M3D5: Battery assembly and testing

12/6/2017

1. LAST Quiz!
2. LAST Prelab Discussion
3. Battery assembly demo: Belcher lab
4. Calculate battery capacity and upload to wiki, refine research proposal and draft figures for mini-report

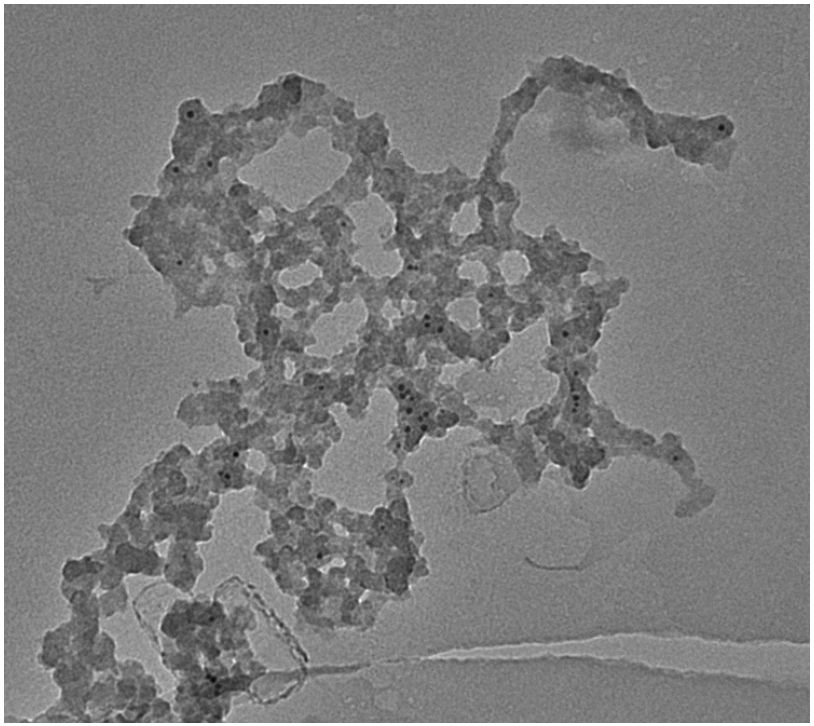
The final countdown…

- Lab notebook entry
  - M3D1 graded by Eric, **due 10pm tonight**
- M3 research proposal
  - Slides due on Stellar Friday, Dec 8th at 1pm
  - Bring one print-out of your slides to 16-336
- M3 mini-report
  - Due on Stellar at 10pm Monday, Dec. 11th
  - Title, background & approach, (no methods, no abstract)
  - Possible figures: TEM images, EDX plot , EDX images, charge/discharge plot, theoretical & actual capacity value for your batteries, class-wide data analysis
  - Short context/future works
- Blog posts
  - Due Friday, Dec. 8th 10 pm
  - Bonus: due Tuesday, Dec. 12th at 10 pm

Figure: TEM images

- At low magnification:
  - extent of biomineralization
  - distribution of gold/nickel
  - overall structure & density
  - uniformity
  - length of nanowires

- At high magnification:
  - size of gold nanoparticles
  - lattice of gold/nickel atoms
  - amorphous *vs*. crystal Fe(III)PO_4
  - diameter of nanowires



