Batteries

General planning of the „Lithium Batteries" lab for the European Master 2007/8

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Objectives:
Students will:

- follow the development of primary and secondary lithium batteries
- become familiar with different types of batteries
- explore the applications of batteries
- study the major components of lithium (ion) cells
- learn which batteries can be recycled
- realize the economic and environmental advantages of using rechargeable batteries

Needs:

Room with avialiables 2 desks and 2 computers or Multimedia Projector
Potentiostat/galvanostat with galvanic cycle mode.
Suplementary materials needed for:
Building the simple battery (included Volta cell)
Daniell cell
Leclanche Cell
Commercially available variety of Li-bat (also disassembled in a controlled mode)
BDS software

Safety issues:

Safety rules
Read directions carefully before you begin any experiments. Clear an area to work.
Wash your hands thoroughly after experimenting
Do always wear eye protection
Keep all chemicals away from your eyes and mouth
Do not eat and drink in your experiment area
Put all pieces of equipment away when finished using them

General First aid information

Indicate the person who should IMMIDIATELLY inform the teacher and ask the other person to help you out if needed.

Eyes: rinse immediately with water. Remove contact lenses if wearing any. Flush eyes with water for 15 min
Swallowed: Rinse mouth
Drink glass full of water or milk. DO NOT INDUCE VOMITING

SKIN: Flush skin thoroughly with water. In all cases, get immediate medical attention if an emergency exists. Bring the chemical container with you.

Materials given to students/preparation:
Exemplary 5 scientific papers (or any material found related to the Battery Performance, Design, Safety, Application) for individual preparation.

Short theoretical introduction[1]

Battery technology has achieved spectacular progress in recent years. The most successful product is the rechargeable lithium ion battery that has reached an established commercial status with a production rate of several millions of units per month. In the decade since the introduction of the firs commercial ion battery, also research and development on virtually every aspects has proceed an unprecedented level.

Probably you have such a battery it in your PC,s or Mac's, cell phones, and MP3 players but it is a strong drive to put them inside the car. They became so common because, they are able to provide the maximum energy in a rechargeable manner available on the market.

If you were to take apart a laptop battery pack or cell (something that **I STRONGLY DO NOT** recommend because of the high risk of shorting out a battery and starting a fire) you would find three thin sheets pressed together and submerged in an organic solvent that acts as the electrolyte.:

1 positive electrode – cathode. The positive electrode is made of lithium cobalt oxide, or lithium manganese oxide or lithium iron phosphate. When the battery charges, ions of lithium move through the electrolyte from the positive electrode to the negative electrode and attach to the carbon. During discharge, the lithium ions move back to the cathode active material from the carbon.

2 negative electrode – anode. The negative electrode is made of different types of graphite but also silicon, tin and tin oxides and composites.

3. separator. The separator is a very thin sheet of microperforated plastic. As the name implies, it separates the positive and negative electrodes while allowing ions to pass through.

As with most batteries you have an outer case made of metal. The use of metal is particularly important here because the battery is pressurized.

The movement of these lithium ions happens at a fairly high voltage, so each cell produces 3.5 volts. This is much higher than for instance the 1.5 volts typical of a normal cell that you

[1] (not enough to well prepare for lab class)
Introduction prepared on the basis of the material found at:
Advances in Lithium-Ion Batteries (Hardcover) by Walter van Schalkwijk (Editor), B. Scrosati (Editor)
B. Scrosati. *Nature* 373 (1995), p. 557.
Journal of Power Sources Volume 100, Issues 1-2, 30 November 2001, Pages 93-100
http://electronics.howstuffworks.com/lithium-ion-battery2.htm

find in the market and helps make lithium-ion batteries more compact in small devices like cell phones.

Usually single cells are combined into the battery packs. Lithium-ion battery packs come in all shapes and sizes, but they all look about the same on the inside.

The lab you will attend provide you information about advanced Li batteries available on the market (and used in real systems including electric cars) but also give you an overview about different cells, testing systems, safety aspects and others listed in the objectives.

