Electronic Supplementary Material (ESI) for New Journal of Chemistry.

Supporting Information

Manganese-Carbon (Mn-C) interaction to host Al^{3+}- ion into β-MnO_2-MWCNT Composite Cathode in Rechargeable Aluminium Ion Batteries

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XRD Table:

Table S1. Peak intensities of MWCNT/β-MnO_2-20%

Peak data of MWCNT/β-MnO_2-20%			
2θ	37.2°	56.2°	72.3°
hkl	101	211	112
d-spacing	2.45 Å	1.69 Å	1.38 Å

Charge-discharge capacity data MWCNT/*β*-MnO_2-20%

Table S2. Charge-discharge capacity data MWCNT/*β*-MnO_2-20%

Sr. No.	Current (mA/g)	Cycle intervals	Discharge capacity
1	100 mA/g	1st cycle	269 mAh/g
		20th cycle	192 mAh/g
2	300 mA/g	21th cycle	190.4 mAh/g
		40th cycle	103.5 mAh/g
3	500 mA/g	41th cycle	102.2 mAh/g
		58th cycle	55.5 mAh/g

SEM and EDAX analysis

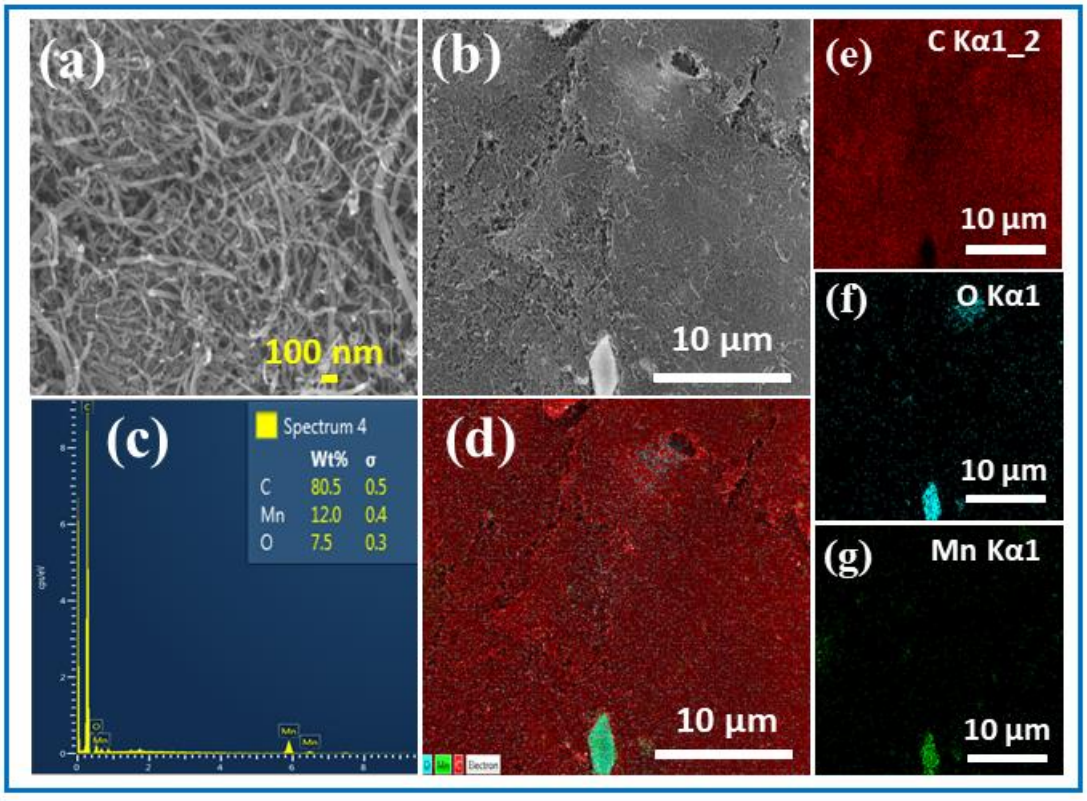


Fig. S1 (a) FE-SEM and (c) Elemental composition by MWCNT/ *β*-MnO_2-20% composite (b-d) Elemental color dot mapping by EDAX Overall composite composition and

