Fig. 1 TOF-SIMS data from various coating samples

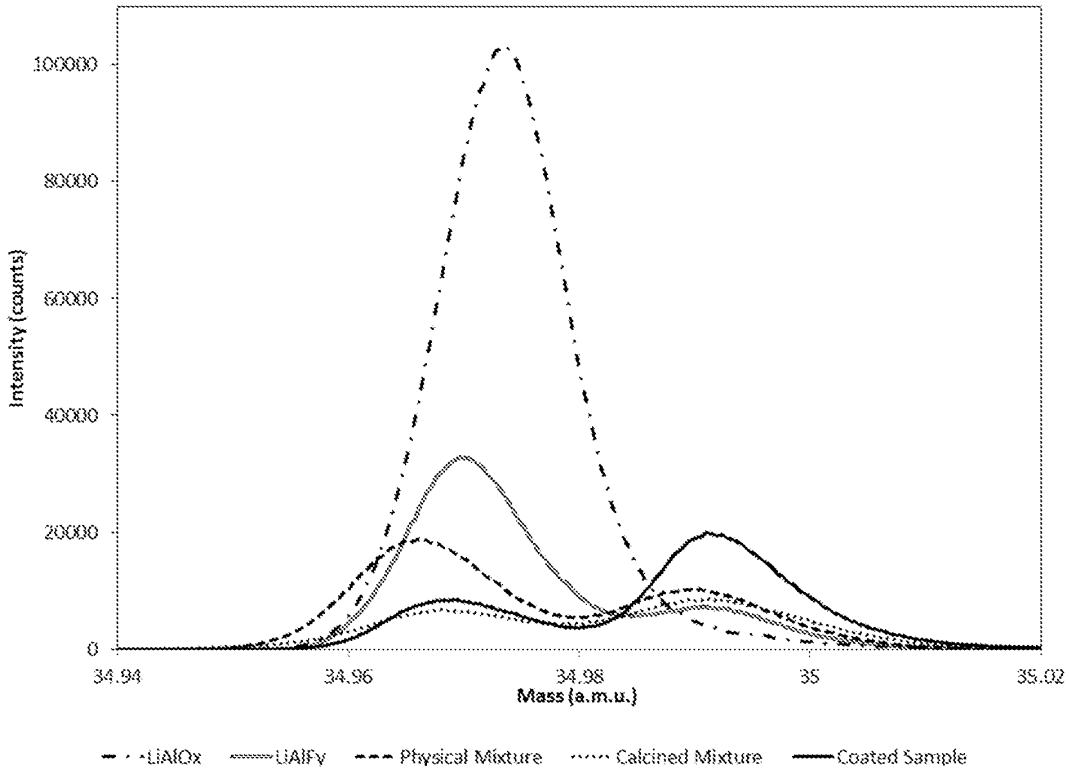
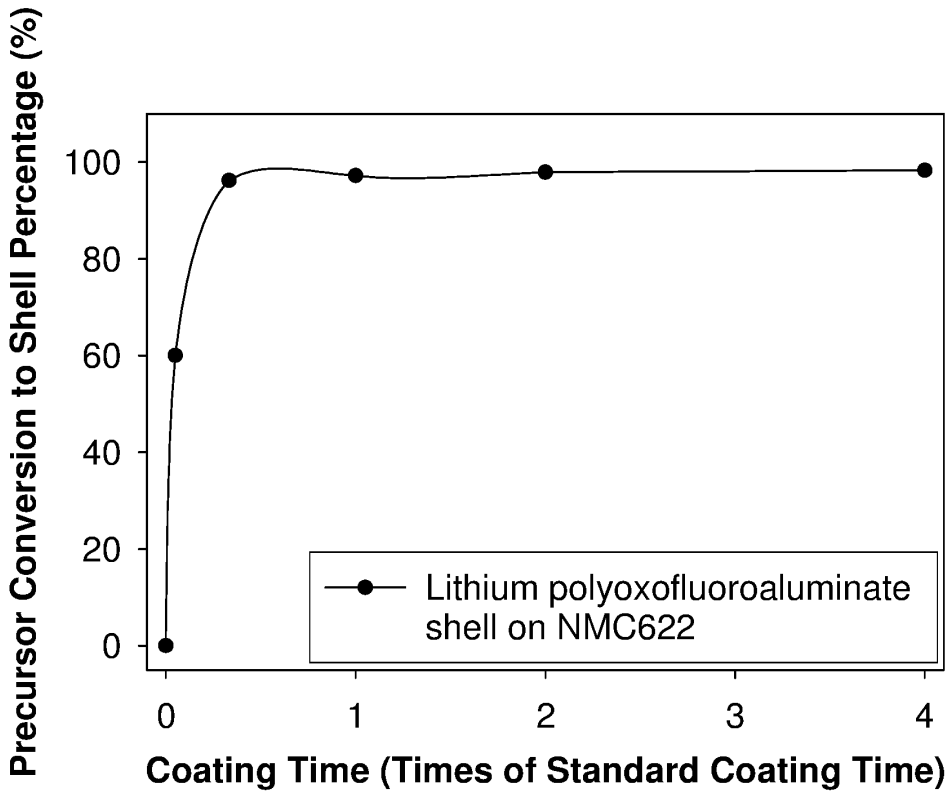


Fig.2 Precursor conversion percentage upon coating process time



Figs.3(a)-3(g) SEM observation of pristine and coated NMC622 particles by LimAlOxFy shell with different Al-F : Al-O molar ratio

