Supplementary Information (SI) for Journal of Materials Chemistry A.
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Supporting Information

Ex-situ and *operando* investigations on $(FeCoCrMnZn)_3O_4$ High Entropy Oxide as Anode for Li ion battery

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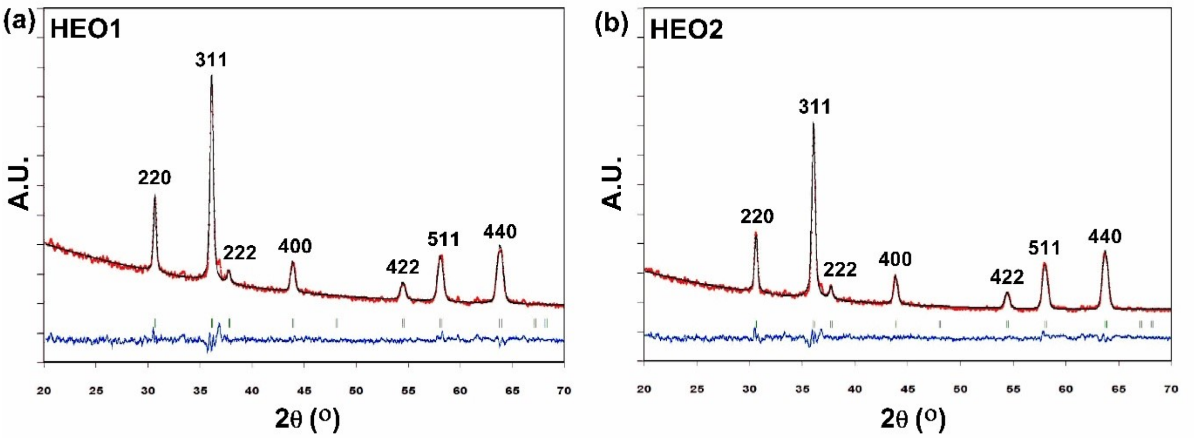