TGA analysis

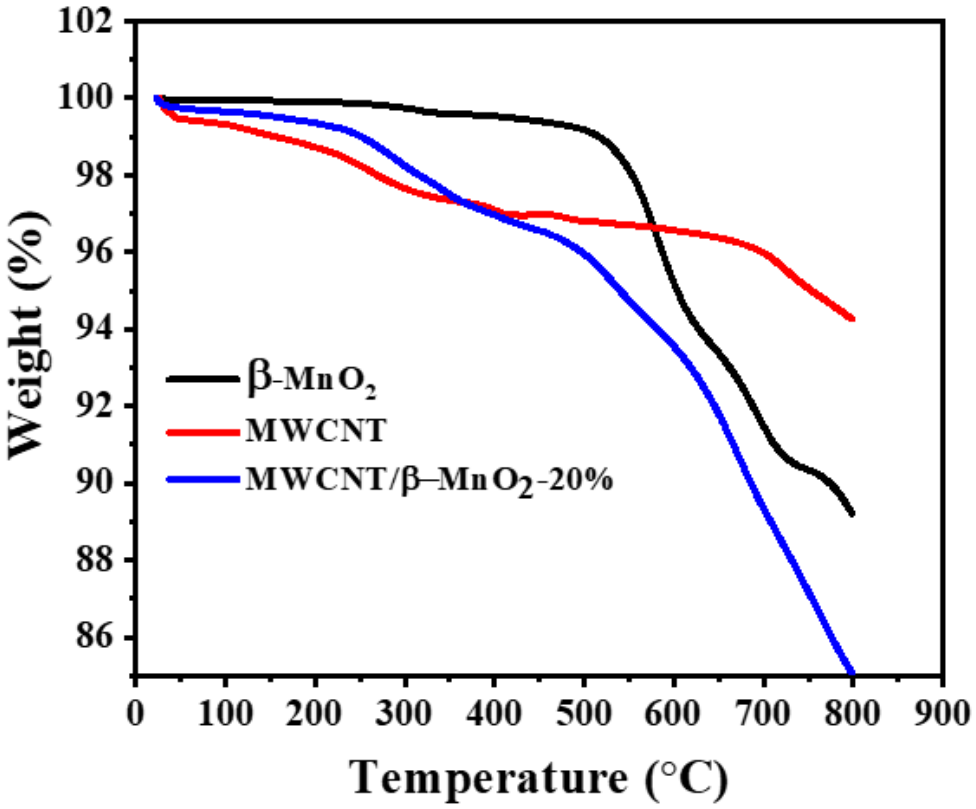


Fig. S2. TGA Analysis of MWCNT/β-MnO_2-20%, MWCNT, β-MnO_2

CV analysis

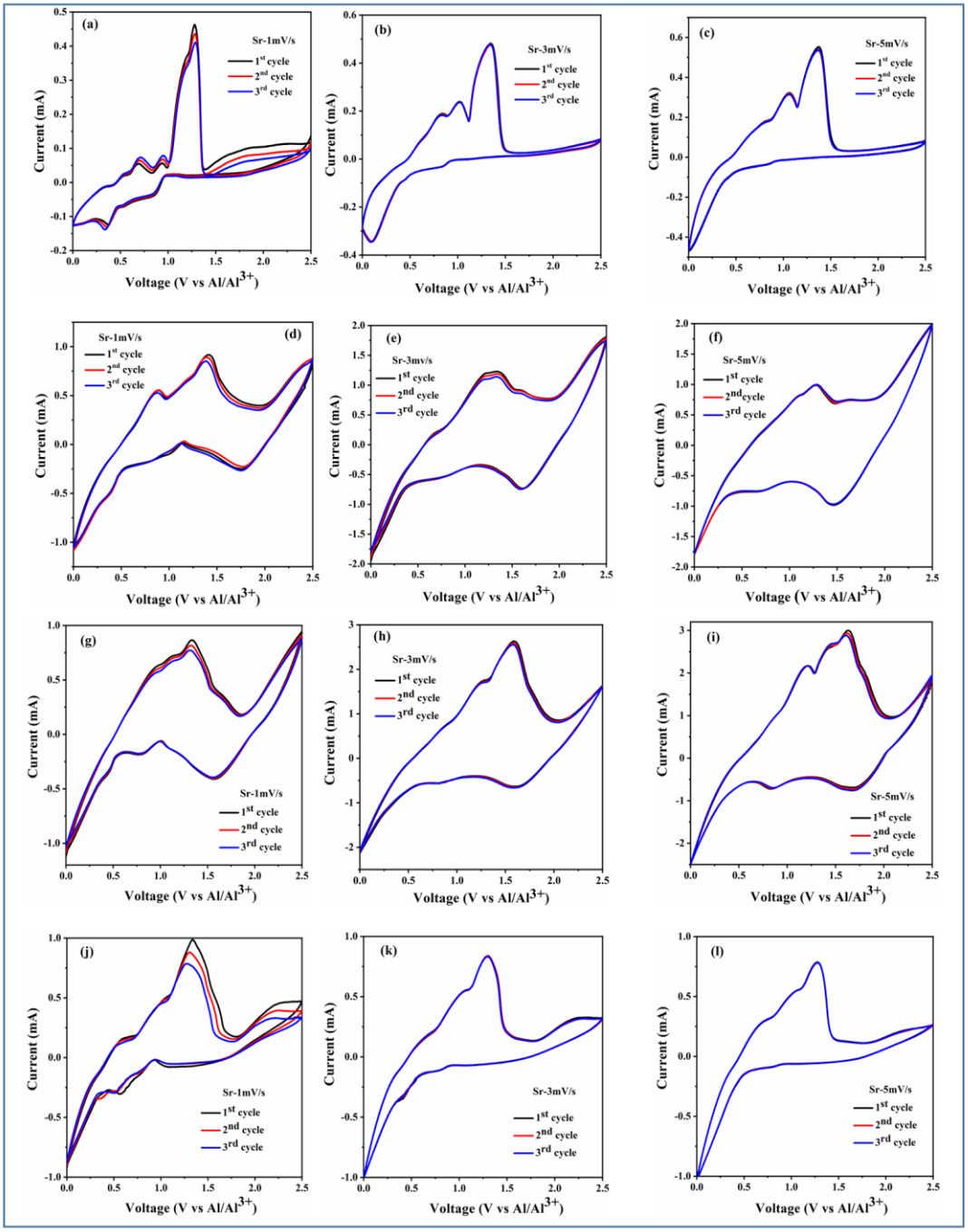


Fig. S3: (a-c) CV plot of 1, 3 and 5 mV/s scan rate β-MnO_2 and (d-f) CV plot of 1, 3 and 5 mV/s scan rate MWCNT and (g-i) CV plot of 1, 3 and 5 mV/s scan rate MWCNT/β-MnO_2-20% and (j-l) CV plot of 1, 3 and 5 mV/s scan rate MWCNT/β-MnO_2-50%