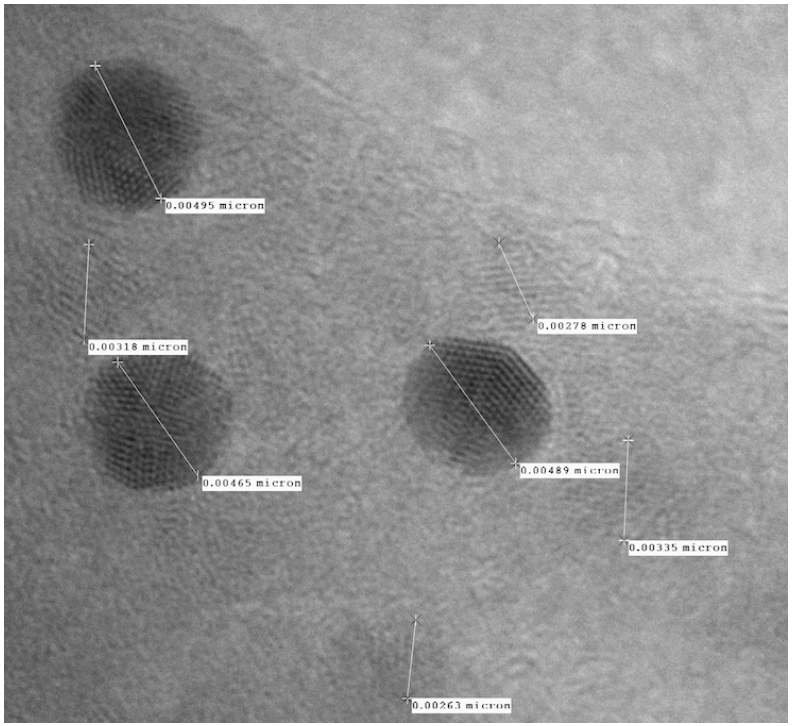
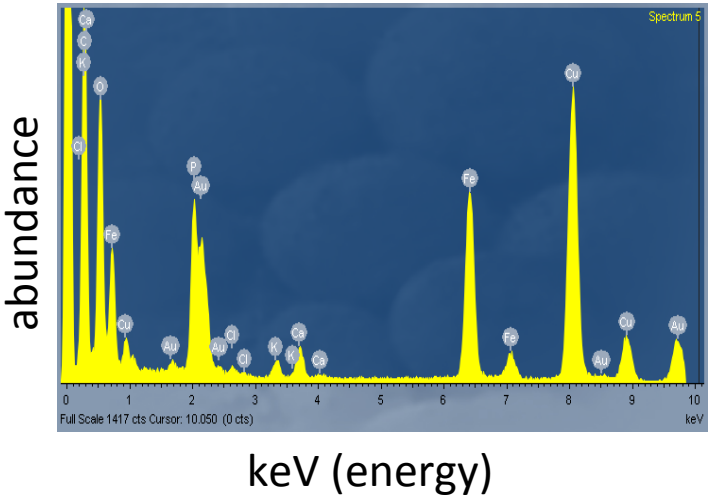
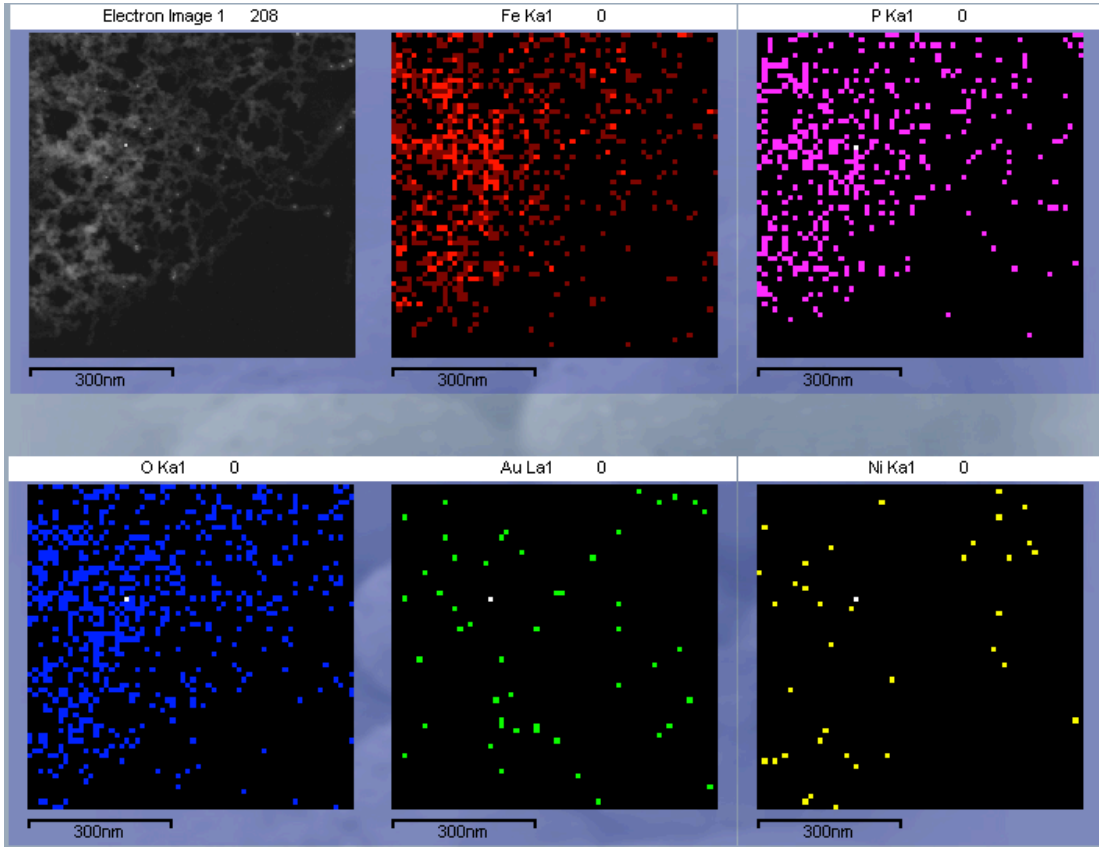