Fig. S1: Le-Bail fitting of the XRD pattern of HEO1 and HEO2

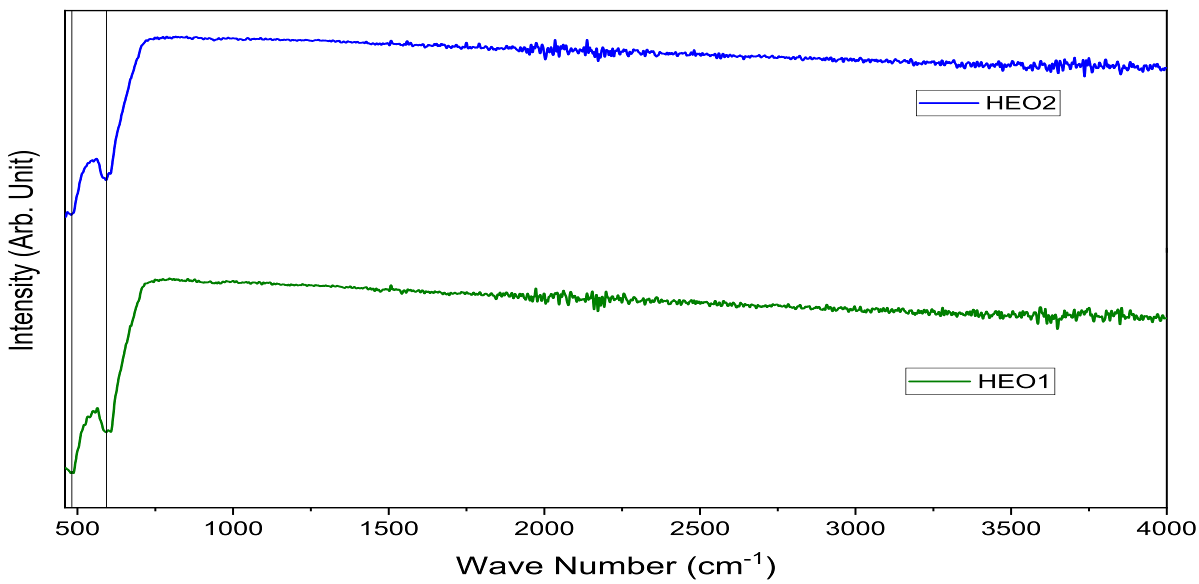

Fig. S2: FTIR spectra of the HEO1 and HEO2

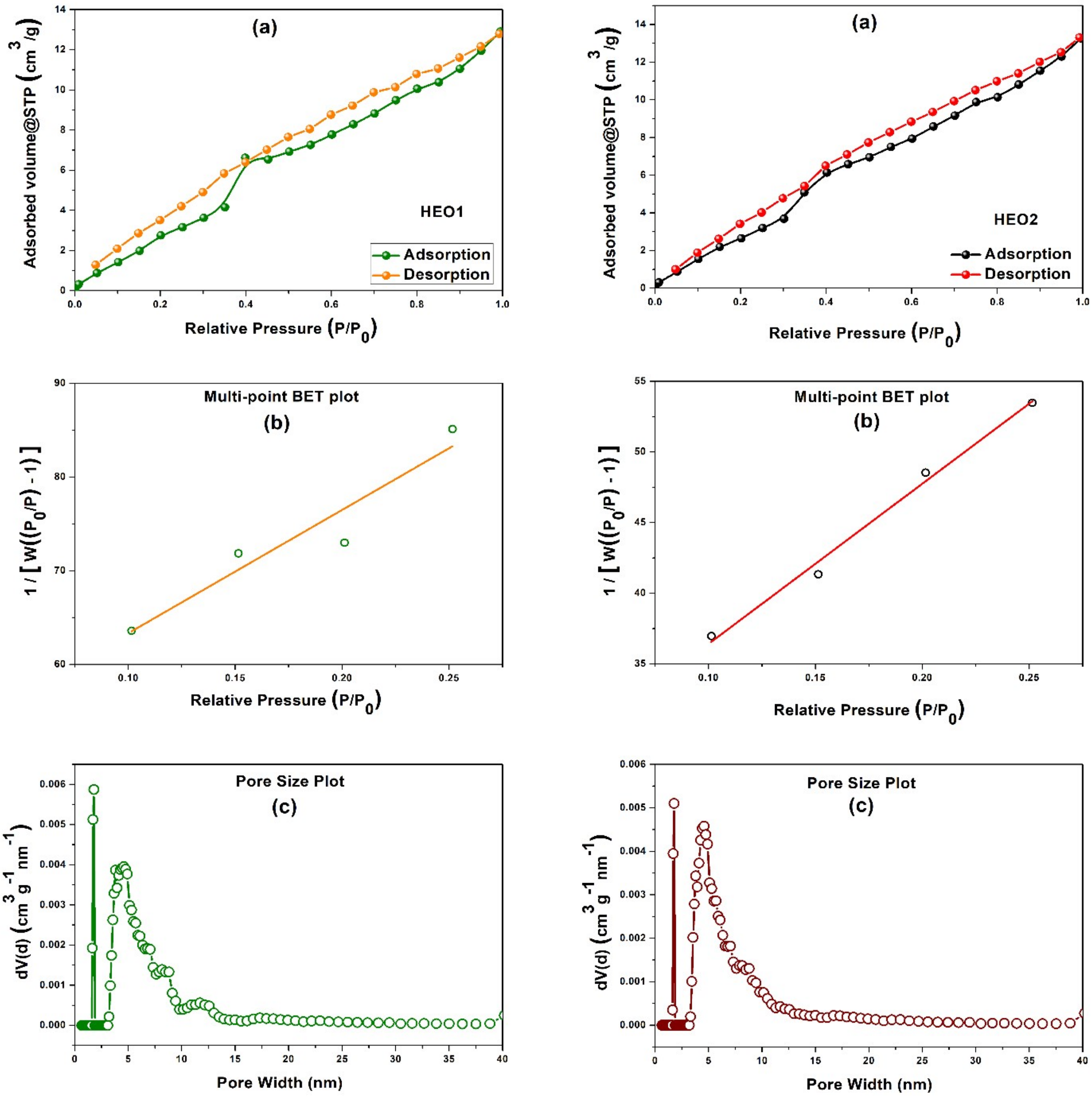

Fig. S3: BET plots of the HEO1 and HEO2.