EIS analysis

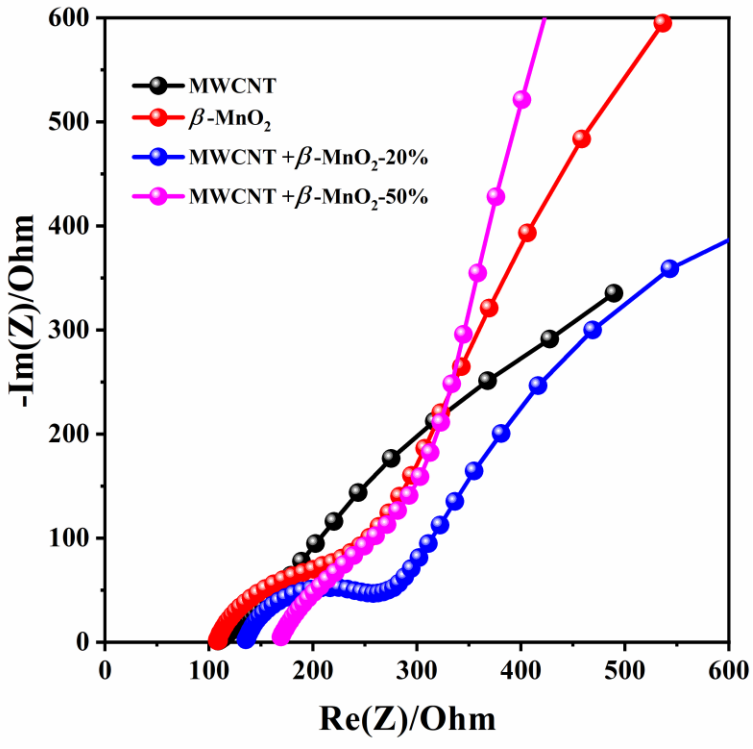
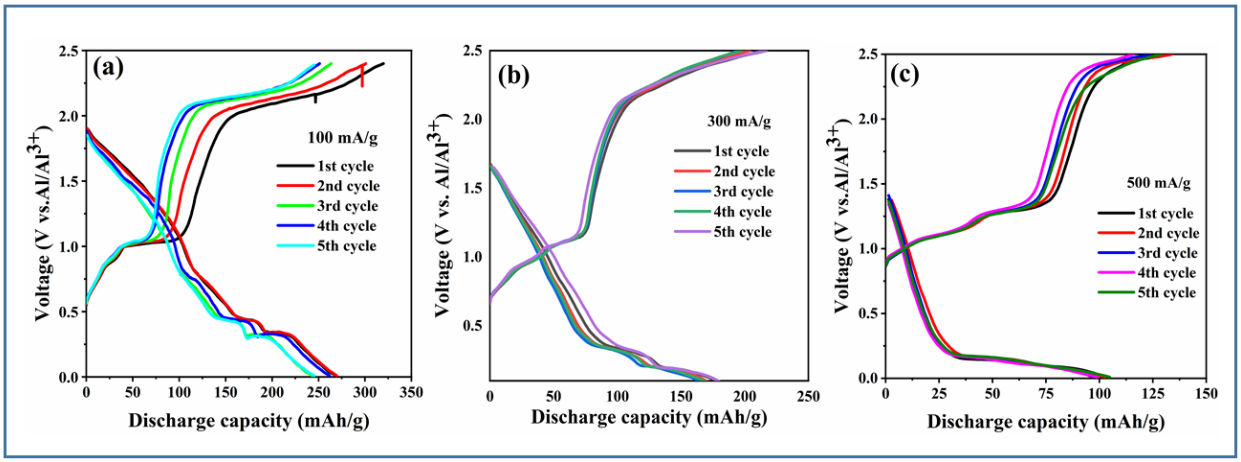


Fig. S4 Electrochemical Impedance Spectroscopy Study of MWCNT, β-MnO_2, MWCNT/β-MnO_2-20%, MWCNT/β-MnO_2-50%, (at 20 kHz to 100 MHz)



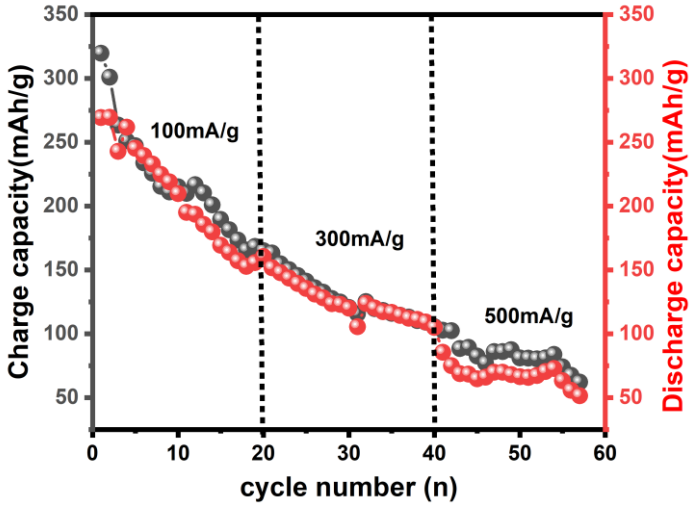


Fig. S5: Charge/discharge at different current rate (a) 100 mA/g, (b) 300 mA/g and (c) 500 mA/g MWCNT/β-MnO_2-20% (d) overall battery performance at various current.