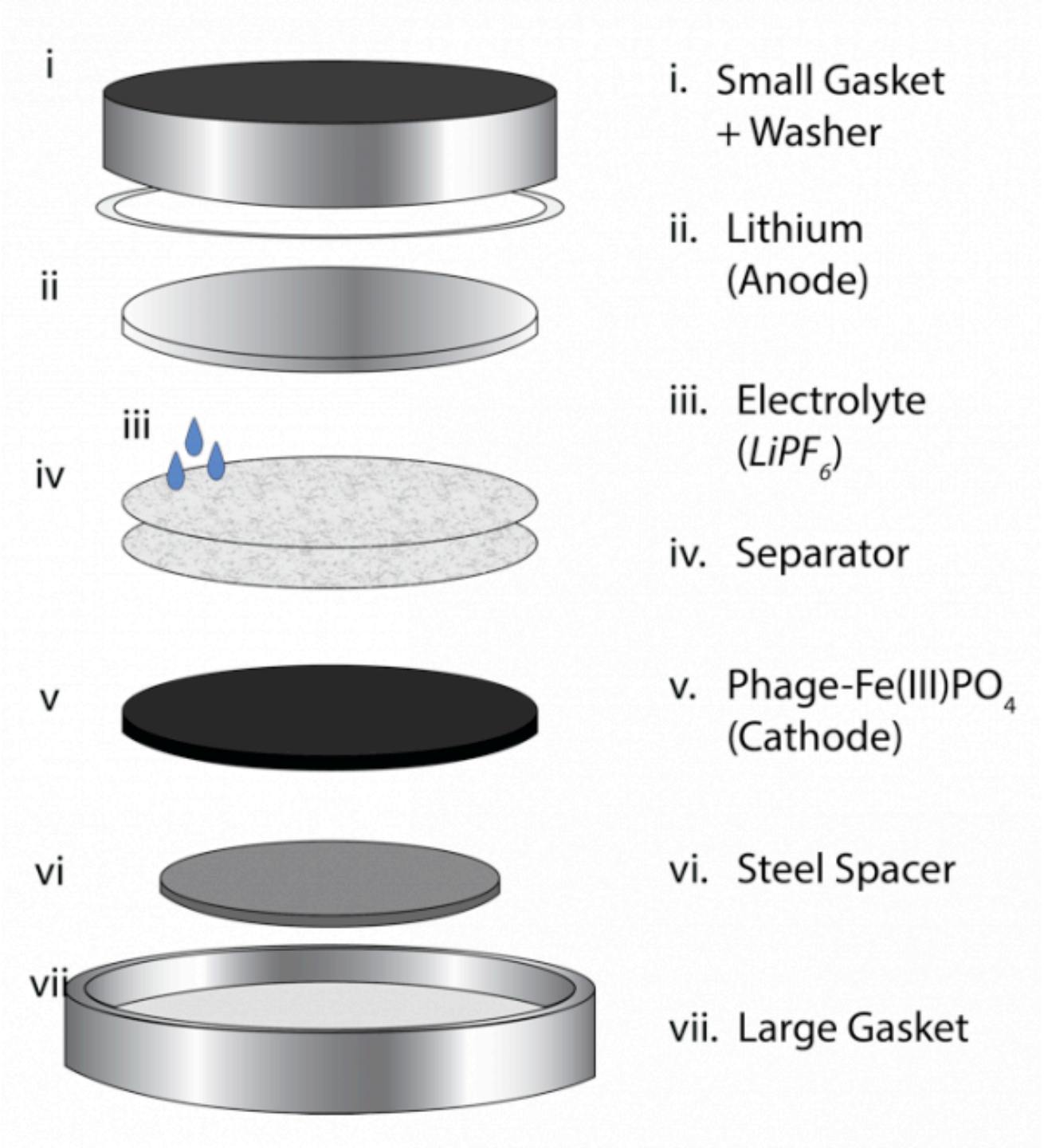
Figure: EDX elemental mapping

- Expected: Fe, P, O, Au, (Cu)
  - contamination? Na, Cl, K
  - stoichiometric ratios?

