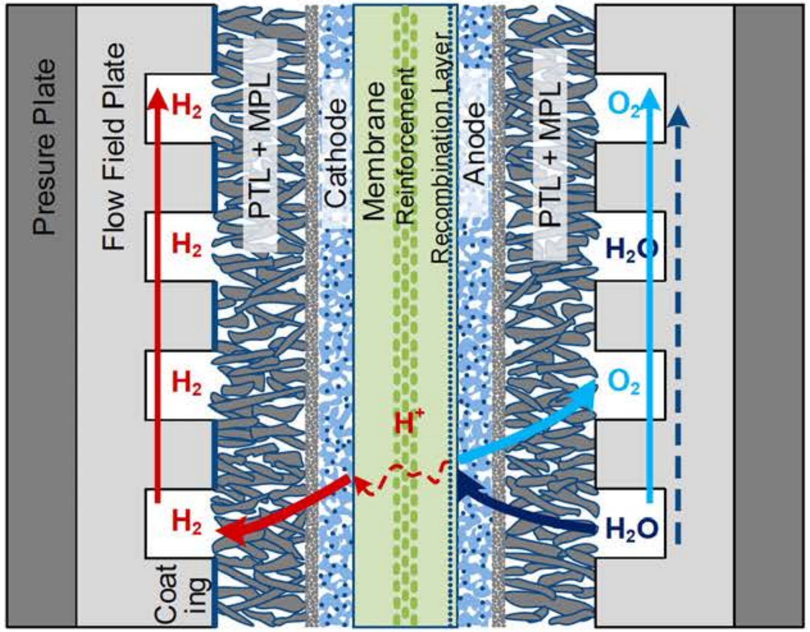
What happens when the stack voltage drops to 5 V?

PEM water electrolysis

October 17, 2023

THE TIMES

PEM electrolysis : Is it sustainable?



Cross section of an advanced PEM electrolysis cell

PTL: Porous Transport Layer (GDL in fuel cell)
MPL: MicroPorous Layer

Fraunhofer Institute for Solar Energy Systems ISE - October 2021

Incremental progresses

Still bipolar electrodes
Still rectangular electrodes (mostly..)
Still operating at up to 30 bars and 60°C
Membranes :
- Still Nafion analogs..PFAS

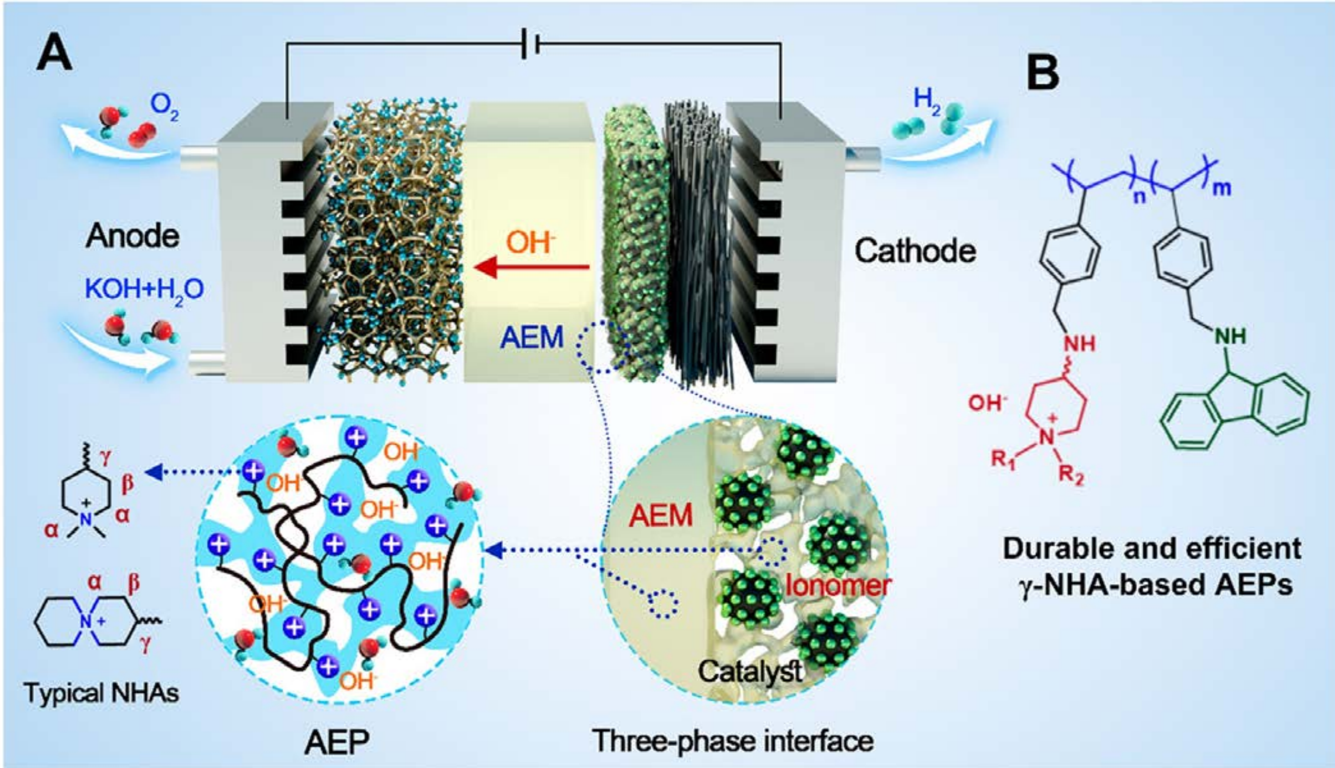
Catalysts :
- Still PGM, e.g. IrO_2
- Ionomers