[2]Scenario:

1st Day (Historical Tour ☺

0. Competence test (Student activity.1)
1. Result discussion.
2. What is a cell/battery? (Task 1. How does the battery works?)
3. Student activity ("Presentation" Student activity no. 2)
4. Intro (refreshment) of the basic information concerned the theoretical background of Lithium battery (Student activity no3 Glosssary) Safety issues (Teacher Demonstration)
5. Presentation of Daniell cell Task 2
6. Presentation of Leclanche Cell Task 3
7. Types of batteries (demonstration) and description of the batteries labels (Activity nr 4 "What is on the label')
8. OCV experiments (Task nr 4)
9. Applications ("Brain storm" Activity nr 5)

2nd Day (Lithium (ion) batteries)

10. Testing (demonstration: type of battery tests, types of testing cells, basic test information) Short introduction about different cyclers and electrochemical stations available on the market (and our lab).
11. Environmental issues and tips (Student Activity no 6)
12. Galvanostatic test ("Galvanic cycle" Task 5)
13. Data processing and analysis (why battery fail?)

Presentation of Battery Design Studio Battery Design Studio
Introduction (workshop1) Intro (Manual)

14. Evaluation

Student activity 1: “Competence test”

Note: example only. Can be changed.

Please answer in max 2 phrases.

1. What is battery? (max 1 phrase)
2. What is secondary battery? (max 1 phrase)
3. What is lithium ion battery? (max 1 phrase)
4. What types of chemical compunds are used in Li ion secondary battery? (list 5)
5. What is that value mean 372 mAh/g? (max 2 phrases)

Task 1. Building a battery[3]

Build a simple battery using the setups provided by a teacher. Explain in the report why this stuff work?

LEMON power

1. Get two juicy lemons. You’ll need to role these firmly on the table to get the juice flowing inside the lemons. Try not to break the peel. The lemon jusice will be the electrolyte between the two electrodes that you will set up next.
2. Make two small slits in the lemon peel about an inch apart. Stick a copper strip in one slit and a zinc strip in the other slit. Make sure the metal strips touch the lemon juice but not each other. Now do the same thing wit the other lemon
3. Now that you have prepared two cells, you are ready to hook them together to make a battery. Use one set of alligator clips to connect the two lemons. Connect one cli to the copper strip in the first lemons. Connect one clip to the copper strip in the first lemon and then the free clip to the zinc strip in the second lemon
4. Grab the second set of alligator clips. Connect one clip to the zinc strip in the first lemon
5. Now grab the third set of alligator clips. Attach one clip to the copper strip in the second lemon
6. You should now have two free clips. Use them to connect the LED, or touch your tongue with them to feel a harmless tingle of electrical current! Just don’t clam the clips to your tongue or to anyone else’s!!!!

1. Touch the other free clip (connected to the black wire leading from the battery) to the cut surface of the potato about an inch form the other clip. Slowly drag it across the surface. Try to write your name or some other “pink potato message”

Digital VOLTA Cell.

1. Remove the electrodes from the foam ball
2. Remove the electronic Module from the top of the wire frame.
3. Install the Fruit by removing the foam Ball and stabbing the Fruit ont the wire Frame

[3] *instruction taken from the „Fruit powered clock” set and “Chemo-electro” set

4. Ajust the height of the fruit by moving the rubber stop up or down about 5 cm of the wire framie is showing above the fruit
5. Replace the Electronic module by inserting the end of the wire frame in the mounting hole at the back of the module
6. Insert the electrodes attached to the module into the fruit as far apart as possible.
7. insert the electrodes of the jumper wire so that each black electrode is next to red electrode about 1 cm between them.
8. If the clock does not begin to run after 60 s, move the electrode closer together (but not touching)
9. If the clocke runs for several days, the holes in the fruit may become dry. When this occurs, reposition the electrodes to new location in the fruit. (It may be necessary to reset the time and date.)
10. From time to time you wil want to change the fruit of vegetable that is powering your clock. Just repeat these easy steps to install a new power source.

Enjooy the reliable time and date information provided by the power of a fresh fruit for the time is ripe. In order to generate the maximum amount of electricity, it is important to insert the tow pairs of electrodes as far as possible form each other in the fruit.
Remember that the electrodes of each pairof each pair (one red and one black) must be close together but not touching an about 1 cm apart. Look again at the electrodes and see how they are inseted in the foam ball

VOLTA STACK.