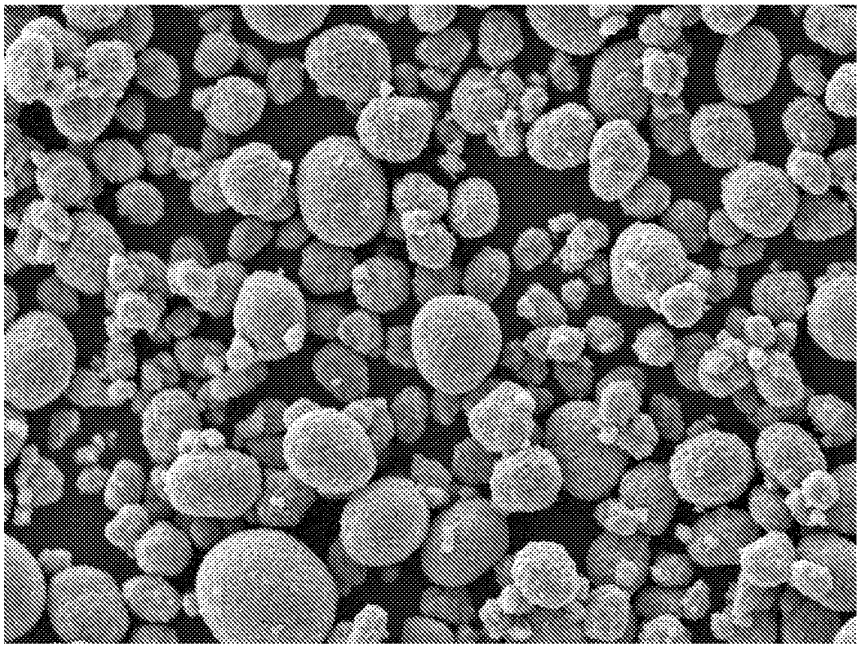


Fig. 3(a) NMC622 pristine

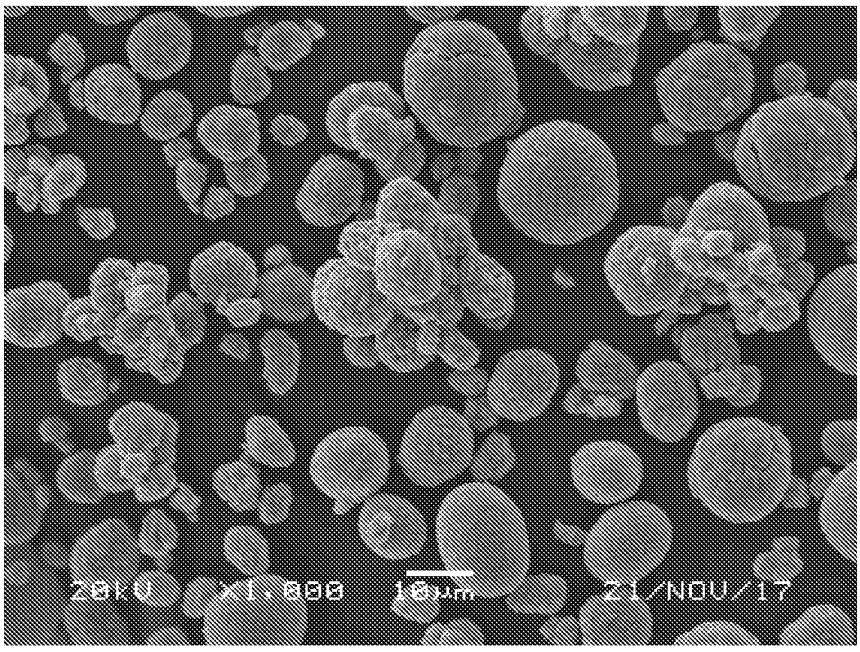


Fig. 3(b) NMC622 coated by $Li_3AlO_{2.85}F_{0.3}$ (Al-F:Al-O = 5:95 mol/mol)

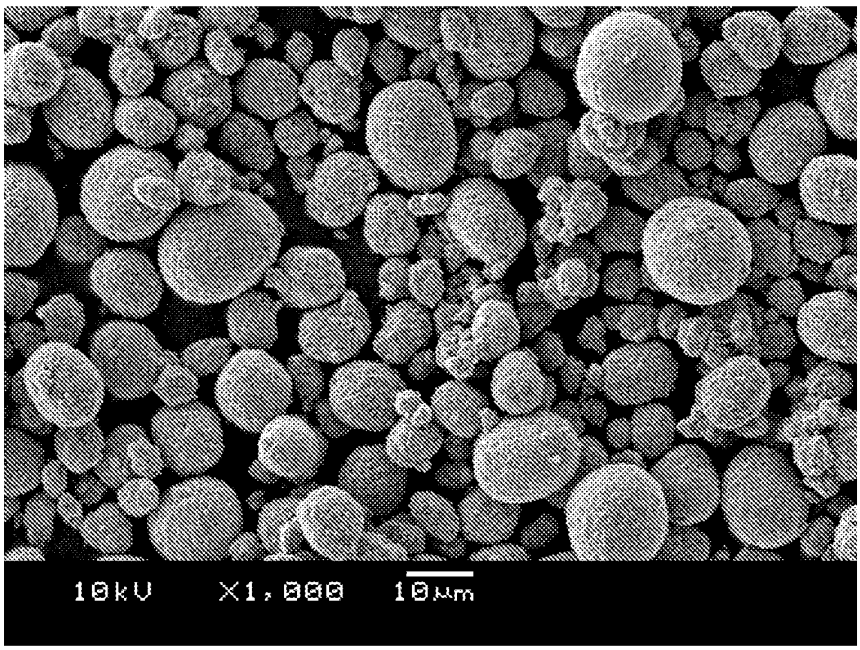


Fig. 3(c) NMC622 coated by $Li_3AlO_{2.1}F_{1.8}$ (Al-F:Al-O = 30:70 mol/mol)

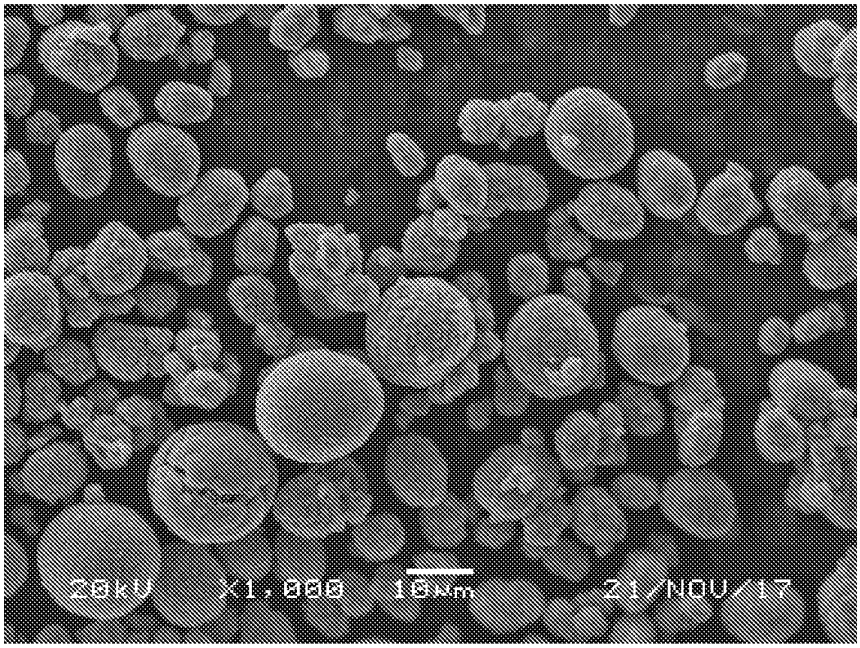


Fig. 3(d) NMC622 coated by $Li_3AlO_{1.5}F_{3.0}$ (Al-F:Al-O = 50:50 mol/mol)

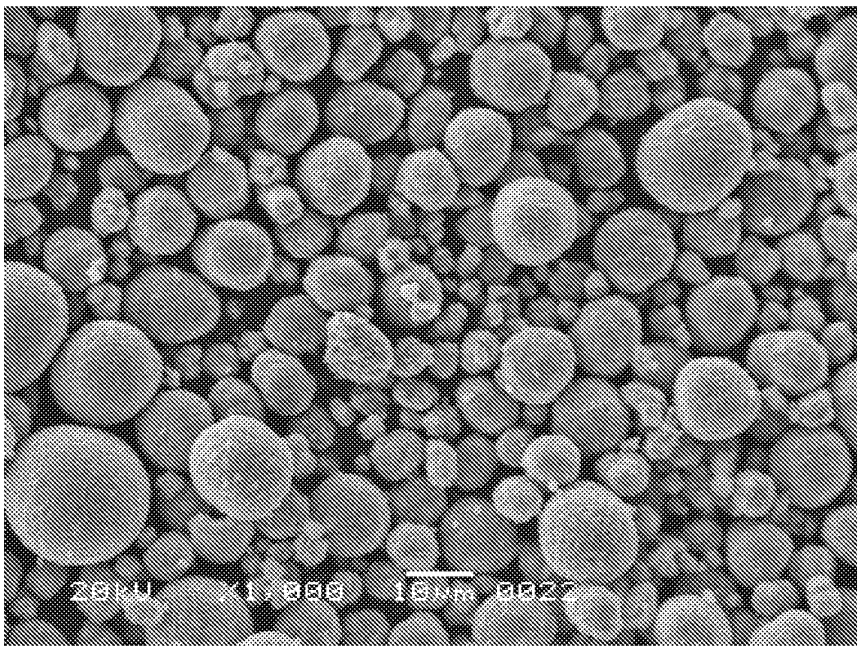


Fig. 3(e) NMC622 coated by $Li_3AlO_{0.9}F_{4.2}$ (Al-F:Al-O = 70:30 mol/mol)

