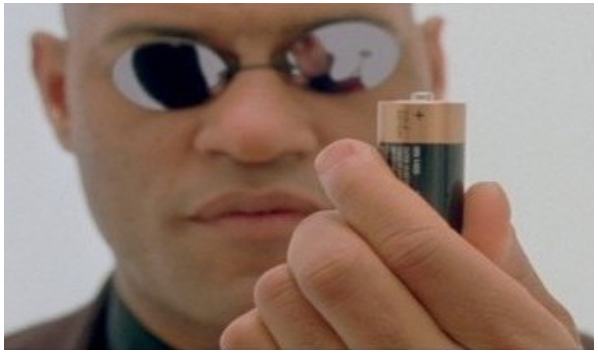
M3D3: Cathode construction

1. Quiz
2. Prelab Discussion
3. Construct cathode material (Belcher Lab)
4. Research Proposal Peer Review Exercise



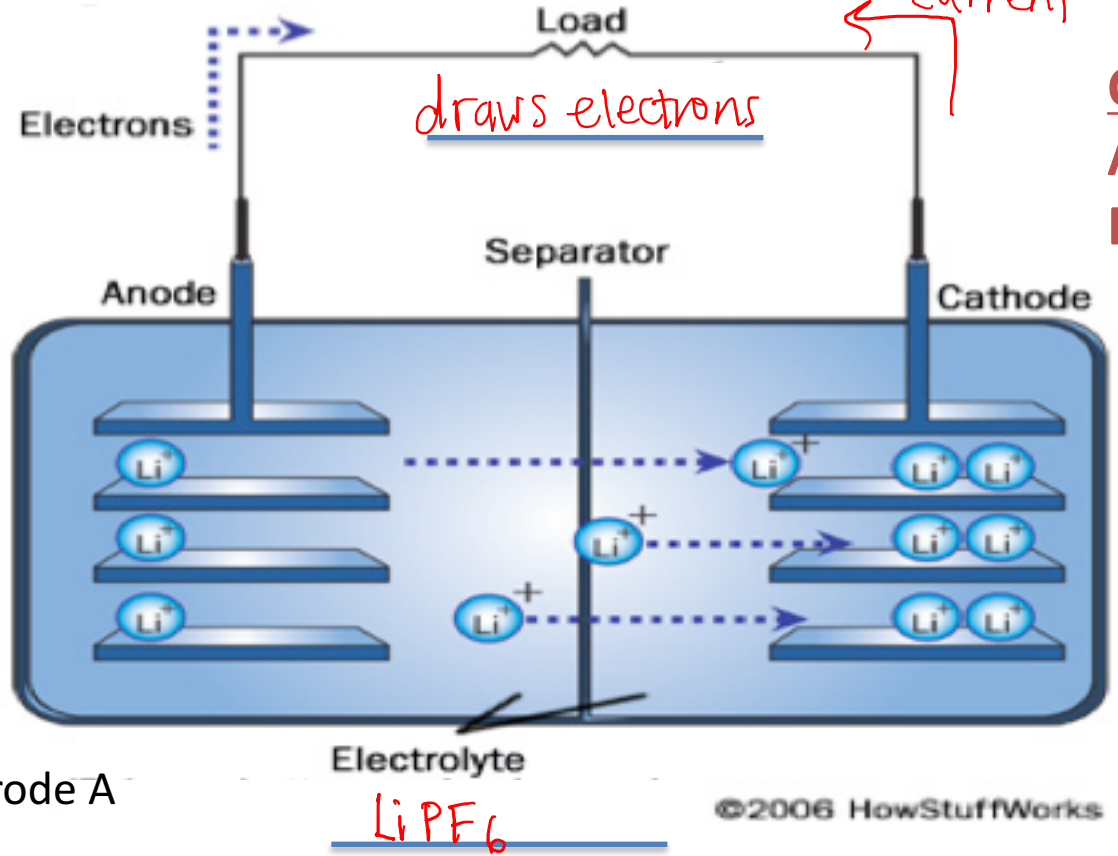
- ***M3 major assignments***
  - Research proposal (20%), slides due 12/6 at 1pm
    - **This is <1.5 weeks away**
    - **Work on this Today!**
  - Mini-report (5%), due 12/10 at 10pm