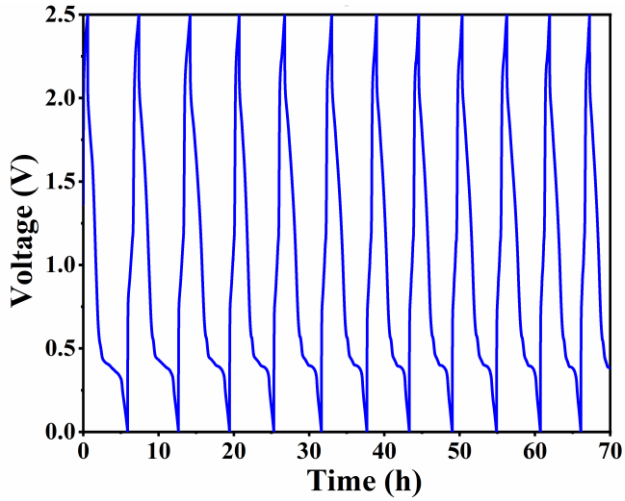


Fig. S6: Charge/discharge cycling at current rate 100 mA/g charge –discharge graph Voltage vs. Time

Cycled FT-IR analysis

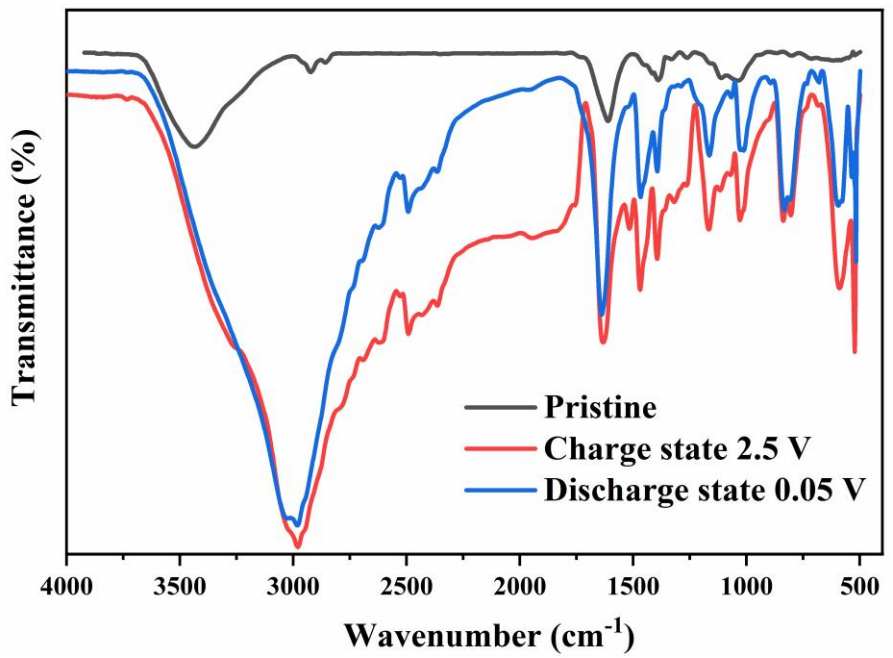


Fig. S7 FT-IR analysis of Pristine material and Cycled charge state cathode material and discharge state cathode material