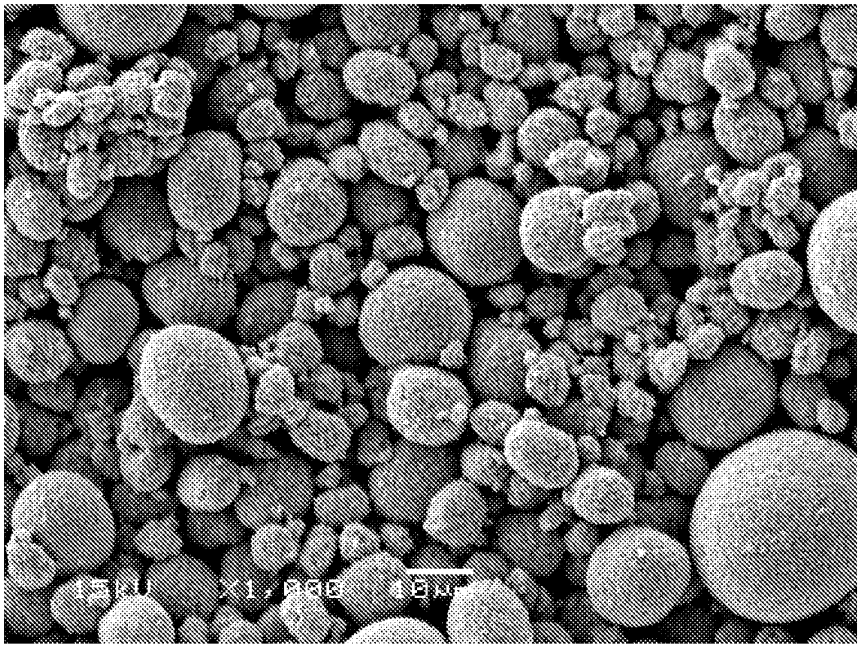


Fig. 3(f) NMC622 coated by $Li_3AlO_{0.45}F_{5.1}$ (Al-F:Al-O = 85:15 mol/mol)

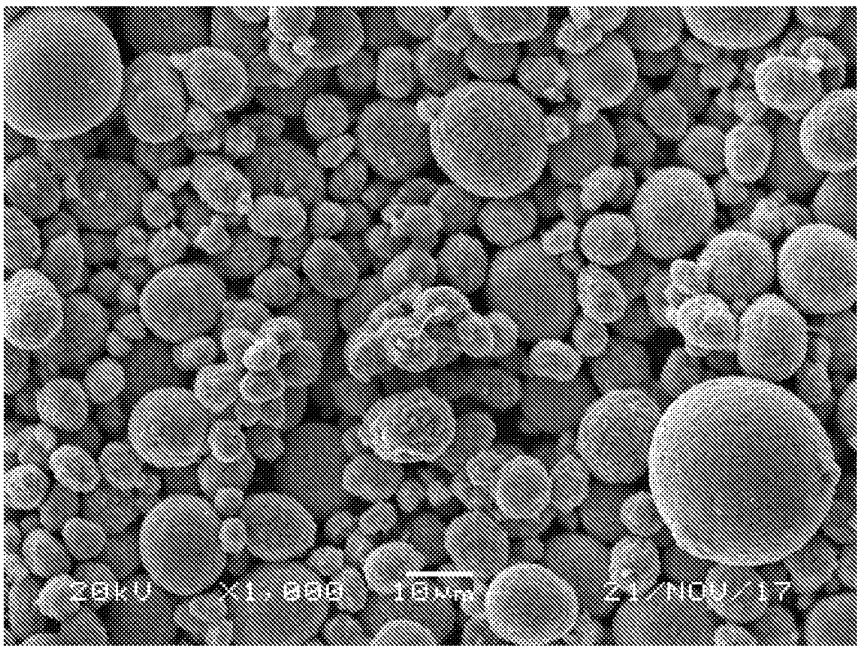


Fig. 3(g) NMC622 coated by $Li_3AlO_{0.15}F_{5.7}$ (Al-F:Al-O = 95:5 mol/mol)

Figs. 4(a)-4(b) SEM observation of NMC622 (a) pristine, (b) $Li_3AlO_{0.9}F_{4.2}$ (Al-F:Al-O = 70:30 mol/mol) coated

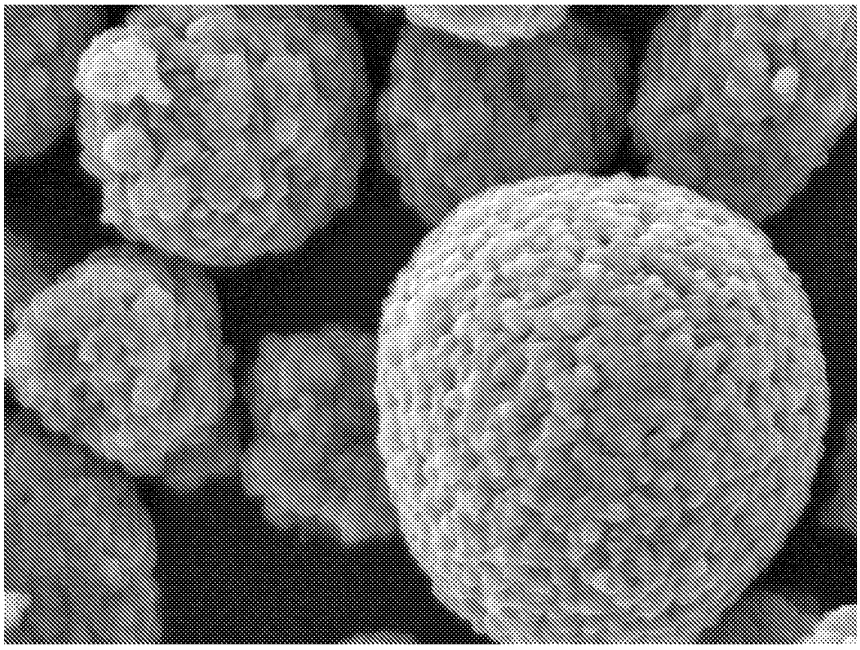


Fig. 4(a) Pristine

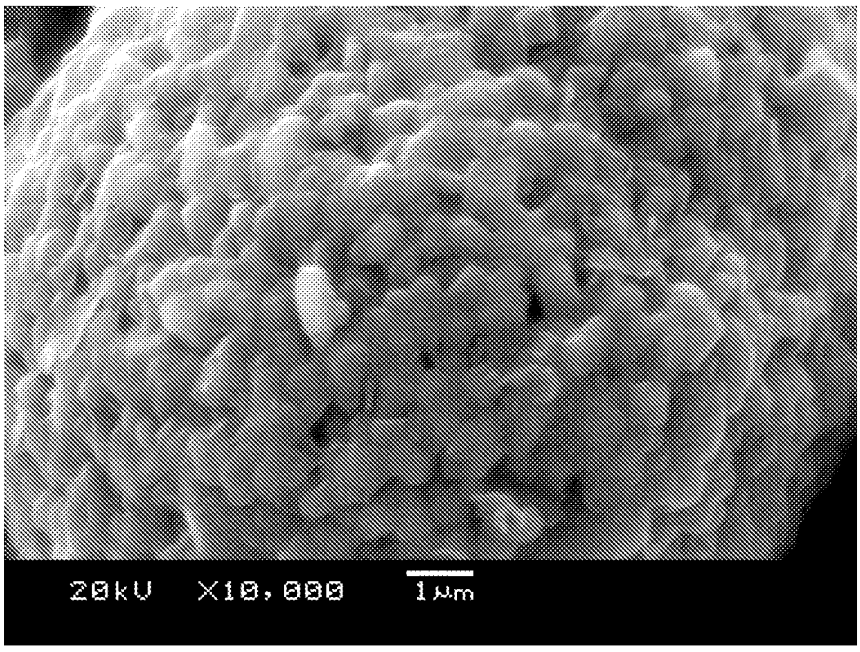


Fig. 4(b) Coated

Figs. 5(a)-5(b) SEM observation of NCA particles (a) pristine, (b) $Li_3AlO_{0.9}F_{4.2}$ (Al-F:Al-O = 70:30 mol/mol) coated NCA particles

