EX ZELLTUM III Exzellenzzentrum für Batteriezellen

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Evaluation of a High Capacitive Cathode Active Material in Lithium-Ion Pouch Cells

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Cell Specifications

Cathode

Mn-rich NCM (250 mAh/g_{AM})
92.5 wt.% Mn-rich NCM
4.0 wt.% Carbon Black
3.5 wt.% PVDF Binder

42% porosity
12.0 mg_{AM}/cm^2
3.0 mAh/cm^2

NCA (185 mAh/g_{AM})
92.5 wt.% NCA
4.0 wt.% Carbon Black
3.5 wt.% PVDF Binder

42% porosity
13.8 mg_{AM}/cm^2
2.6 mAh/cm^2

Anode

Graphite (355 mAh/g_{AM})
97.0 wt.% Graphite
1.5 wt.% CMC Binder
1.5 wt.% SBR Binder

30% porosity
9.8 mg_{AM}/cm^2 (Mn-rich NCM)
8.9 mg_{AM}/cm^2 (NCA)
3.5 mAh/cm^2 (Mn-rich NCM)
3.2 mAh/cm^2 (NCA)

Electrolyte

Quantity equals 1.5 x pore volume
1 M $LiPF_6$, FEC & DEC based (Mn-rich NCM)
1 M $LiPF_6$, EC & DEC based (NCA)

Separator

Celgard C2500 (PP)
55% porosity

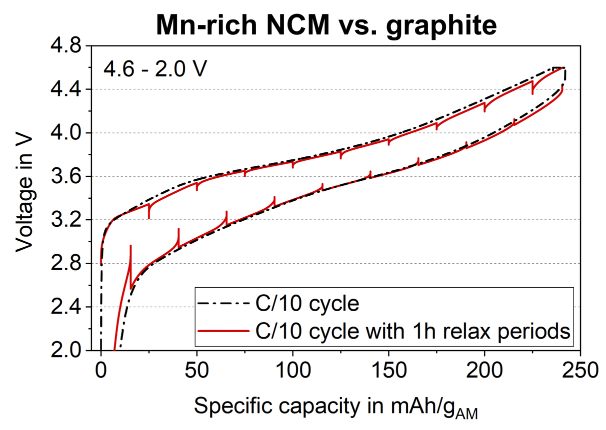
	Mn-rich NCM	NCA
# cathodes	16	15
# anodes	17	16
cathode AM mass	28 g	32 g
cell mass	112 g	116 g
cell capacity	6.4 Ah	5.8 Ah

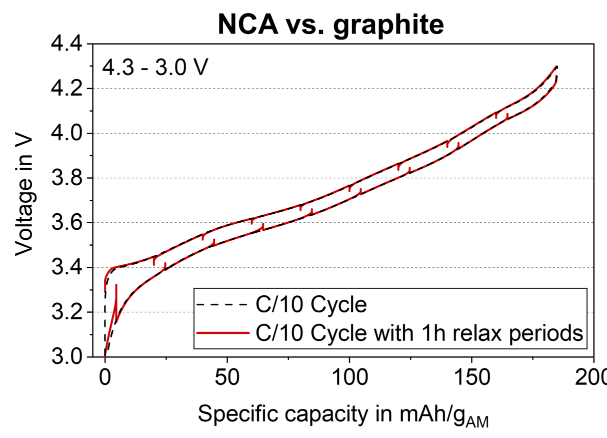
Both cell types were designed to have a comparable energy of 19 Wh and an areal capacity of 3.2 mAh/cm² at a 1C discharge.

Cathode Active Materials

Mn-rich NCM
0.33 Li_2MnO_3 x 0.67 $LiMeO_2$ (Me = Ni, Co, Mn)
- 250 mAh/g_{AM}
- Manganese-rich
- overlithiated