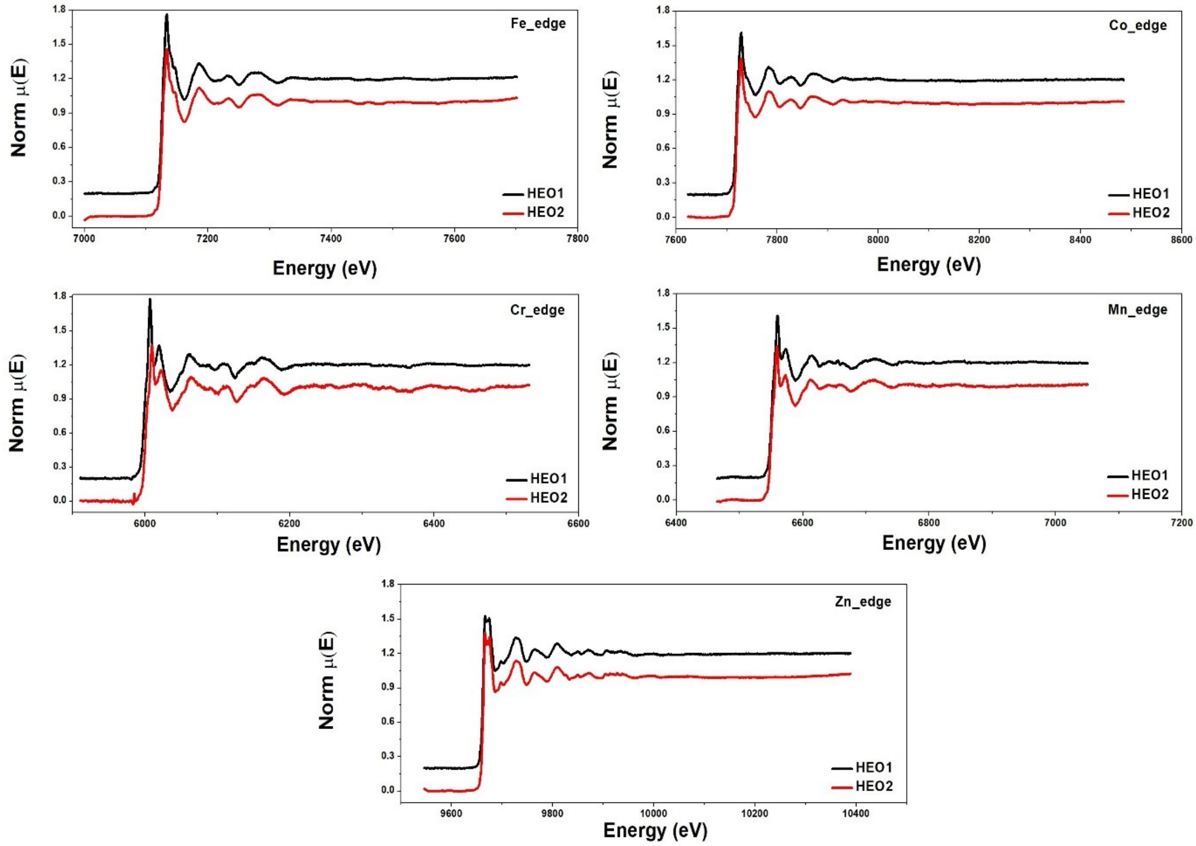

Fig. S4: EXAFS spectra of HEO1 and HEO2 samples at different element edges

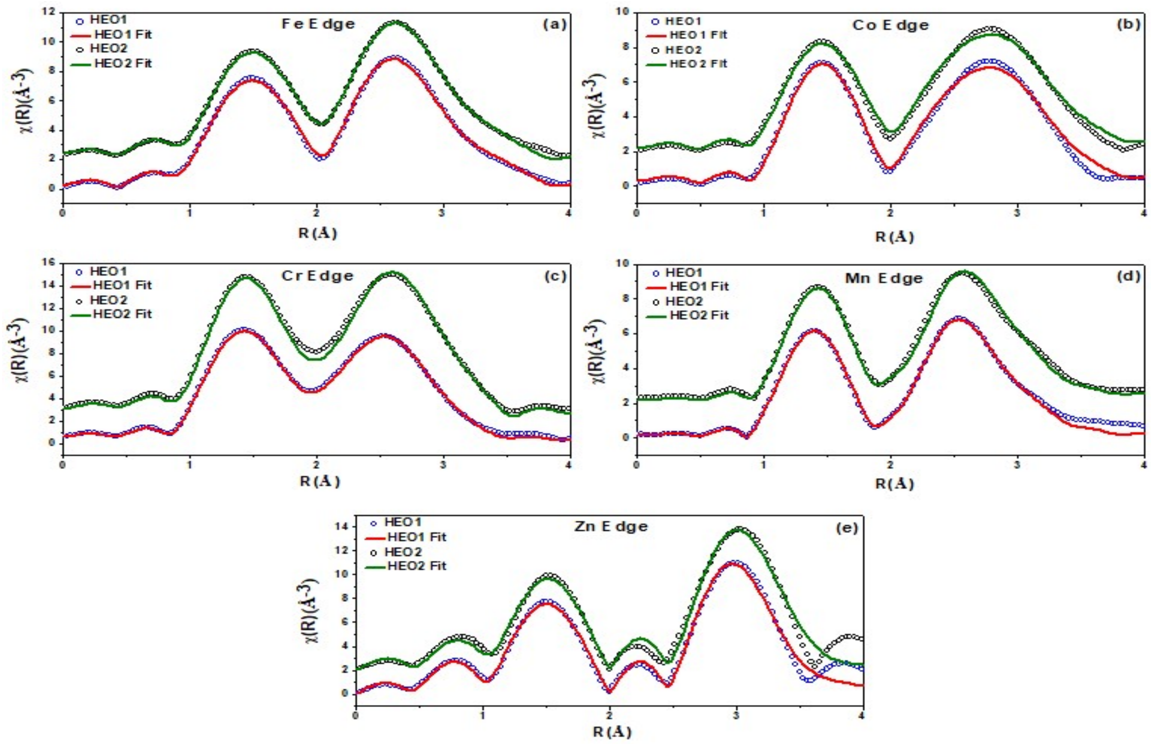

Fig. S5: Experimental $\chi(R)$ **versus R** plots **of HEO1 and HEO2 samples at different element edges alongwith best fit theoretical curves.**