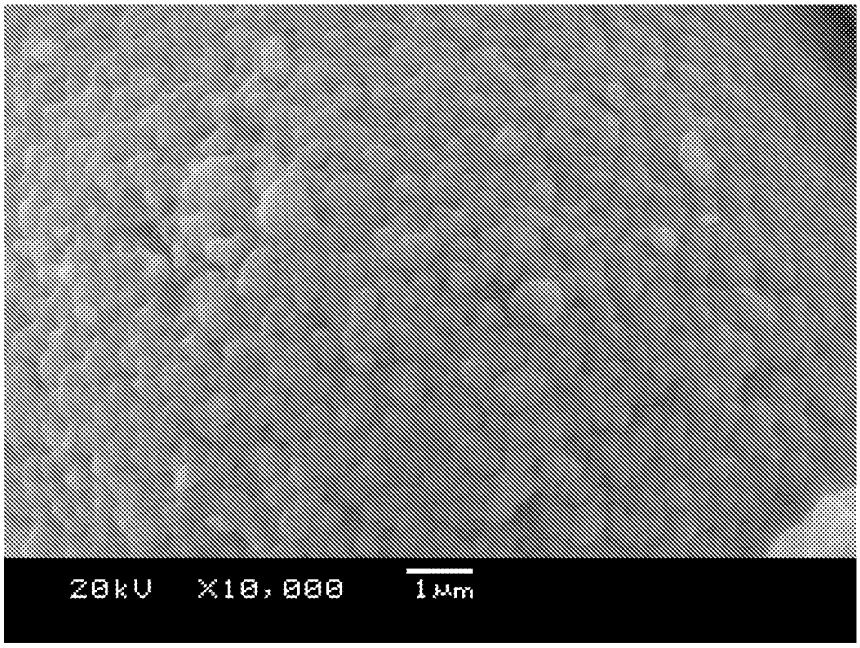


Fig. 5(a) NCA pristine

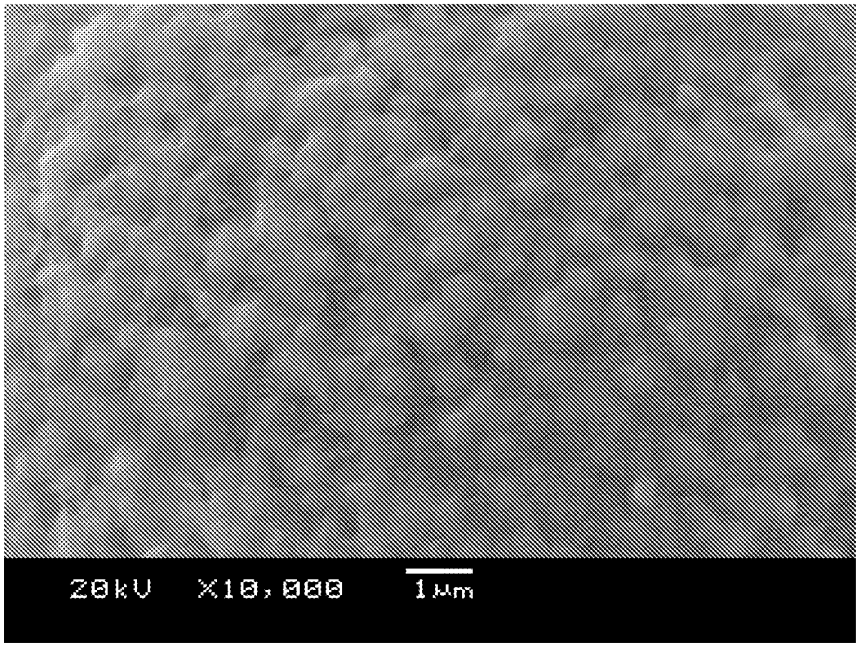


Fig. 5(b) NCA coated

Figs. 6(a)-6(b) SEM observation of LCO particles (a) pristine, (b) $Li_3AlO_{0.9}F_{4.2}$ (Al-F:Al-O = 70:30 mol/mol) coated

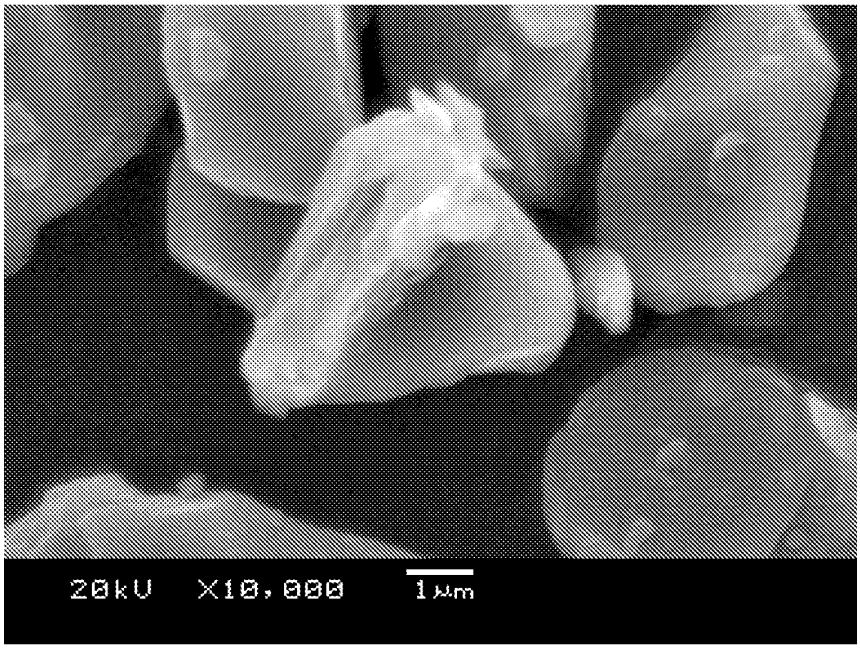


Fig. 6(a) Pristine

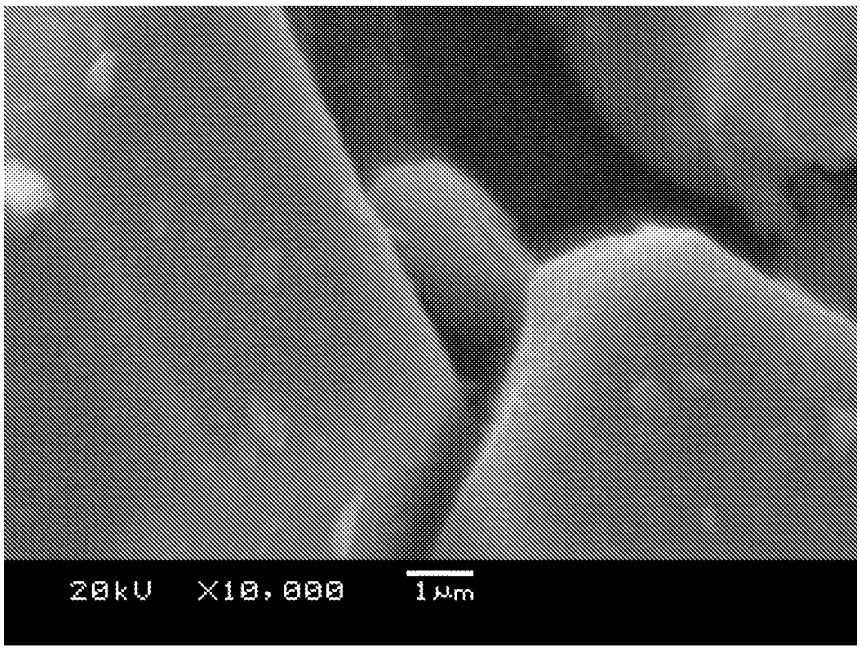


Fig. 6(b) Coated

Figs. 7(a)-7(e) SEM observation of different coating materials by different coating methods