- **M3D4 Homework,** **Both parts submitted as a team**
  - Research Proposal Presentation outline (wiki, google doc, benchling)
    - ***Address topics in HW prompt for full credit***
  - Outline Background and Approach for mini-report ***with references***
    - http://belcherlab.mit.edu/publications/

Is this battery discharging or charging?

current

Anode:
Lithium
metal



Cathode:
AuNPs
Fe(III) PO_4

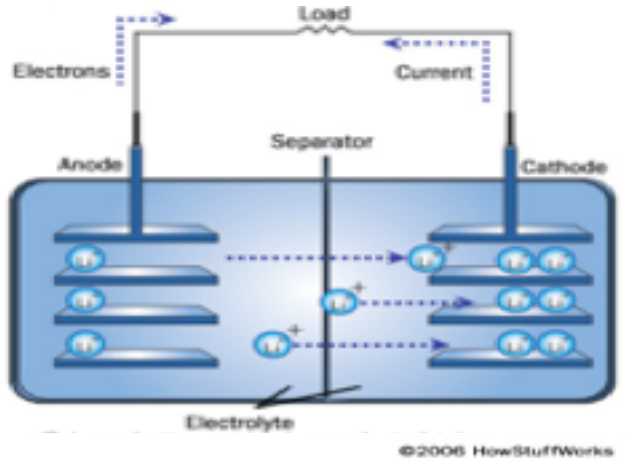
Li^+
Fe(II)PO4

Electrode A

Electrode B

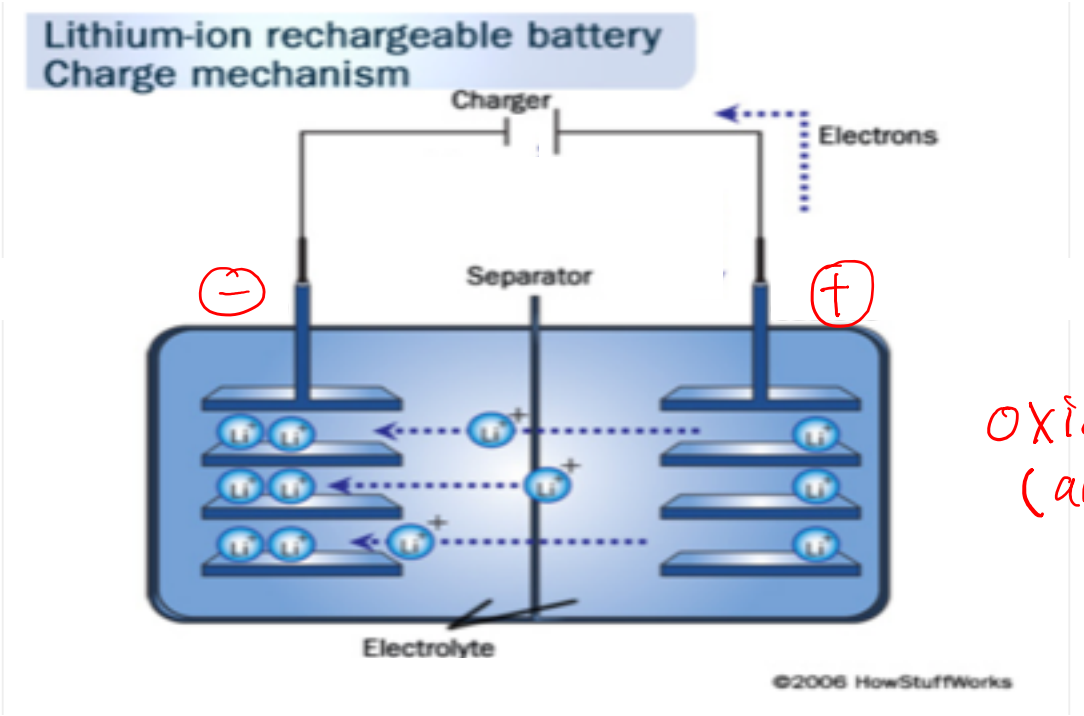
Cathode is (+) During Spontaneous Discharge

- Oxidation/Reduction occurs at the cathode (accepts e-)
- Oxidation/Reduction occurs at the anode (donates e-)
- *Electrons* flow from + / — to + / —
- During discharge, Electrode B is the cathode and is positively charged.