Cycled XRD analysis

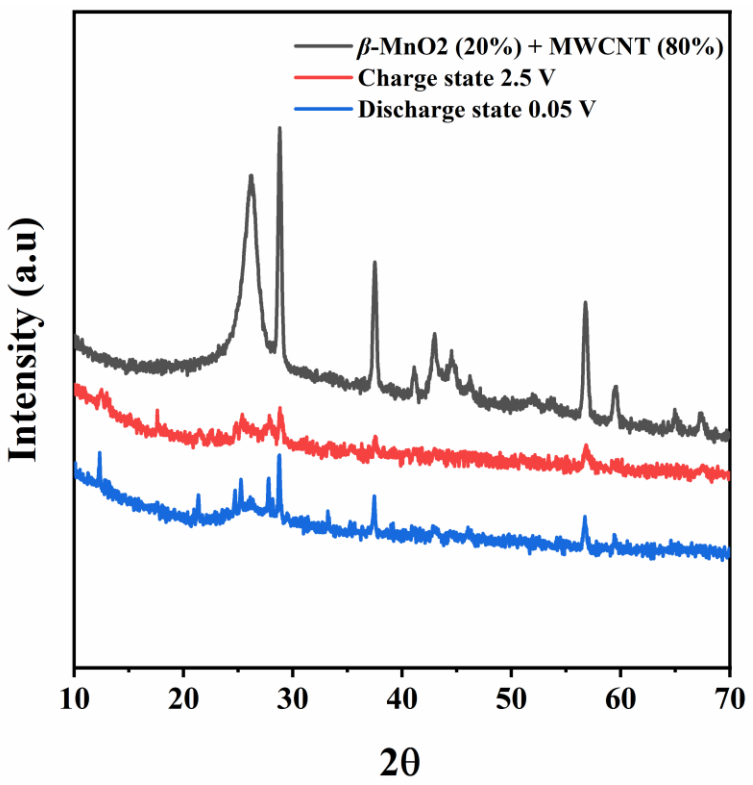


Fig. S8 XRD analysis of Cycled charge state cathode material and discharge state cathode material

Table 3. Comparison of the Electrochemical Performance in the Present Work with those of Previously Reported

S.No	Electrode	Electrolyte	Current	capacity (mAh/g)	Cycle no	Ref. No
1	α -MnO_2	$AlCl_3$/[EMIm]Cl in (1.3:1) $AlCl_3$-IL electrolyte	500 mA g^{-1}	100 mAh g-1	65	1
2	Birnessite MnO_2	aqueous $Al(OTF)_3$ and $MnSO_4$	100 mA g^{-1}	320 mAh g-1	65	2
3	$Al_xMnO_2 \cdot nH_2O$	$Al(OTF)_3$ (5M) solution	30 mA g^{-1}	467 mAh g-1 55 mAh g-1	1st cycle 65 cycle	3
4	Zn−Al electrode	$Al(OTF)_3$ aqueous electrolyte	100 mAg^{-1}	460 mAh g-1	80	4
5	α-MnO_2	4:1:1 of $AlCl_3 \cdot 6H_2O$, $MnSO_4 \cdot 6H_2O$ and water	500 mA g^{-1}	285 mAh g-1	500	5
6	Al_xMnO_2 cathode	2M $Al(OTF)_3$ aqueous electrolyte	500 mA g^{-1}	400 mAh g-1	400	6
7	δ-MnO_2	1-Ethyl-3-methylimidazolium chloride ([EMIm]) and $AlCl_3$ (1:1 in weight)	100 mA g^{-1}	59 mAh g-1 29 mAhg-1	1st cycle 100 cycle	7
This work	β-MnO_2 (20%) + MWCNT (80%)	Triethyl amine hydrochloride (TEA.HCl)and $AlCl_3$ (1:1.5 in mol)	100 mA g^{-1}	269 mAh g-1 55 mAh g-1	1st cycle 65th cycle	-

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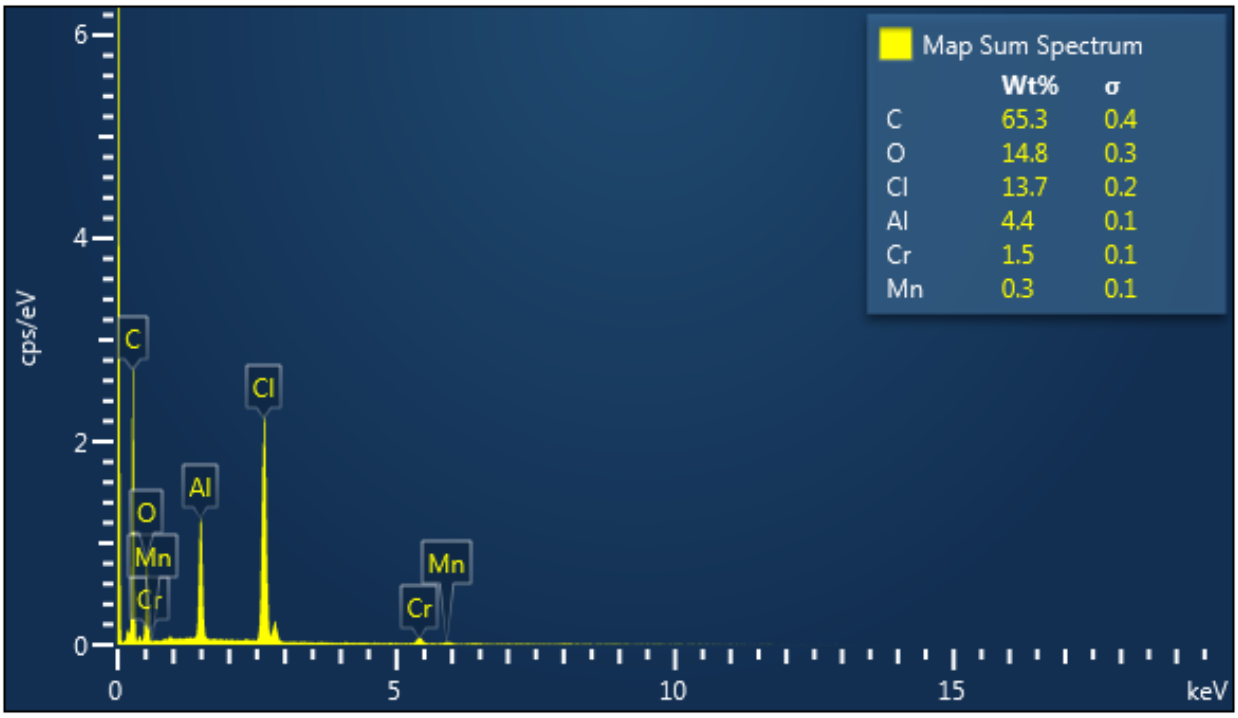

