Lithium nickel cobalt aluminium oxides wikipedia

Lithium nickel cobalt aluminium oxides wikipedia

The two materials NCA and NMC have related structures, quite similar electrochemical behaviour and show similar performance, in particular relatively high energy densities and relatively high performance. Noteworthy, Ni is cycled during the battery operation between oxidation states +2 and +3.5, Co- between +2 and +3, and Mn and Al remain electrochemically inactive.[3]

It is estimated that the NCA battery pack in a Tesla Model 3 contains between 4.5 and 9.5 kg of cobalt and 11.6 kg of lithium.[4]

Lithium nickel oxide LiNiO2, which is closely related to NCA, or nickel(IV) oxide NiO2 itself, cannot yet be used as a battery material because it is mechanically unstable, shows a rapid loss of capacity and has safety issues.[5]

To make NCA more resistant, in particular for batteries that need to operate at temperatures above 50 ?C, the NCA active material is usually coated. The coatings demonstrated in research may comprise fluorides such as aluminium fluoride AlF3, crystalline oxides (e.g. CoO2, TiO2, NMC) or glassy oxides (silicon dioxide SiO2) or phosphates such as FePO4.[2]

Lithium nickel manganese cobalt oxides (abbreviated NMC, Li-NMC, LNMC, or NCM) are mixed metal oxides of lithium, nickel, manganese and cobalt with the general formula LiNixMnyCo1-x-yO2. These materials are commonly used in lithium-ion batteries for mobile devices and electric vehicles, acting as the positively charged cathode.

There is a particular interest in optimizing NMC for electric vehicle applications because of the material''s high energy density and operating voltage. Reducing the cobalt content in NMC is also a current target, owing to ethical issues with cobalt mining and the metal''s high cost.[1] Furthermore, an increased nickel content provides more capacity within the stable operation window.[2]

NMC materials have layered structures similar to the individual metal oxide compound lithium cobalt oxide (LiCoO2).[3] Lithium ions intercalate between the layers upon discharging, remaining between the lattice planes until the battery gets charged, at which point the lithium de-intercalates and moves to the anode.[4]

Sol-gel methods are another common NMC synthesis method. In this method, transition metal precursors are dissolved in a nitrate or acetate solution, then combined with a lithium nitrate or lithium acetate and citric acid solution. This mixture is stirred and heated to about 80 ?C under basic conditions until a viscous gel forms. The gel is dried at around 120 ?C and calcined twice, once at 450 ?C and again at

800-900 ?C, to obtain NMC material.[12]

Hydrothermal treatment can be paired with either the coprecipitation or sol-gel routes. It involves heating the coprecipitate or gel precursors in an autoclave. The treated precursors are then filtered off and calcined normally. Hydrothermal treatments before calcination improves the crystallinity of NMC, which increases the material''s performance in cells. However, this comes at the cost of longer material processing times.[12]

As of 2023, the biggest producers of NMC materials include EcoPro,[21] Ronbay Technology,[22] Easpring and Umicore.[23]

Arumugam Manthiram has reported that the relative positioning of the metals'' 3d bands to the oxygen 2p band leads to each metal''s role within NMC cathode materials. The manganese 3d band is above the oxygen 2p band, resulting in manganese''s high chemical stability. The cobalt and nickel 3d bands overlap the oxygen 2p band, allowing them to charge to their 4+ oxidation states without the oxygen ions losing electron density.[25]