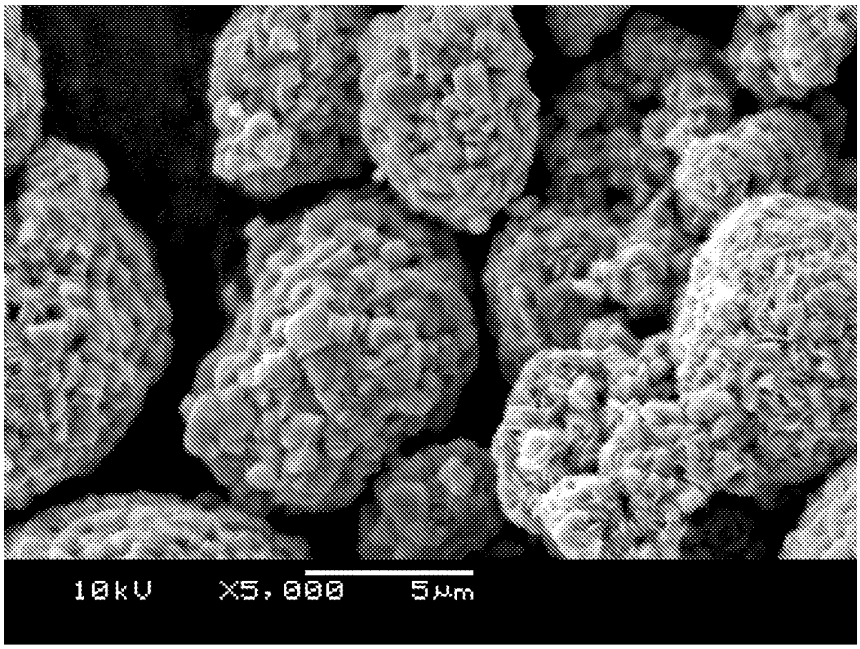


Fig. 7 (a) Aqueous solution coating of $Li_3AlO_{2.1}F_{1.8}$ (Al-F:Al-O = 30:70 mol/mol) on NMC622 core particles

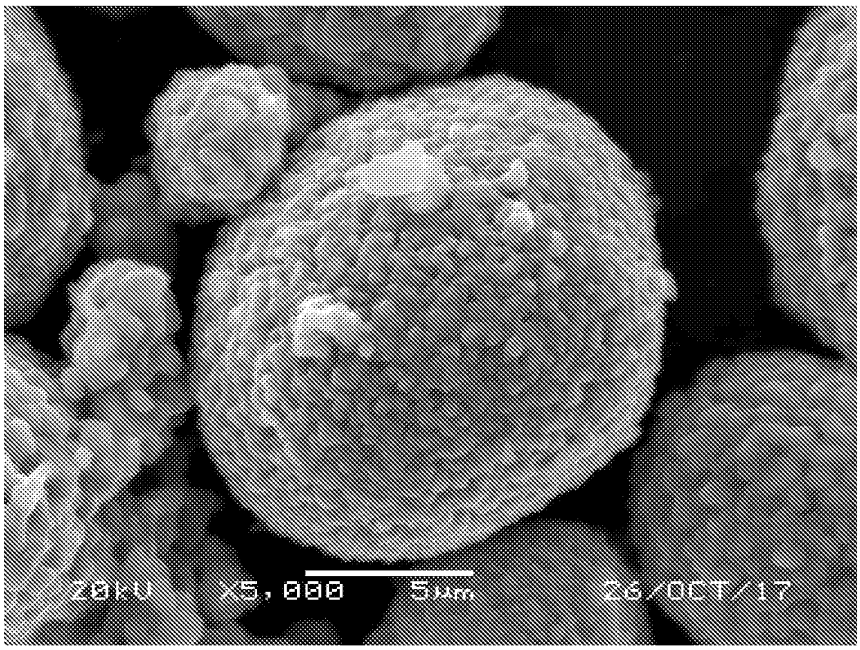


Fig. 7(b) Aqueous solution coating of Li2Ti0.93Zr0.07O2.79F0.42 on NMC622 core particles

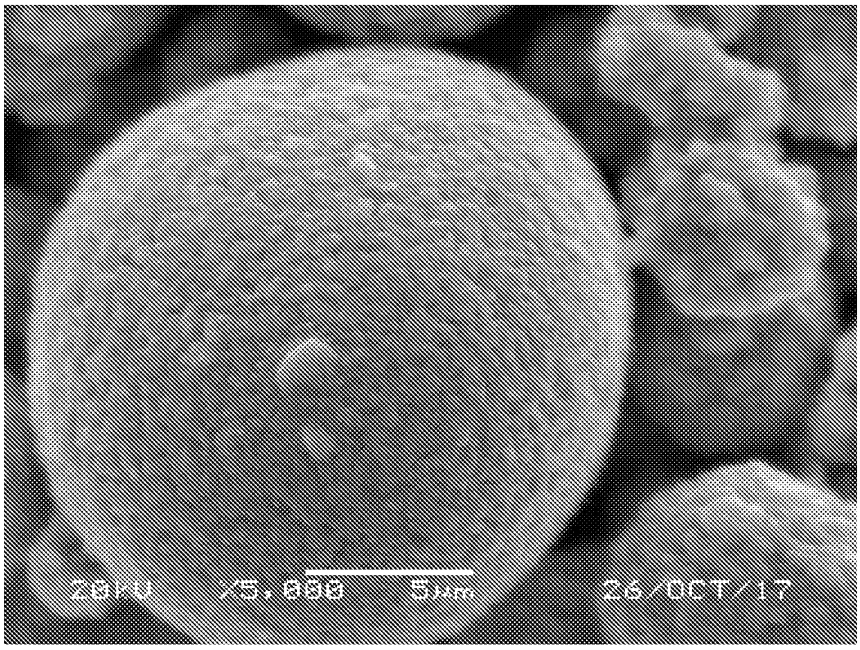


Fig. 7(c) Solvent solution coating of $Li_3AlO_{0.9}F_{4.2}$ (Al-F:Al-O = 70:30 mol/mol) on NMC622 core particles

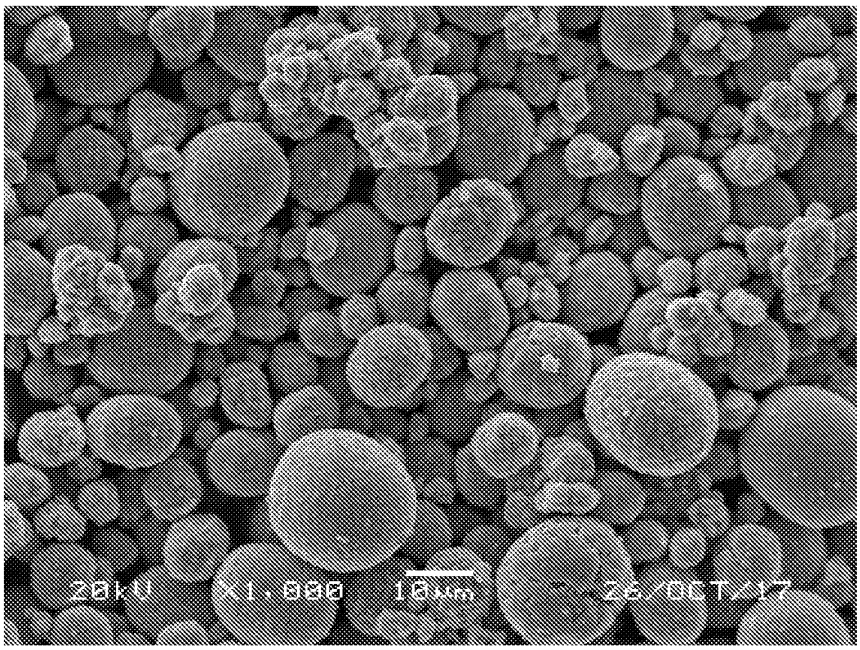


Fig. 7(d) Solid blending coating of Li3AlO1.5F3 (Al-F:Al-O = 50:50 mol/mol) on NMC622 core particles

