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Types of Lithium batteries

1) $Li_xMn_2O_4$ – LMO

Cathode MnO_2

↓

Spinel structure – 3d

+

- thermal stability
- safety
- low resistance

–

- life-span

Current ratings → 20 – 30A (moderate heat)

used in power tools, medical instruments, xEVs.

capacity 1/3rd of LCs

It is blended with cobalt LMO (NMC)

LMO provides better power
NMC provide better capacity.

25% capacity ↑ Silicon is added to ~~negative~~ anode.
but stresses also increase due to
ΔV of silicon

Specific energy 100 – 150 Wh/kg

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Charge (C rate) 0.7 - 1 C till 4.2 V
& 3h charge time

Discharge 1C ; 2.5 cut off

Cycle life ~~500-1000~~ 300 - 700

Relevancy less

NMC — ($LiNiMnCoO_2$)

In 18650 NMC cell max is 2800 mAh optimized for capacity
to 5 A

Specific power - 2000 mAh 20 A

Cathode is NMC - 1-1-1
or 5·3·2
or other combn

N	M	C
+ high specific energy + cost	+ spinel + low R	- cost

Specific energy	150 - 220	
Charge C	0.7 - 1C	4.2 till
Discharge C	1C	2.5 cut off
Cycle	1000 - 2000	
Application	Ebikes, EVs	
Relevancy	Leading relevancy.	

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LFP — $LiFePO_4$

- Phosphate as the cathode → high current rating & long life.
- Lower nominal voltage 3.3V
- Has high self-discharge rate can cause (balancing issues)
- no tolerance for moisture
- Specific energy ~~3.2V~~ 90-120 Wh/kg
- Charge (C-rate) 1C typical charges to 3.66V 3H
- Discharge — 1C, 2.5 cutoff
- Cycle life 2000+
- ~~Application~~ Relevancy moderate

NCA — $LiNiCoAlO_2$

- High specific energy: 250 Wh/kg

Voltage range: 3.0 - 4.2V
C-rate charge: 0.7C to 4.2V (3hrs)
C-rate discharge: 1C, 3V cutoff
Cycle: 500
Application: Tesla powertrain
relevancy: growth potential

Contd Notemaniped

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LTO - ($Li_2Ti_3O_3$)

anode is $LiTi_3O_3$ not graphite - spinel

Cathode can be LMO/NMC

- Can give high discharge current upto 10C
- High thermal stability
- Low nominal voltage — 2.4
- Specific energy 50 - 80 wh/kg
- C rate charge 1C - 5C till 2.85V
- C rate discharge 10C, 1.8 with LCO/LTO
- Cycle 3000 - 7000
- Application UPS, small EV, ~~sto~~ solar powered street light.
- very safe

~~20~~ Relevancy: Allows fast charge.

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LCO - ($LiCoO_2$)

- High specific energy
- 2 d flow
- short span
- low thermal stability
- C-rate should be not more than 1
- toxic

V = 3.6

Cycls 500 - 1000

Nickel-rich no longer relevant

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1.1.1

Introduction to Battery Management system.

It is an embedded system

functions.

→ Protect human → detect unsafe condn

→ Protect cells from abuse / failure cases

→ Prolong life

→ Maintain battery in limits.

⇒

Lithium need BMS, cannot be overcharged.

cheap battery, can be replaceable

Large battery, best mgmt,

HEV → PHEV

Small battery

engine on always

PHEV

Big battery

Electric mode

↓

E-Rev

Big battery

Stronger battery

↓

EV

Largest battery pack

250 — 600 V

1000 Amps under peak load.

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Battery terminology.