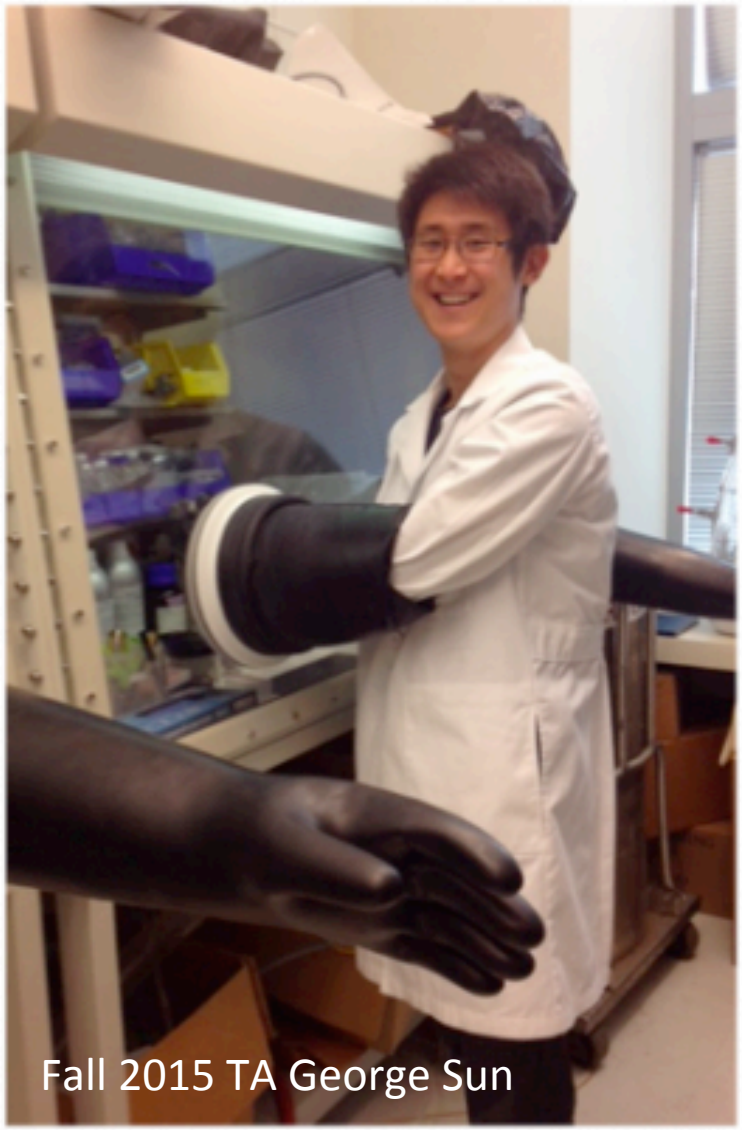




Today: Battery assembly

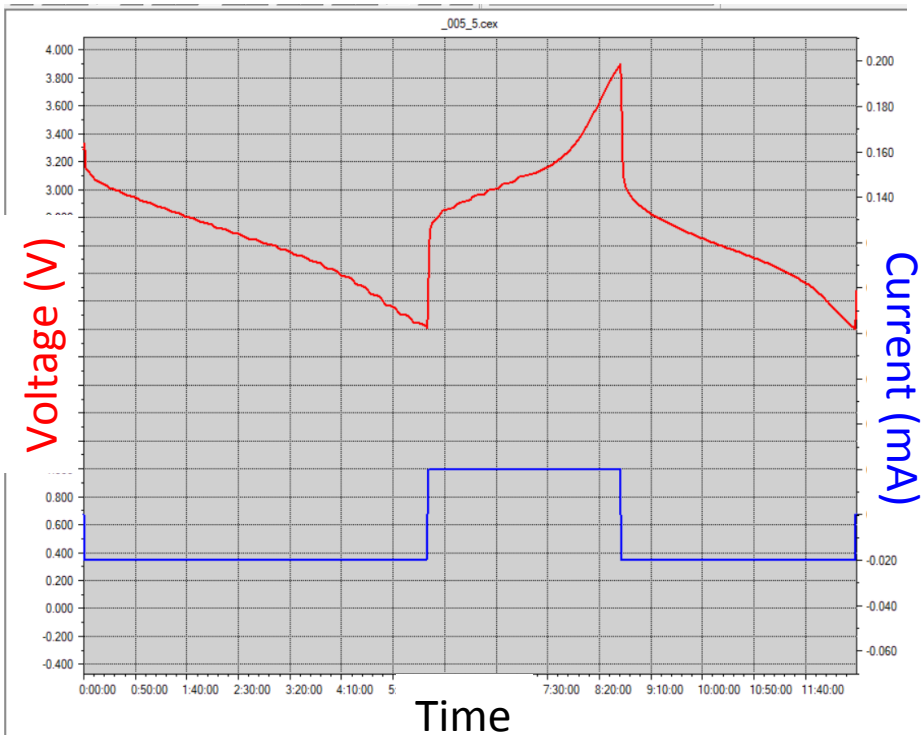


Batteries assembled in argon chamber



Measuring battery capacity

- **Theoretical capacity** of Fe(II)PO4 (crystalline) battery~ 178 mAh/g
- Measure the **actual capacity** of your batteries using galvanostat
  - Keep current constant (- 0.02 mA, record time to discharge)
  - Record voltage (ideally constant) as charge (capacity) stored in battery fluctuates (drops during discharge)