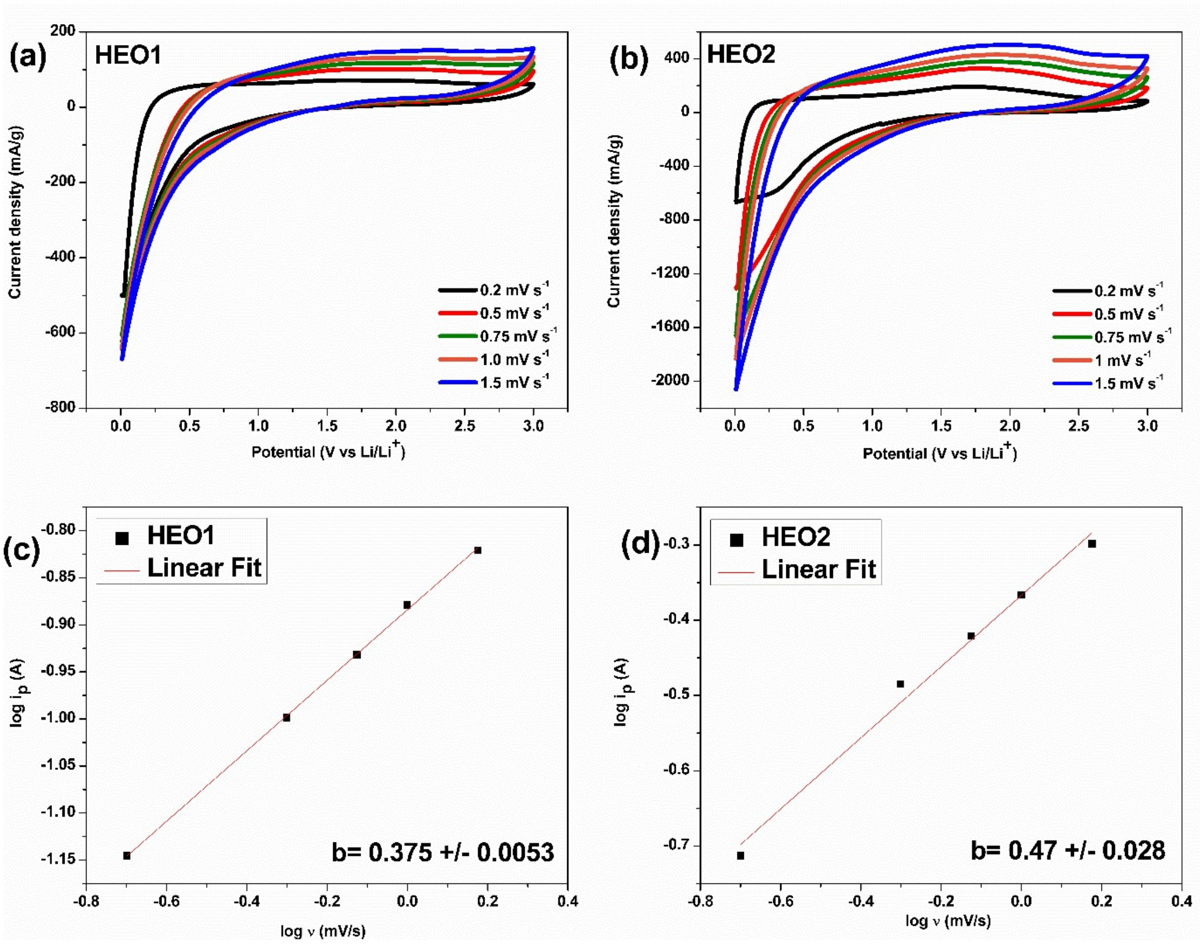

Fig. S6: CV plots of (a) HEO1 and (b) HEO2 at different scan rates. Log of anodic peak current versus log of scan rate plot for (c) HEO1 and (d) HEO2 samples

