Lithium Ion Batteries with Different Cathode Material

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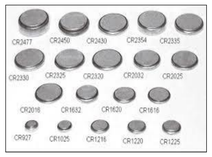
Abstract

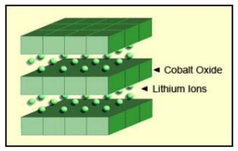
Lithium ion batteries are the most common batteries used in everyday life because of its low maintenance and self discharge ability makes it less than half of nickel-based systems. It has Nominal voltage of 3.6-4.3V which can directly power electronics. It uses cathode, anode and electrolyte as conductor. Currently cathode material used in the batteries are Lithium cobalt oxide. Cobalt is one the hazardous and costly element to mine. In this research we try to find replacement of cobalt with Manganese oxide and copper doped manganese oxide

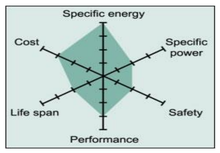
Why replace cobalt with manganese ?

- Easily available
- Can be found in several foods
- Relatively easy to process
- Cheaper in comparison to cobalt
- Environmentally friendly and safe

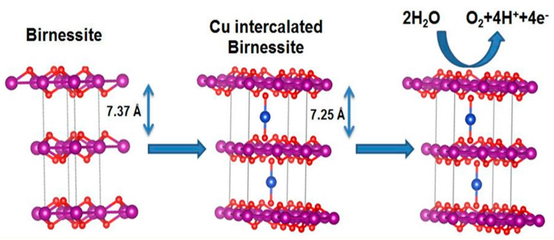


Background



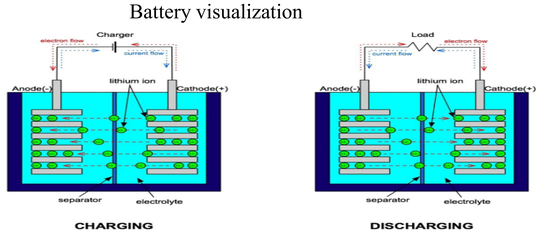


- High specific energy
- Cathode has layered structure
- Should not be charged at current higher than its C-rating
- Forcing fast charge or applying higher load can cause overheating and undue stress



- The layered manganese oxide $LiMnO_2$ is constructed from layers of manganese/oxide octahedra
- High working current
- Suitable for discharging in low currents – pulses discharging possibility
- Long shelf life duration – capacity lost 5% a year
- Provides 25% capacity boost

Battery visualization

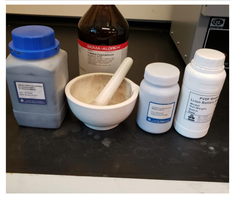


Methodology

Bone mill for preparing Birnessite

Different Active Material

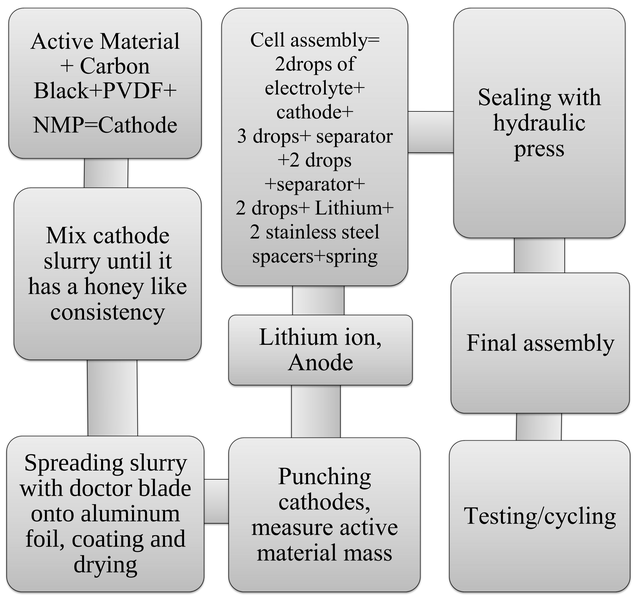
Mortar and pestle for preparing slurry



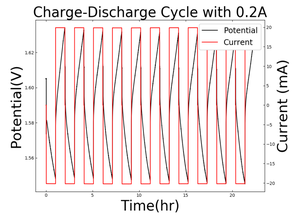
Doctor blade for setting slurry thickness