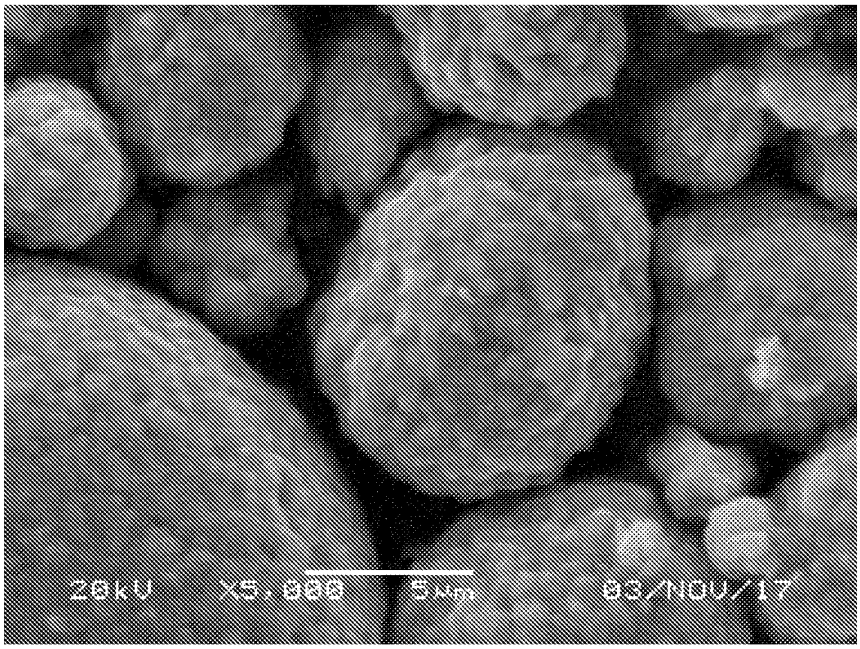


Fig. 7(e) Sol-gel coating of $Li_{1.9}2Ti_{0.47}Al_{0.16}Zr_{0.13}Si_{0.24}O_{2.49}F_{0.78}$ on NMC622 core particles

Fig. 8 Battery cycling test result for LCO material with $Li_3AlO_{0.9}F_{4.2}$ shell (Al-F:Al-O = 70:30 mol/mol)

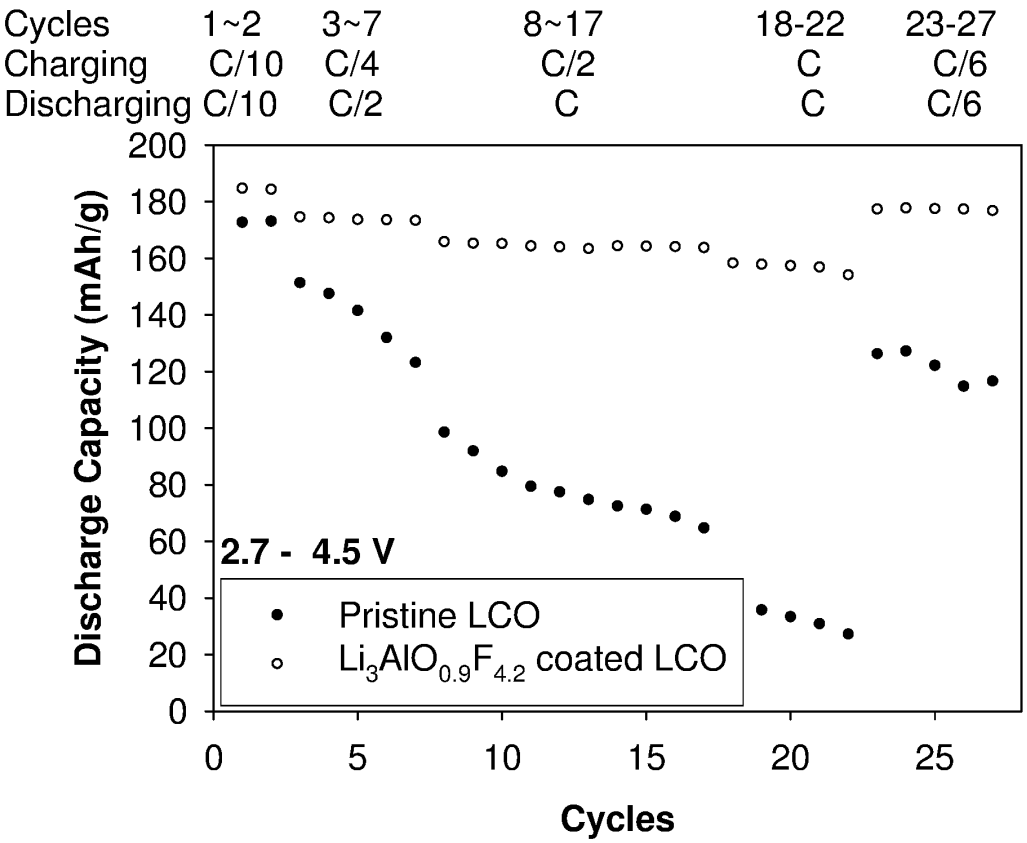


Fig. 9 Battery cycling test result for LCO cathode material coated by $Li_3Al_{0.3}In_{0.7}O_{0.9}F_{4.2}$ shell

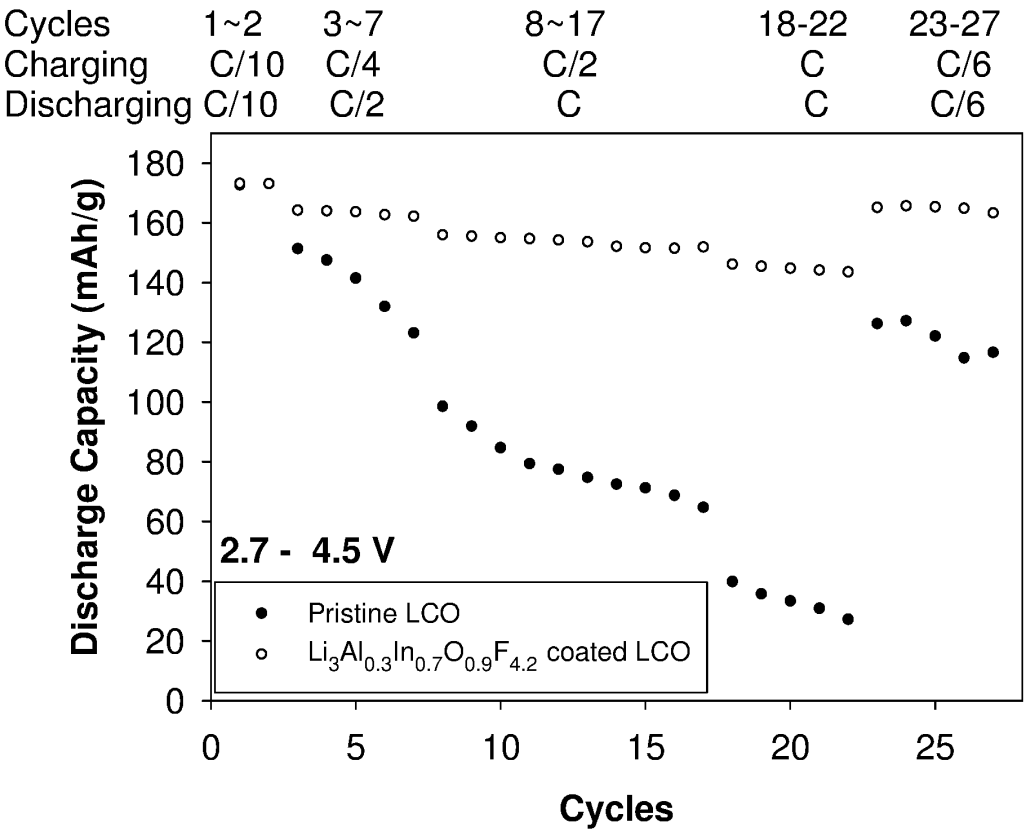


Fig. 10 Battery cycling test result for $LiNi_{0.6}Mn_{0.2}Co_{0.2}O_2$ cathode material coated by $Li_3AlO_{0.9}F_{4.2}$ shell (Al-F:Al-O = 70:30 mol/mol)