NCA
$LiNi_{0.81}Co_{0.15}Al_{0.04}O_2$
- 185 mAh/g_{AM}
- Nickel-rich



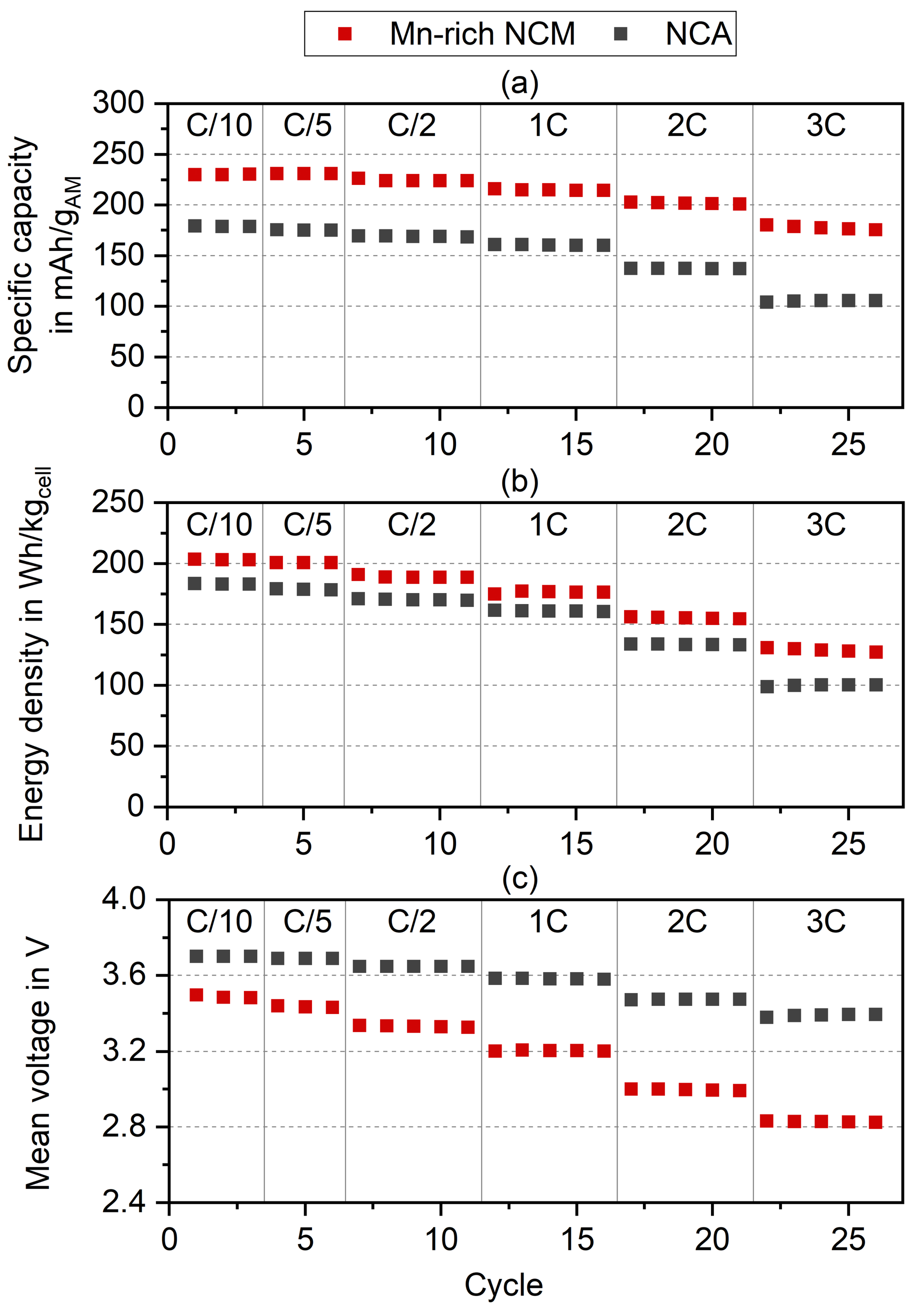


Raw material prices[1]
Mn: 2 €/kg
Co: 30 €/kg
Ni: 15 €/kg
Li: 15 €/kg

- Cathode active material accounts for up to 50% of costs on cell level[2,3]
- Mn-rich NCM is currently around 20% cheaper than NCA

Rate Capability Test

CCCV CH @ C/2 | 4.6 - 2.0 V (Mn-rich NCM)
CC DCH | 4.3 - 3.0 V (NCA)
T_{amb} = 25 °C