Basically, Voltas pile was a messy stack (pile) of discs made of two types of metal - one silver, the other zinc. The discs were separated from each other by a piece of cloth or cardboard that had been soaked in salt water (brine). Volta found that this wet stack of dissimilar metals created a small electric current, and this current could be drawn off through wires and used for experiments. However, a pile could generate only a small voltage of 1-2 volts. Several piles - a battery of them - could be assembled side by side and connected to each other with metal strips to create a high power energy source.
Compose a Volta pile from coins and Aluminum foil cloth and acid and power a clock. Measure the OCV.

ALKALINE CELL
Build a cell using KOH (6M Remember about SAFETY!!!! Use Gloves Glass and protective coat), Zn powder, MnO_2 and cloth. Power a clock and measure the OCV.

Student activity 2: Glossary

Competition between two groups in matching the definitions with the basic terms used in battery industry.

Task 2:
Daniell cell

1. Make solutions: Saturated solution of copper sulphate in water and 10% solution of zinc sulphate
2. Fill the proper compartments of the the cell equipped with a ceramic connector.
3. Place the electrodes

4. Connect the circuit: cell, resistors and a multimeter

Record the U plot as a function of current. (so called discharge profile, ohmic characteristic) From the U=f(I) relation calculate the sum of internal resistance and polarization and SEM.

Note: Measurements should be done in a large range of resistors. Don't use a small resistance in order to avoid the discharge of the cell. Start with a high value of resistance. Collect as many points as you can.

Task 3: Leclanche cell
1. Make a solution of 20% of zinc chloride. Cathode have been prepared before (paste consisted of manganese dioxide, graphite, starch, electrolyte is palced in the glass with a ceramic junction).
2. Place the graphite electrode in the paste and the whole thing should be placed in the crystallizer with a zinc chloride solution.
3. Place the zinc electrode in the solution.
4. Connect the circuit and use the same procedure as before (U=f(I))

Task 4. OCV
Measure the OCV of the different types of batteries using a multimeter

Student activity 3: Brain storm
Crucial parameters for different applications (brain storm in 2 groups). Open discussion. Short report.

Student activity 4: Battery tips
False or true. Recapitulation of Day 1.

Day 2.
Task 5: Place a battery in a holder and discharge charge discharge it using a formula discussed by a teacher using a VMP cycler.
Typically: Li primary cell discharge till 2,7V using a 5mA current (Experiment/New/GCPL and set the current and time) **DO NOT CHARGE THIS COIN CELL START WITH DISCHARGE AND THAT WILL BE THE ONLY STEP**
Li – ion cell between 3,5 -2,7 V using 400mA current 1 full cycle. (use the formula M-Marcinek-GCPLsetting.mps on the Desktop of the VMP instrument

Task 6 Model building
Cell,Open existing cell /He 18650spiral 1/+Formulation/NiCo

- Change an input, build the cell, and viewthe report. Try the following:
- Vary the loading on the positive or negative – how does this affect cell
- capacity?
- Vary the stoichiometries of the electrodes– how deos this affect cell capacity?
- Vary jellyroll diameter.

- Vary weight fractions of active materials.

Note: Change parameter than change a file name and thant build the model right clicking on the file name

Optimize the cathode/anode formulation formulation

Task 6. Cycler
Procedure/Add new procedure/Cycler
Task: Build the procedure and run it on the battery

Task 7. Finding a capacity using outviewer
Procedure/open existing procedure/RT
RT right click on the cell/run on cell

Open outwiever/ Volts vs entire test vs Amp/hrs

Advanced activity (depend on time):
Task 8. Perform the compare chemistry test
Task 9. Perform the porosity effect

Report form:

Names:

Goal of the lab:

Describe the main types of batteries **<u>in condensed</u>** manner. Concentrate on the Li-ion cells and the other “cells” developed historically but not presented in the lab. Provide a source.

(Describe basic components of the batteries/advantages/disadvantages, chemistry)

On Task 1 what was the main components of the system Anode/Cathode/Electrolyte. Explain why and how it is working?

Task 2 and Task 3 Report a label:

R/Ohm	U/V	I/A
1000000		
…..		
Minimum reached		

Make a plot. U=f(I)

From the U=f(I) relation calculate the sum of internal resistance and polarization and SEM

Make a conclusion

Task 4. Report the types of batteries and their OCVs. What does this values represent?

Task 5. Report the discharge/charge regime(s) of the cell.
Report a capacity in mAh
Report a conclusion.

Task 6, Task 7, Task 8, Task 9 BDS. Conclusions from the experiments