Fig. S9 Cycled charge state cathode material EDX

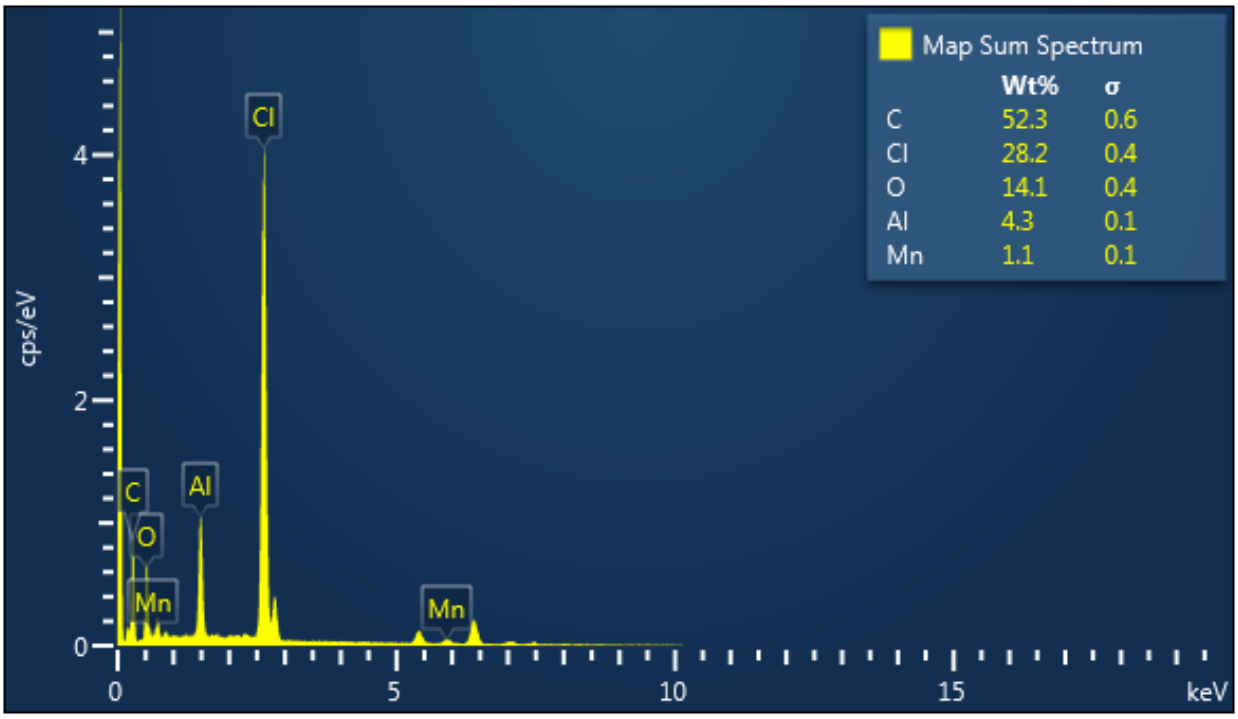

Fig. S10 Cycled discharge state cathode material EDX