Key advantages:
- Compact
- Clean
- Flexible

Key drawbacks :
- Acidic environment
- High oxidation potentials
- Nanoparticles dissolution and precipitation

Robust Piperidinium-Enriched Polystyrene Ionomers for Anion Exchange Membrane Fuel Cells and Water Electrolyzers

NiFeOOH Ni foam anode   Pt/C cathode   Ni bipolar plates



Xile Hu

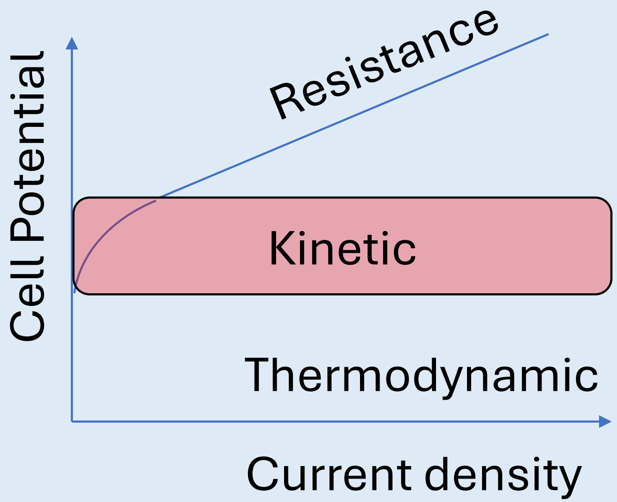
NovaMea

The cell can be run stably at 2 or 3 A ·cm^{-2} over 1,100 h in 1 M KOH

ACS Energy Lett. 2023, 8, 4043−4051

EPFL

Water electrolysis : What to improve?



Membranes

Electrocatalysts

Temperature

The plant control

Alkaline electrolysers for large systems (> 5MW)
PEM electrolysers for intermittent systems (< 5MW)

AEM electrolysers may replace PEM electrolysers

Conclusion

Electrochemistry is a fundamental science at the heart of the electrification of our modern societies.

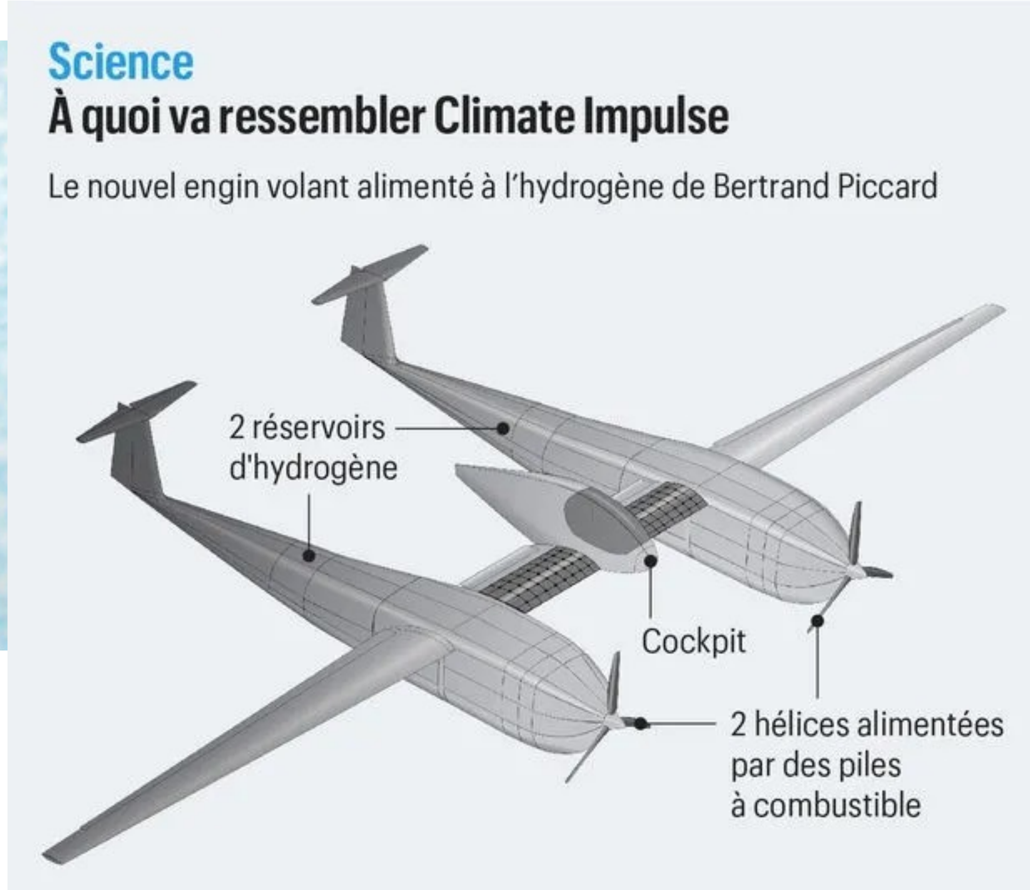
It has important applications in:

- Iontronics
- Energy storage
- Hydrogen production
- Chemical production e.g. Chlorine
- Electrometallurgy e.g. Aluminium
- Production of acids and bases for extractive industries
- …

From fundamental science to race track...

Green GT
Hydrogen Pioneers

CLIMATE IMPULSE



Thank you!

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11-09-2024