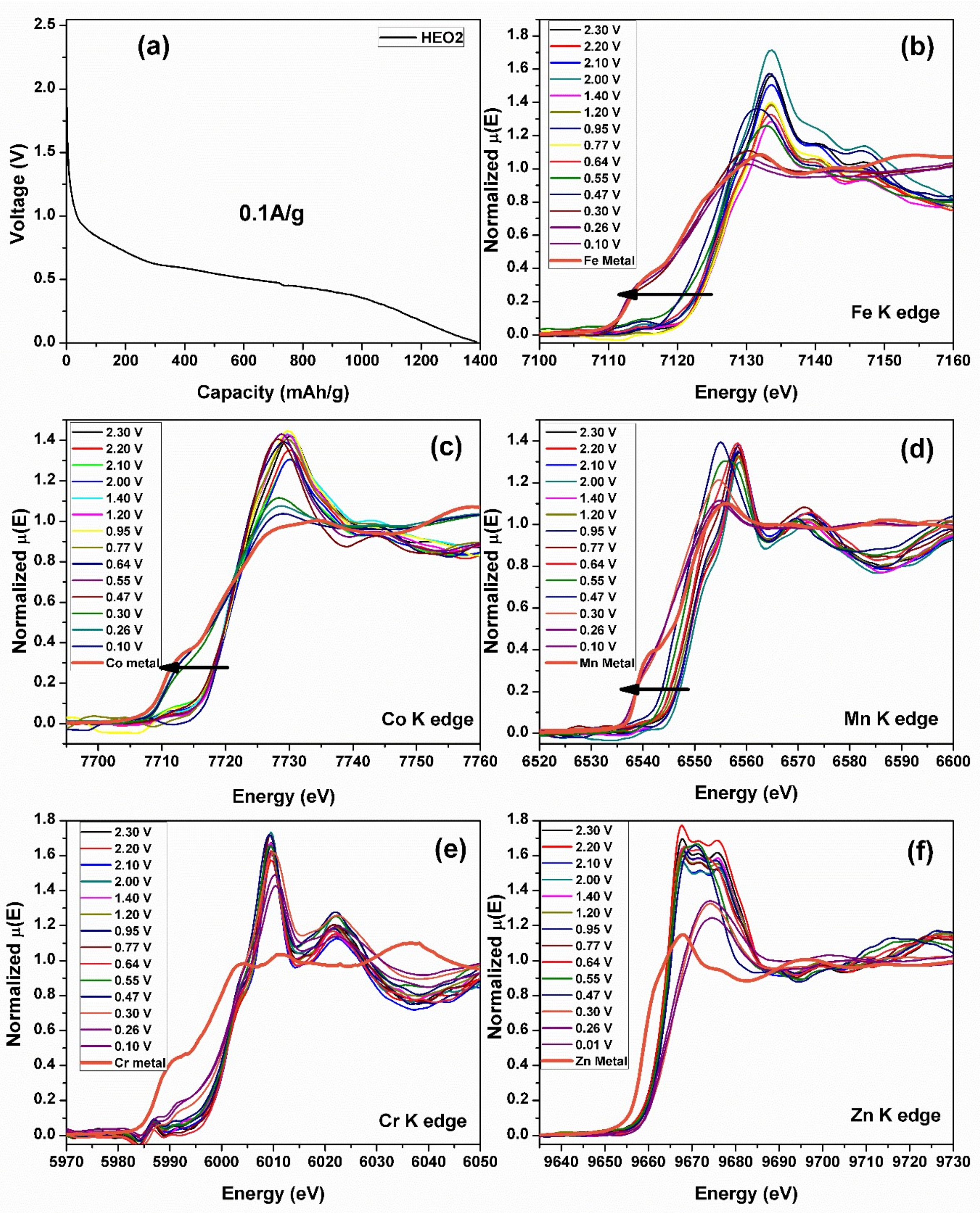

Fig. S7: (a) Voltage Profile during discharging of HEO2 anode at the rate of 0.1 A/g. (b)-(f) operando XANES plots during Lithiation of HEO2 at different element edges.