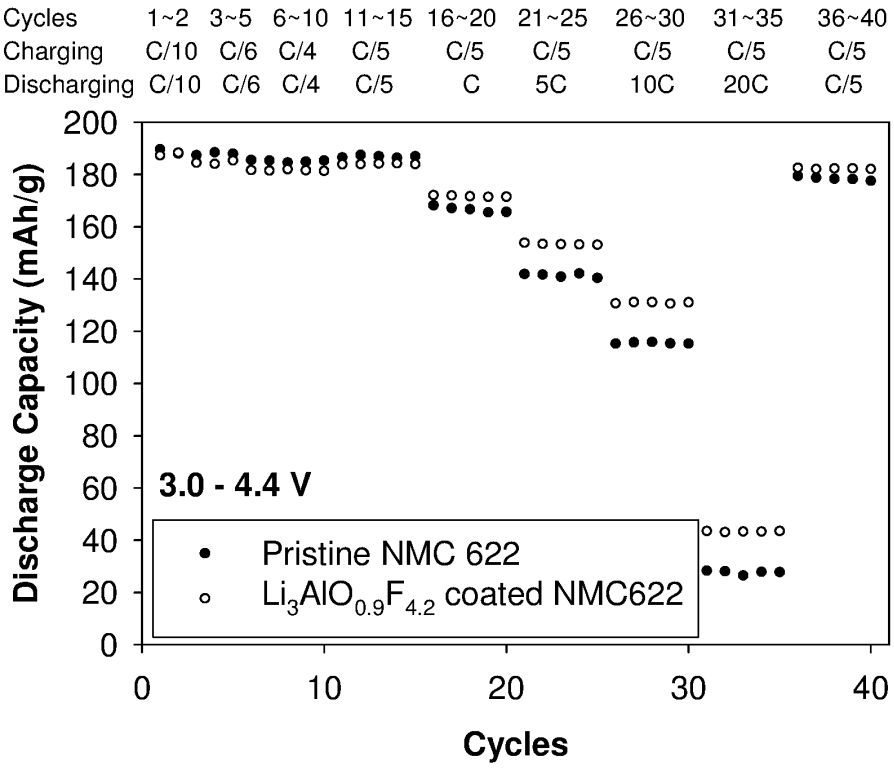


Fig. 11 Battery cycling test result for $LiNi_{0.8}Mn_{0.1}Co_{0.1}O_2$ cathode material coated by $Li_3AlO_{0.9}F_{4.2}$ shell (Al-F:Al-O = 70:30 mol/mol)

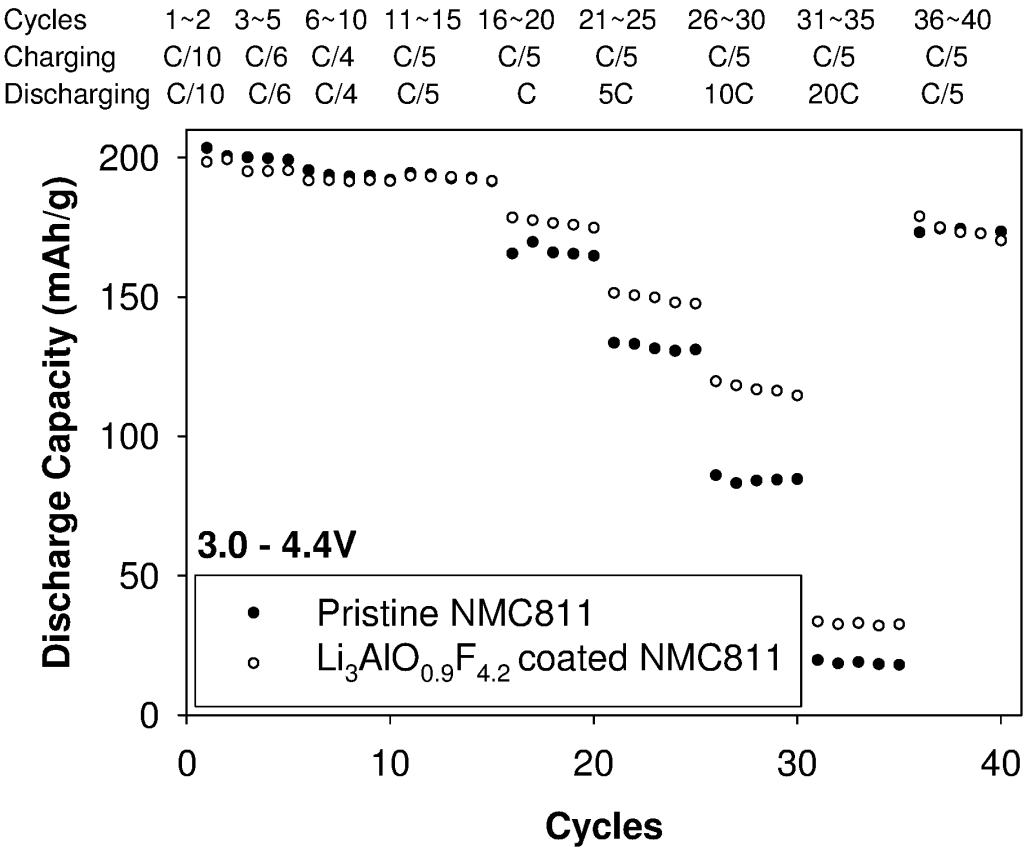


Fig. 12 Battery cycling test result for $LiNi_{0.8}Co_{0.15}Al_{0.05}O_2$ cathode material coated by $Li_3AlO_{2.1}F_{1.8}$ (Al-F:Al-O = 30:70 mol/mol) through aqueous solution coating method

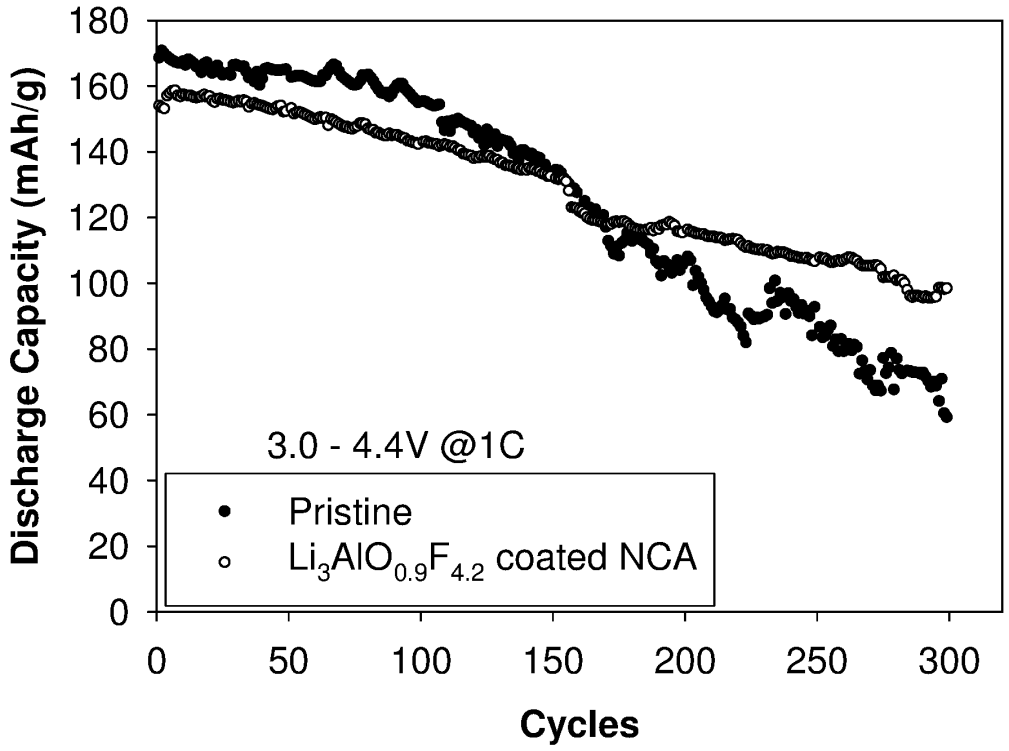


Fig. 13 Battery cycling test result for $LiNi_{0.8}Co_{0.15}Al_{0.05}O_2$ cathode material coated by $Li_3AlO_{2.1}F_{1.8}$ (Al-F:Al-O = 30:70 mol/mol) through solvent solution coating method