Slurry drying in oven at 120°C

Battery assembly

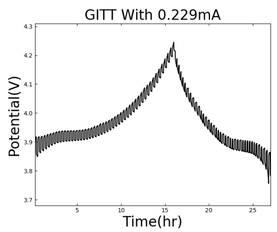


Charge and discharge cycle of lithium ion battery



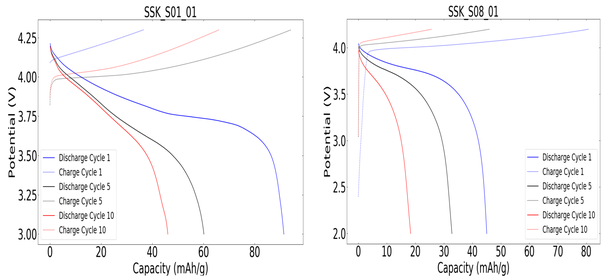
- Used to characterize batteries' life time behavior
- Number of charge cycles reflect battery cathode stability
- Measures the number of charge and discharge cycles before it loses capacity

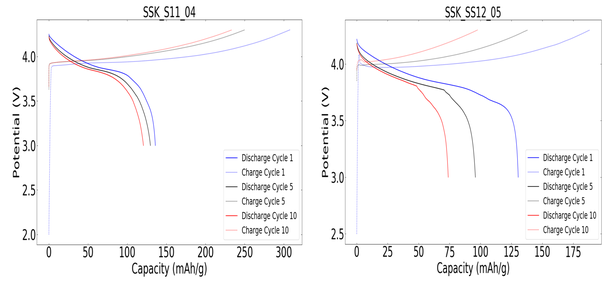
GITT



- Galvanostatic intermittent titration technique
- Charge-discharge pulse each 10 minutes long, followed by 10 minutes rest
- It tell us how fast Li^+ ions move in the CoO_2 material
- Diffusion constant can be calculated
- High Li^+ diffusion can lead to higher power density
- Transport properties of lithium can be obtained

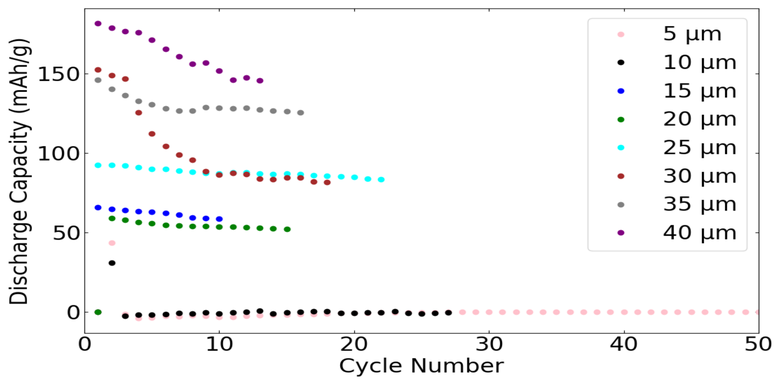
Results





Slurry	Material	Active Material (mg)	Capacity (mAh)
SSK_S01_01	LCO	10.9323	2.99545
SSK_S08_01	LCO	11.493	3.149082
SSK_S11_04	LCO	12.7723	3.5861
SSK_SS12_05	LCO	13.9	3.8086

- C-rate is a measure of the rate at which a battery is discharged relative to its maximum capacity
- Higher C rate produces lower measured capacity



Conclusion

- Making slurry with different doctor blade setting gave us the better visualization of discharge capacity vs cycle number
- More thick slurry gave us high discharge capacity but less cycle number
- NMP and PVDF mixing does not require vortexing it dilutes itself in 30-50 minutes
- Possible parameters for improving batteries have been eliminated (NMP concentration with 30% more, using 1/5 of active material to make areal loading 5 times less).

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