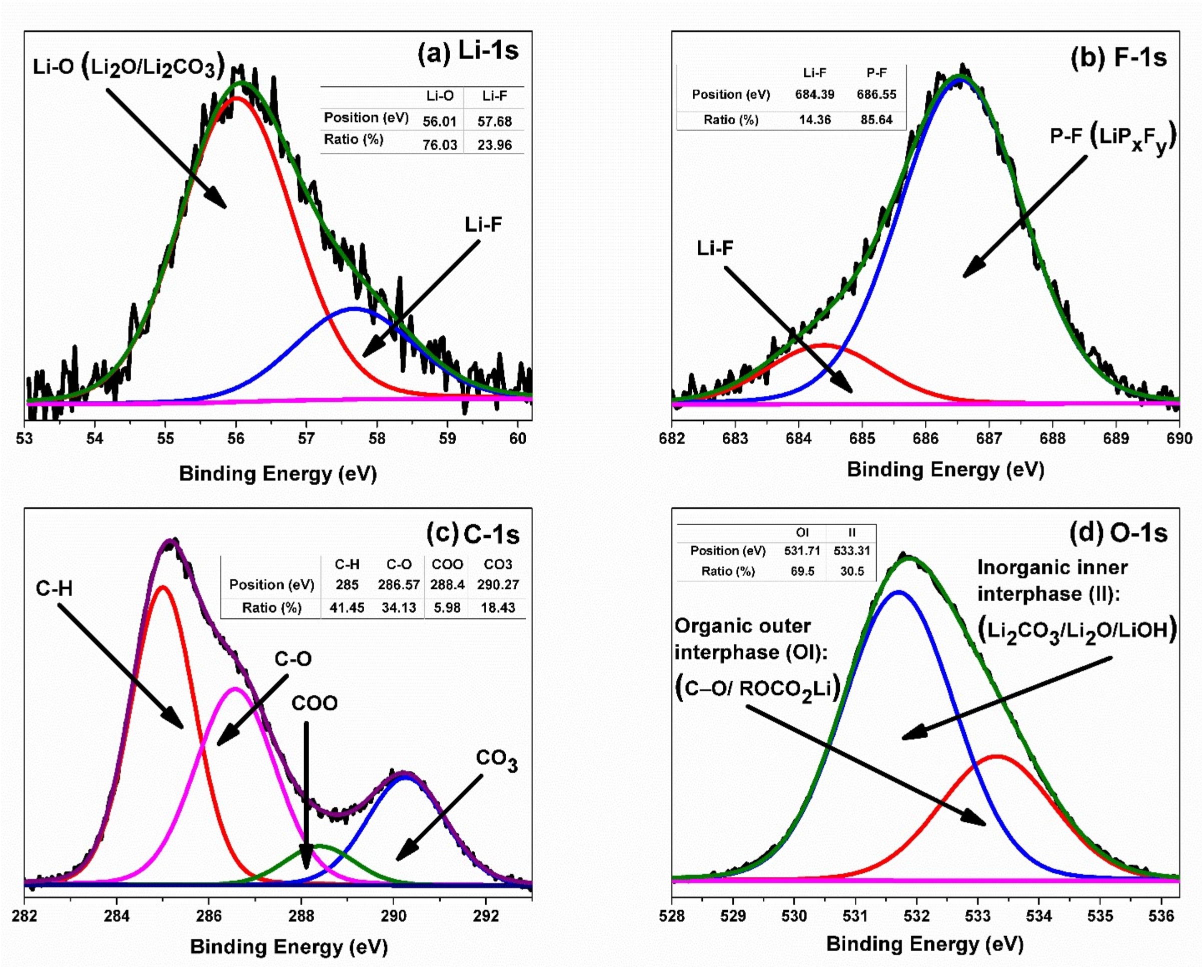

Fig. S8: Li 1s, F 1s, C 1s and O 1s XPS spectra of HEO2 anode before cycling

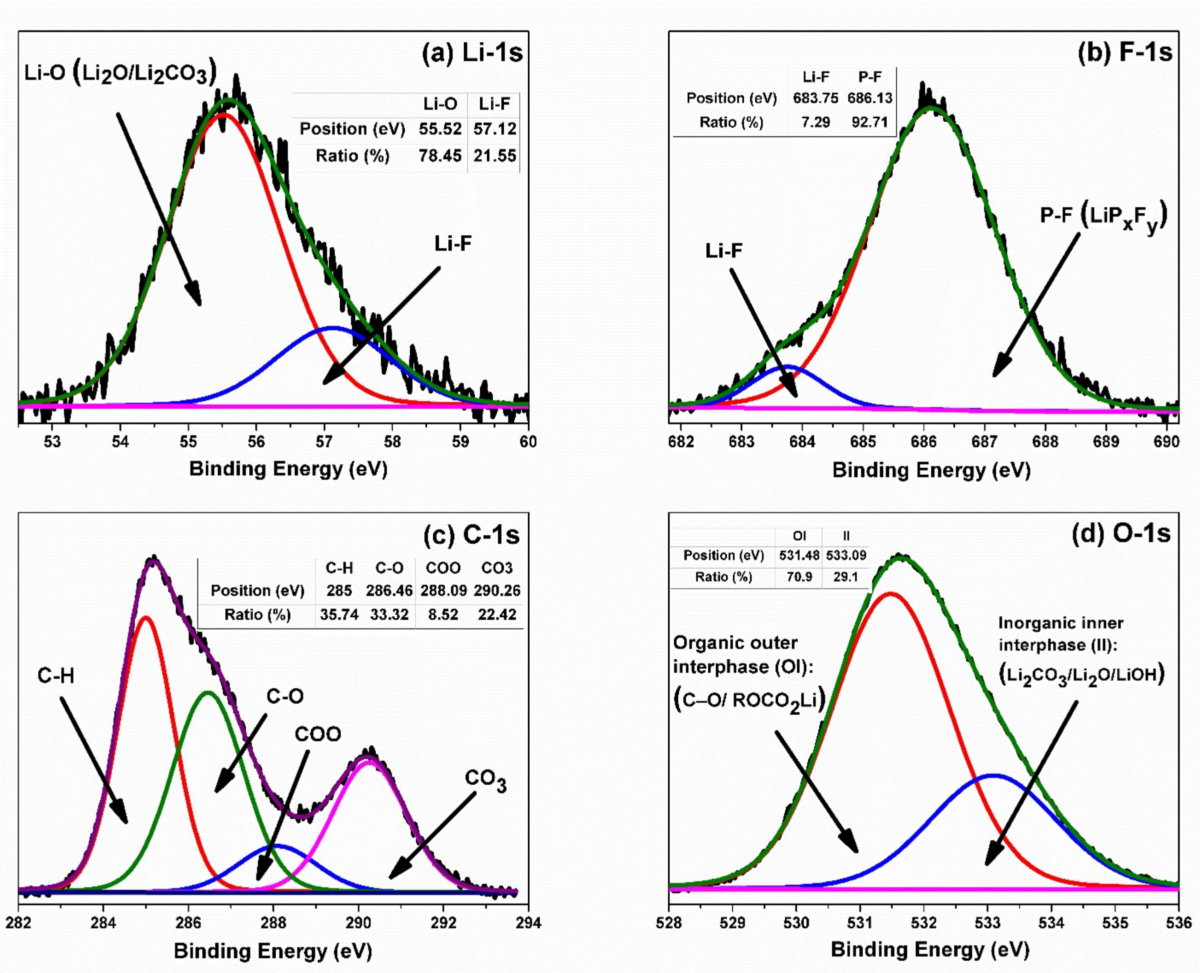

Fig. S9: Li 1s, F 1s, C 1s and O 1s XPS spectra of HEO2 anode after 100 cycles at 1 A/g current rate

Table S1: EXAFS Fitting Parameters of HEO1 and HEO2 samples at different metal K edges

Zn	**HEO1**		**R_{factor} = 0.0048, So^2= 0.976**
Path	**R (Å)**	**N**	**σ^2 (Å^2)**
Zn-O_1	1.97±0.01	3.6±0.1	0.0041±0.0007
Zn-TM_{oct}	3.47±0.01	12	0.0053±0.0006
Zn-O_2	3.41±0.05	12	0.0319±0.0061
Zn-TM_{tet}	3.64±0.02	4	0.00013±0.0005
Zn	**HEO2**		**R_{factor} = 0.0066, So^2= 0.976**
Path	**R (Å)**	**N**	**σ^2 (Å^2)**
Zn-O_1	1.97±0.01	3.4±0.1	0.0034±0.0007

Zn-TM$_{oct}$	3.48±0.01	12	0.0048±0.0006
Zn-O$_2$	3.42±0.03	12	0.0318±0.0080
Zn-TM$_{tet}$	3.63±0.01	4	0.00012±0.0009