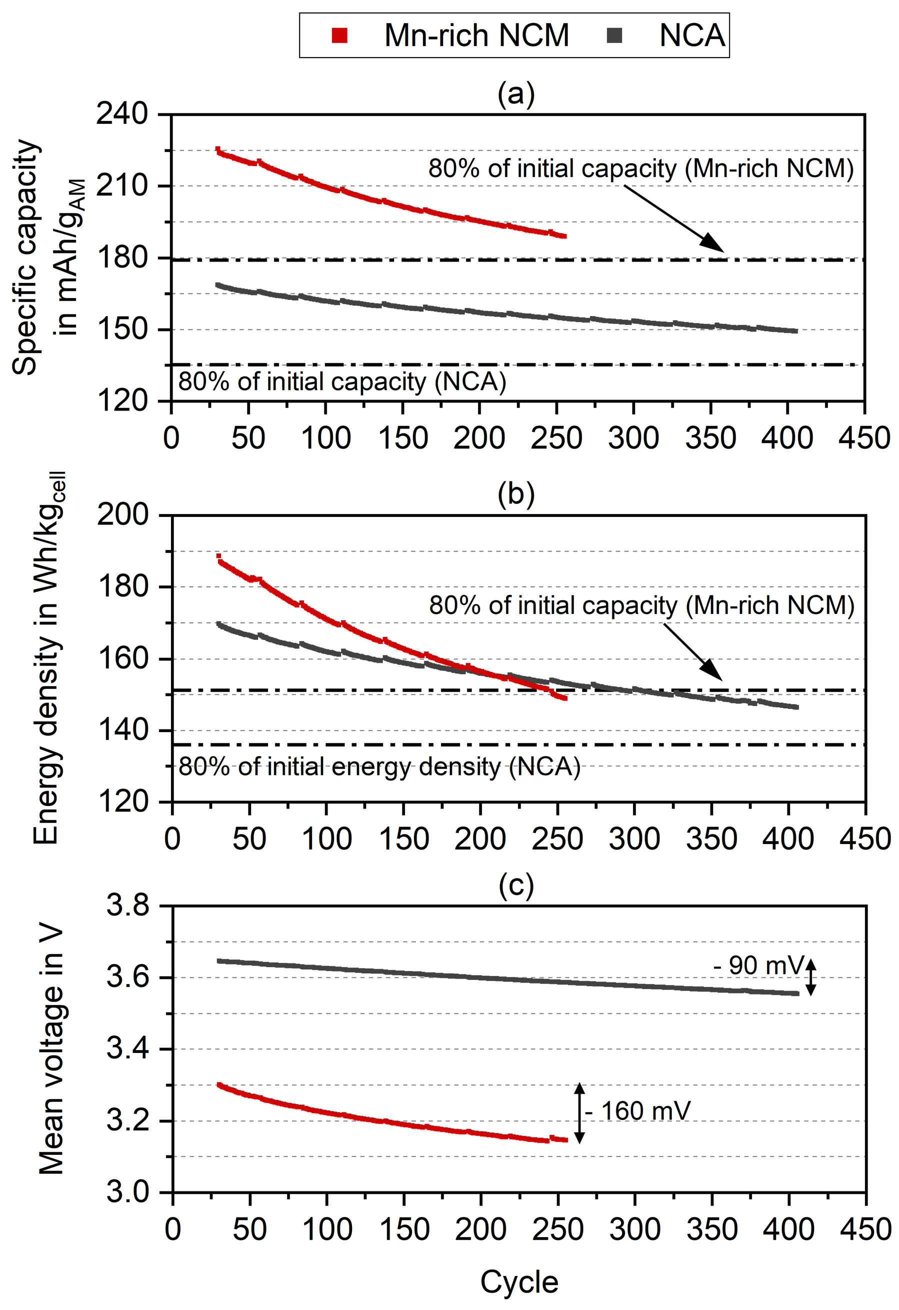


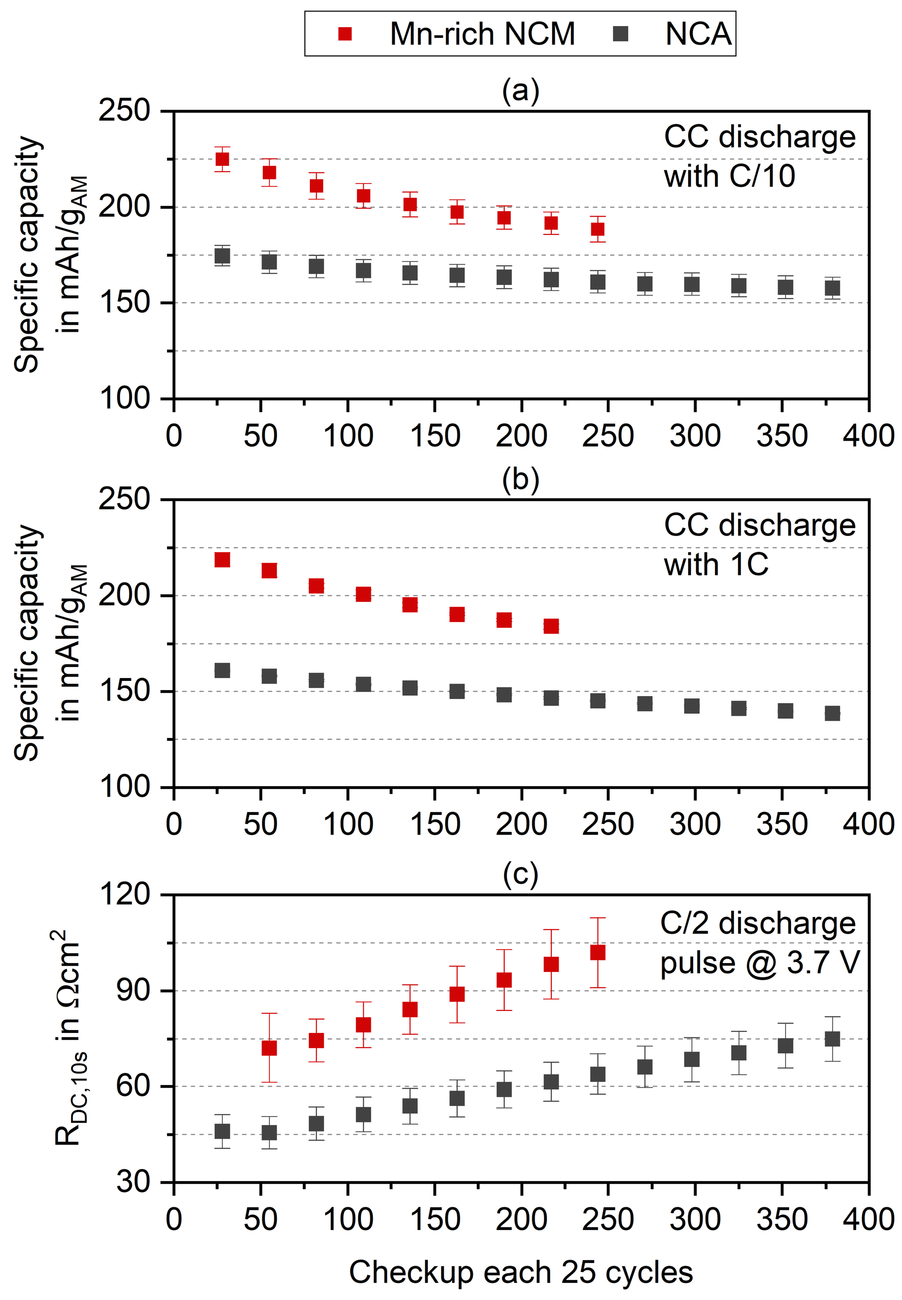
Mn-rich NCM cells show a better performance
+30% in specific capacity
+10% in energy density (lower discharge voltage)

Aging Study

CCCV CH @ C/2 | 4.6 - 2.0 V (Mn-rich NCM)
CC DCH @ C/2 | 4.3 - 3.0 V (NCA)
T_{amb} = 25 °C

Checkup each 25 cycles
C/10 & 1C capacity check
DCIR pulse test (C/2 DCH for 10s)





- Mechanical defects in Mn-rich NCM cells after 250 cycles caused by continuous gassing due to electrolyte decomposition
- Specific capacity of Mn-rich NCM lies well above NCA, but shows a slightly faster decrease
- Faster decrease in energy density caused by additional voltage fading, which is more pronounced for Mn-rich NCM
- Voltage fading caused by structural changes in material lattice[4]
- Energy density of NCA overtakes Mn-rich NCM after 210 cycles

- $R_{DC,10s}$ of Mn-rich NCM higher, but influenced by a strong SOC dependence[4]
- 1C discharge capacity slightly lower than C/10 discharge capacity, though the decrease shows a comparable trend
- Capacity loss not influenced by rising cell resistance, but rather by loss of lithium

80% SOH	Mn-rich NCM	NCA
specific capacity	400 cycles*	1000 cycles
energy density	250 cycles	750 cycles

*extrapolation

Conclusions

- Prevention of electrolyte decomposition in Mn-rich NCM cell systems necessary in order to reach longer lifetime
- Need for stable electrolyte systems, especially at higher voltages
- Mn-rich NCM appears a promising high capacity cathode active material when issues are adressed

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[1] Metalary, www.metalary.com, accessed 15th January 2020.
[2] Wentker et al., Energies 12 (3) (2019) 504.
[3] The Faraday Institution, Executive Summary - UK electric vehicle and battery production potential to 2040 (2019).
[4] Teufl et al., Journal of The Electrochemical Society 166 (6) (2019) A1275-A1284.

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