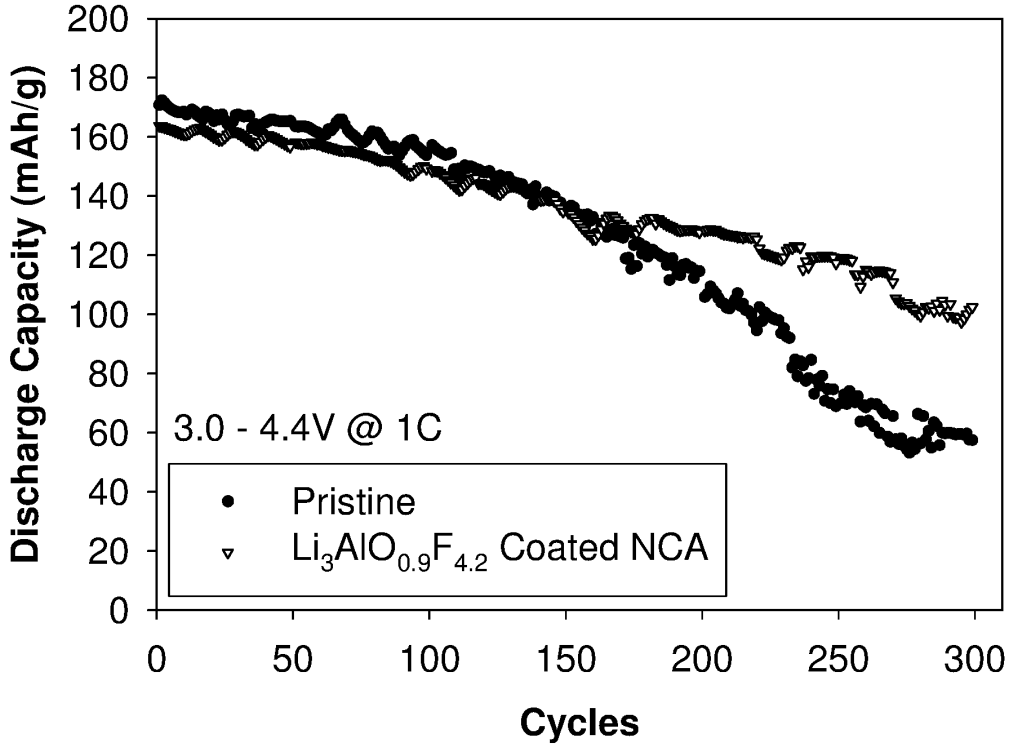
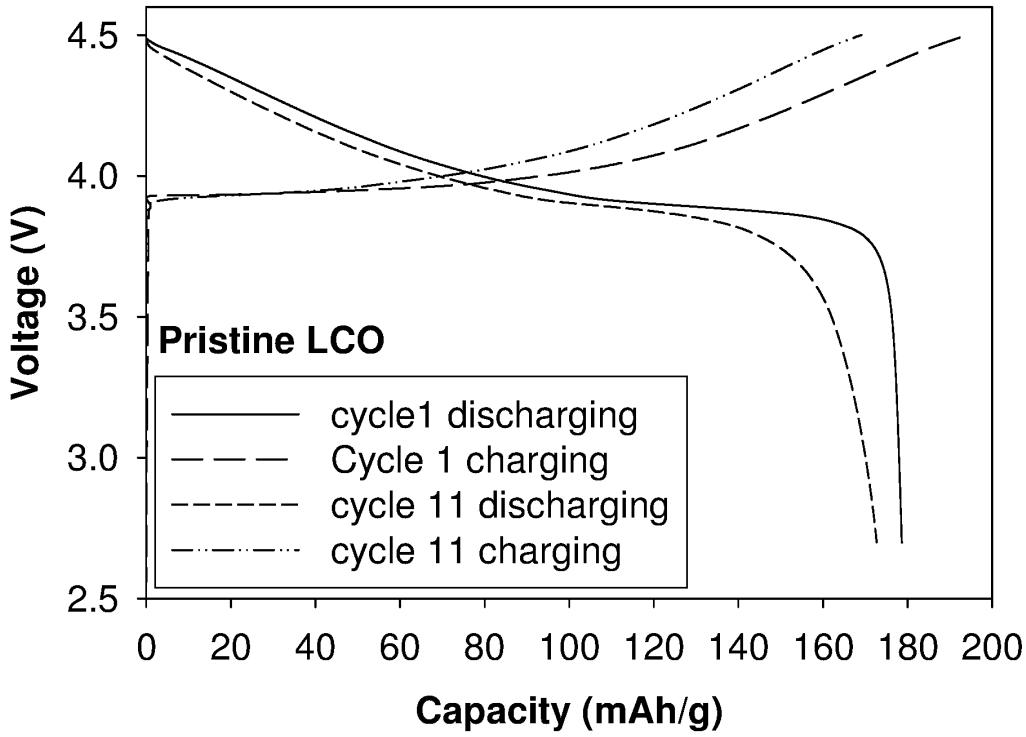
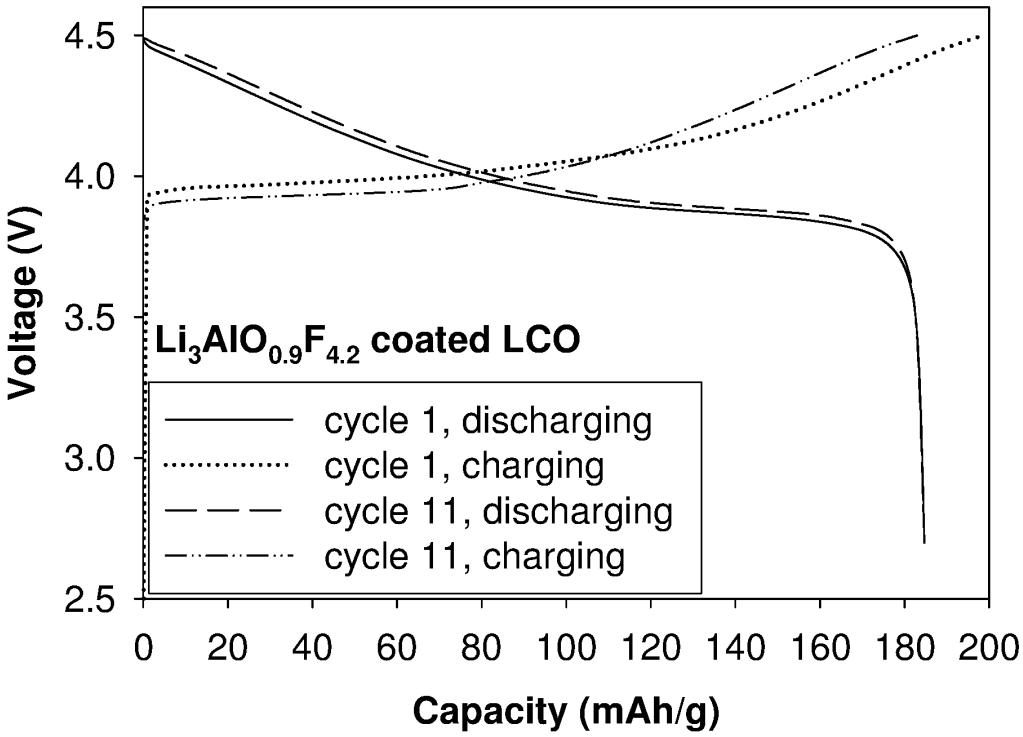


Fig. 14 Voltage and capacity relationship for pristine LCO and coated LCO




4.5
4.0
3.5
3.0
2.5
Voltage (V)
Li3AlO0.9F4.2 coated LCO
cycle 1, discharging
cycle 1, charging
cycle 11, discharging
cycle 11, charging
0
20
40
60
80
100
120
140
160
180
200
Capacity (mAh/g)