Fe	HEO1	**R_{factor} = 0.0016, So^2 =0.821**	
Path	**R (Å)**	**N**	**σ^2 (Å^2)**
Fe-O$_1$	2.00±0.01	5.9±0.3	0.0061±0.0009
Fe-TM$_{oct}$	2.96±0.01	6	0.0056±0.0005
Fe-TM$_{tet}$	3.49±0.01	6	0.0066±0.0006
Fe-O$_2$	3.57±0.03	6	0.0274±0.0088
Fe	**HEO2**	**R_{factor} = 0.0021, So^2 =0.821**	
Path	**R (Å)**	**N**	**σ^2 (Å^2)**
Fe-O$_1$	2.00±0.01	5.1±0.3	0.0044±0.0004
Fe-TM$_{oct}$	2.97±0.01	6	0.0052±0.0003
Fe-TM$_{tet}$	3.49±0.02	6	0.0073±0.0007
Fe-O$_2$	3.57	6	0.00274±0.0074

Co	HEO1	**R_{factor} = 0.0092, So^2= 0.901**	
Path	**R (Å)**	**N**	**σ^2 (Å^2)**
Co-O$_1$	1.97±0.01	4.9±0.3	0.0071±0.0011
Co-TM$_{oct}$	2.93±0.01	6	0.0105±0.0013
Co-TM$_{tet}$	3.47±0.01	6	0.0063±0.0013
Co-O$_2$	3.33±0.05	6	0.0306±0.0080
Co	**HEO2**	**R_{factor} = 0.0123, So^2= 0.901**	
Path	**R (Å)**	**N**	**σ^2 (Å^2)**
Co-O$_1$	1.98±0.01	4.5±0.3	0.0072±0.0013