Electrode A Electrode B

During (re)charge, electron flow is reversed



Reduction (cathode)

oxidation (anode)

Electrode A

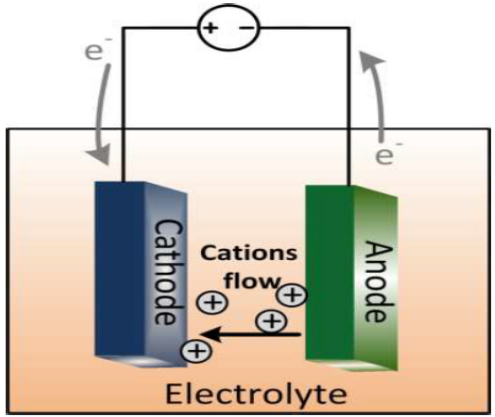
Electrode B

NOVA documentary:
“Search for the Super Battery”

https://youtu.be/a4McN9OYDwg?t=770

What is battery capacity?

$A = \frac{C}{s}$



from Dr. Maryam Moradi

- Quantity of electricity (charge) involved for the electrochemical reaction between the active materials in the battery
- For our Fe(III)-phage batteries, the theoretical (gravimetric) specific capacity is 178 mA*h/g
- Units: $\left(\frac{\text{charge}}{\text{time}}\right)\left(\frac{\text{time}}{\text{mass}}\right) = \frac{\text{charge}}{\text{mass}}$
- Capacity calculated from
  - total # of electrons that can be accepted
  - charge of those electrons
  - and atomic mass
- Why will our batteries not achieve theoretical specific capacity?

additional mass in denominator from additives (phage, gold, teflon...).

How do phage scaffolds improve batteries?

- Ion diffusivity → nano structuring active material
  - What is the advantage of nano structures?

    higher surface area : volume ratio
- Electronic Conductivity → integrating additives
  - How do phage improve integration of additives?

    • binding of phage to additives

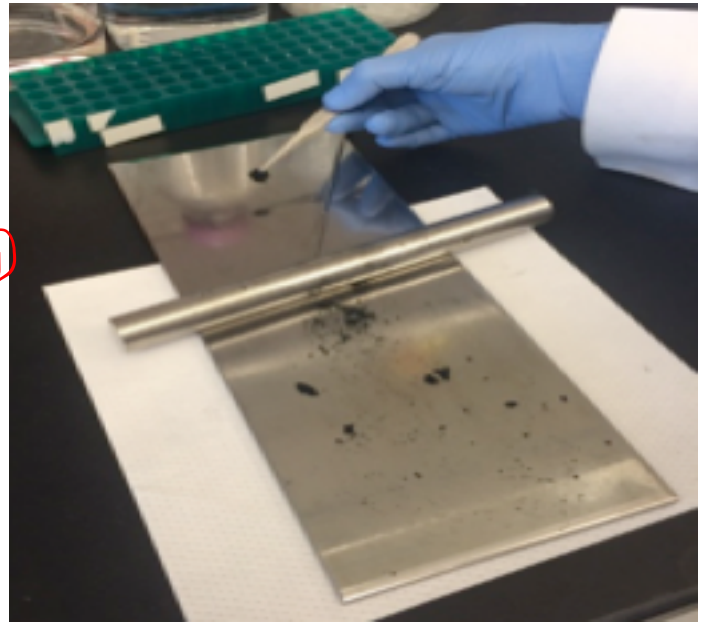
    • ability to select binding properties via phage display

Example: Adding carbon nanotubes to phage cathode

from M.Moradi

How will you construct your cathode?

1. Weigh AuNP-Fe(III)-phage nanowires (active material)
2. Mix with Super P (carbon material, increase conductivity) and PTFE (binder)
3. Roll cathode material into thin sheet
4. 'Punch out' cathode disc
5. Weigh cathode (why?)
6. Dry cathode (why?)



→ - make sure it fits / control amount in cathode
- calculate theoretical capacity

→ improve binding (remove unwanted solvents)

Today in lab…

Note: Likely to choose M3D3 for notebook grading:
Include cathode weights & notes from peer review

1. Construct cathode Belcher lab
   - Bring lab coat and eye protection
   - Bring a notebook and something to write with
2. Research proposal peer exercise
   - Everyone must be the “presenter” and “listener” at least once
   - Partner assignments will depend on timing of cathode construction

➢ M3D4HW: (see slide 2) You cannot make major changes to your research proposal idea after Friday (11/30)!