Calculate actual battery capacity by dividing by mass of active material

	Index	Charge-Cap/mAh	Discharge-Cap/mAh
[-]	001	0.0000	0.1117
[+]	0001 Rest		0:01:00
[+]	0002 Discharge CC		5:32:40
[+]	0003 Rest		0:01:00
[-]	002	0.0625	0.0760
[+]	0004 Charge CC		3:06:10
[+]	0005 Rest		0:01:00
[+]	0006 Discharge CC		3:46:51
[+]	0007 Rest		0:01:00

Discharge capacity example:

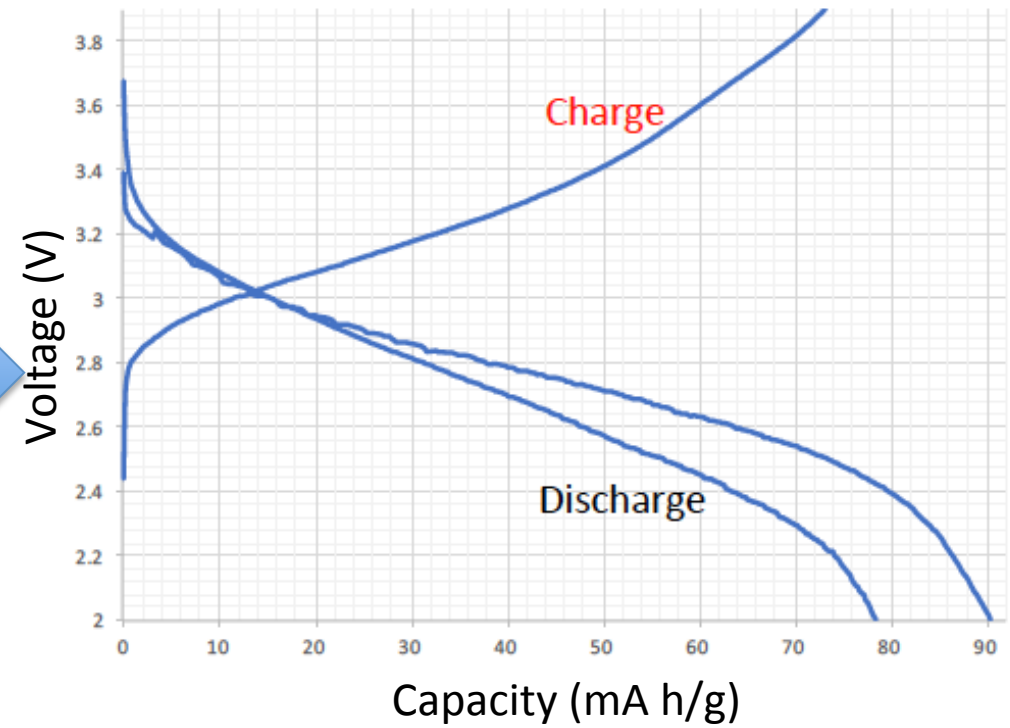
$$\frac{0.1117\ \text{mAh}}{1.97\text{mg} \times 0.7} \times \frac{1000\text{mg}}{\text{g}} = 81.0\ \text{mAh/g}$$