- Cell → smallest
- Battery → cells > 1

- 12 V car battery → 2V × 6 — series
- Voltage changes when full & near empty.
- nearly charged voltage
  ↓
  Cell Nominal voltage (Average voltage)
- NiCad, NiMH → 1.2V
  Li-Ion — Over 3V
- Cell (nominal) capacity. Ah / mAh
  amount of current / hours

C-rate

20Ah
- 20A — 1h — 1C
- 10A — 2h — C/2
- ...
- 2A — 10h — C/10
- 200A — 6m — 10C

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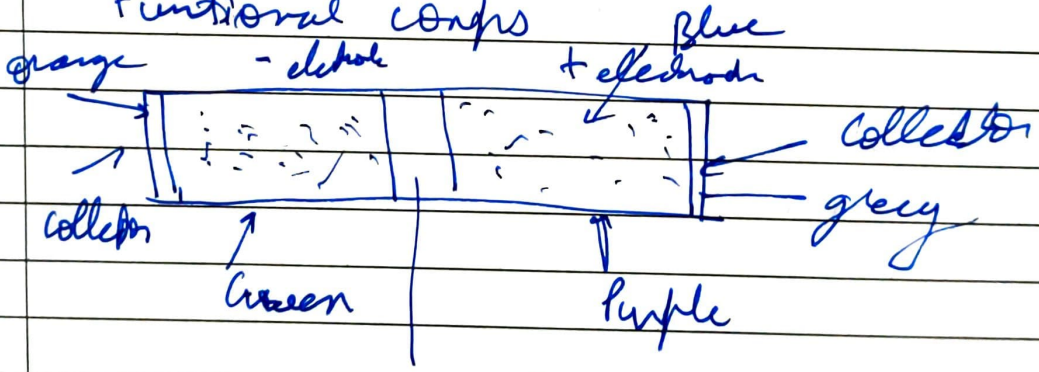
nom-V x nom-Capacity = Total energy

3.7V x 1.9Ah = 7.03Wh

In series V = n x nom-V
C = nom-C (current same)

In parallel
V = nom-V
C = n x nom-C



Negative electrode
Discharge OIL → oxidation is loss of e⁻
charge RIG → Reduction is gain

Positive electrode:
Discharge RIG
charge OIL

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Electrolyte should be · Electrolyte conductor
× electron conductor

Separator — avoids short-circuit

collectors → are metal foil.

Daniel cell $Zn^{2+} + 2e^- \rightleftharpoons Zn$ −0.76

$Cu^{2+} + 2e^- \rightleftharpoons Cu$ 0.34

$0.34 - (-0.76V) = 1.1$

Reduce — Oxidation

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- Lithium ions intercalation not Redox

. negative electrode for
graphite Lithium manganese oxide.

. We use binders - attach lithium to the electrode
conducting additive - to enhance electron conduction

Negative electrodes Li stored in vacancies.

cylinder cell prism cell pouch cell
↓ ↓
spiraled. stacked

squished

large waste less waste
space

- Natural graphite Hard carbon
more parallel grain boundaries

packed for a ratio

: LTO - 3d structure
- ~~good~~ very good life
- But high potential for @ space

Silicon

1 Li — 6 C
4 Li — 1 Si 24:1

for C volume change when charged & discharged is 10%.

for Si it is 400% atoms & strain.

Positive

Lithium cobalt oxide ($Li_x CoO_2$)

- It is layered
- Li intercalates inside CoO_6 Octahedra
- in laptop, phones.
- Malabsibility problems
  1. cost
  2. toxic
  3. x can go from 0.5 to 1
     so only half of the potential.
- can be replaced by Ni Co Mn
  ↓ ↓
  TV T
  stable
- NCA (Aluminium) used in Tesla

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$Li_2Mn_2O_4$

- Spinel structure 3D
- LMO unstable when $x > 1$ (anode cond')
- cheaper / safer
- short life, moisture can oxidize.

Olivine (Li_xFePO_4)

+ - low cost, low toxic
- - low energy density, low open circuit potential & low specific energy due to Fe

also - ID -
- low conductance hence additive carbon black added.

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water dissociates @ 2V aqueous ✗

PbA ✓ (anode)

Electrolyte used are
- Ethyl carbonate EC
- propyl carbonate PC
- Dimethyl carbonate DMC
- ethyl-methyl carbonate EMC
- Di ethyl carbonate DEC

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Left

Mostly electrolyte used is $LiPF_6$

↓

Lost participate in Rx

Diffusion: thin porous sheets

Current collector: +ve electrode

↓

Al foil as long as >2V

-ve electrod

Copper foil as long as < 2V