Co-TM$_{oct}$	2.94±0.01	6	0.0105±0.0013
Co-TM$_{tet}$	3.48±0.01	6	0.0062±0.0013
Co-O$_2$	3.34±0.05	6	0.0283±0.0091

Cr	**HEO1**	**R_{factor} = 0.0009, So^2 =0.900**	
Path	**R (Å)**	**N**	**σ^2 (Å^2)**
Cr-O$_1$	1.95±0.01	5.1±0.2	0.0010±0.0005
Cr-TM$_{oct}$	2.94±0.01	6	0.0040±0.0005
Cr-TM$_{tet}$	3.50±0.02	6	0.0153±0.0019
Cr-O$_2$	3.77±0.01	6	0.0010±0.0007
Cr	**HEO2**	**R_{factor} = 0.0052, So^2 =0.900**	
Path	**R (Å)**	**N**	**σ^2 (Å^2)**
Cr-O$_1$	1.94±0.01	5.9±0.1	0.0010±0.0009
Cr-TM$_{oct}$	2.93±0.01	6	0.0013±0.0008
Cr-TM$_{tet}$	3.41±0.08	6	0.0166±0.0050
Cr-O$_2$	3.77±0.05	6	0.0010±0.0009

Mn	**HEO1**	**R_{factor} = 0.0015, So^2= 0.810**	
Path	**R (Å)**	**N**	**σ^2 (Å^2)**
Mn-O$_1$	1.90±0.01	5.7±0.4	0.0097±0.0005
Mn-TM$_{oct}$	2.94±0.01	6	0.0105±0.0005
Mn-TM$_{tet}$	3.32±0.01	6	0.0177±0.0014
Mn-O$_2$	3.39±0.01	6	0.0011±0.0007
Mn	**HEO2**	**R_{factor} = 0.0070, So^2= 0.810**	

Path	R (Å)	N	σ^2 ($Å^2$)
Mn-O$_1$	1.90±0.01	5.9±0.3	0.0091±0.0010
Mn-TM$_{oct}$	2.94±0.01	6	0.0101±0.0015
Mn-TM$_{tet}$	3.32±0.02	6	0.0185±0.0035
Mn-O$_2$	3.34±0.01	6	0.0012±0.0009

Table S2 Crystal field stabilization energy (CFSE) of the selected elements.

Ions	d_n	Tetrahedral (-Dq)	Octahedral (-Dq)
Cr^{3+}	3	3.56	12
Mn^{3+}	4	1.78	6
Fe^{3+}	5	0	0
Fe^{2+}	6	2.67	4
Co^{3+}	6	2.67	4
Co^{2+}	7	5.34	8
Zn^{2+}	10	0	0

Table S3: EIS Fitting parameters of fresh and cycled HEO1 and HEO2 electrodes

Parameters	HEO1	HEO2	HEO1 after 100 cycles at 0.1A/g	HEO2 after 100 cycles at 0.1A/g	HEO1 after 450 cycles at 1A/g	HEO2 after 450 cycles at 1A/g
R_{sol} (Ω)	4.45 ± 0.04	3.63 ± 0.06	4.06 ± 0.11	4.11 ± 0.11	4.70 ±0.15	4.92 ±0.12
Y_0	(3.065 ± 1.085)×10^{-5}	(2.89 ± 1.27)×10^{-5}	(1.67 ±1.15)×10^{-4}	(1.63 ±1.42)×10^{-4}	(3.68 ±0.37)×10^{-4}	(2.27 ± 0.21)×10^{-4}
α	0.7758 ±0.0038	0.7574 ± 0.0067	0.5676 ± 0.0158	0.5819 ± 0.0088	0.5033 ±0.011	0.5464 ± 0.0095
R_{ct} (Ω)	69.59 ±0.69	294 ± 9.72	134.1 ±25.2	47.35 ±1.22	41.04 ±1.53	37.25 ± 1.02
σ (Ω $s^{0.5}$)	36.95 ± 0.29	79.56 ±1.33	332.27 ±1.43	85.65 ±1.45	18.62 ±0.14	13.12 ±0.07
C_{dl} (μF)	5.18 ±0.62	6.28 ± 0.88	9.31 ±1.54	4.91 ±0.74	5.79 ±0.93	4.32 ±0.68

D (cm^2 s^{-1})	(1.62 ± 0.02)×10^{-12}	(3.49 ±0.12)×10^{-13}	(2.00 ±0.17)×10^{-14}	(3.01 ±0.10)×10^{-13}	(6.37 ±0.09)×10^{-12}	(1.28 ±0.01)×10^{-11}