- In report: Report all charge and discharge capacities
- On wiki: Post best (highest) discharge capacity only

Figure: Voltage profile (charge and discharge)

	A	B	C	D	E	F
1			_005_5			
Font	dex	Mode	Period			
3	1	Rest	0:01:00			
4	Index	TestTime	Voltage/V	Current/m/	Capacity/m	State
5	1	0:00:00	3.2918	0	0	R
6	2	0:01:00	3.3336	0	0	R
7	Index	Mode	Period			
8	2	Discharge (	5:32:40			
9	Index	TestTime	Voltage/V	Current/m/	Capacity/m	State
10	3	0:01:00	3.2865	-0.0202	0	D_CC
11	4	0:02:00	3.16	-0.0202	0.0003	D_CC
12	5	0:03:00	3.1436	-0.0202	0.0007	D_CC
13	6	0:04:00	3.1343	-0.0202	0.001	D_CC
14	7	0:05:00	3.1256	-0.0202	0.0013	D_CC
15	8	0:06:00	3.1191	-0.0202	0.0017	D_CC
16	9	0:07:00	3.1095	-0.0202	0.002	D_CC
17	10	0:08:00	3.1008	-0.0202	0.0024	D_C
18	11	0:09:00	3.0921	-0.0202	0.0027	D_C
19	12	0:10:00	3.0822	-0.0202	0.003	D_C
20	13	0:11:00	3.0735	-0.0202	0.0034	D_CC
21	14	0:12:00	3.0683	-0.0202	0.0037	D_CC
22	15	0:13:00	3.0627	-0.0202	0.004	D_CC
23	16	0:14:00	3.0608	-0.0202	0.0044	D_CC
24	17	0:15:00	3.0577	-0.0202	0.0047	D_CC
25	18	0:16:00	3.0531	-0.0202	0.005	D_CC
26	19	0:17:00	3.0509	-0.0202	0.0054	D_CC
27	20	0:18:00	3.0475	-0.0202	0.0057	D_CC
28	21	0:19:00	3.0428	-0.0202	0.006	D_CC
29	22	0:20:00	3.0394	-0.0202	0.0064	D_CC
30	23	0:21:00	3.0363	-0.0202	0.0067	D_CC
31	24	0:22:00	3.0317	-0.0202	0.0071	D_CC
32	25	0:23:00	3.0242	-0.0202	0.0074	D_CC
33	26	0:24:00	3.018	-0.0202	0.0077	D_CC
34	27	0:25:00	3.0128	-0.0202	0.0081	D_CC
35	28	0:26:00	3.0084	-0.0202	0.0084	D_CC
36	29	0:27:00	3.005	-0.0202	0.0087	D_CC
37	30	0:28:00	3.0035	-0.0202	0.0091	D_CC
38	31	0:29:00	3.0013	-0.0202	0.0094	D_CC
39	32	0:30:00	2.9991	-0.0202	0.0097	D_CC

From Excel data, plot voltage vs capacity



divide by (cathode mass (mg) * 0.7) *1000 mg/g

Today in lab…

- Battery assembly in Belcher lab
  - **Thank you Jifa and Shuya!**

- Capacity calculations in lab: How does the material or size of NP affect battery capacity?

- Use your time wisely:
  - Upload data to wiki
  - Improve your research proposal slides
  - Practice your presentation
  - Ask for feedback!