Yunpeng Hou
Pengfei Zhou, Huanju Meng, Zhen Zhang, Zhanliang Tao* and Jun Chen*
Key Laboratory of Advanced Energy Materials Chemistry (Ministry of Education), College of Chemistry, Nankai University, Tianjin, China

chenabc@nankai.edu.cn

High-performance layered Ni-rich $LiNi_{1-x-y}Co_xAl_yO_2$ cathode materials for lithium ion batteries

Lithium ion batteries (LIBs) are expected to be used as energy storage technologies for electric vehicles, renewable power stations, and smart grids. One of the great challenges for LIBs is to develop advanced cathode materials in terms of high capacity, long cycling life, and high thermal stability. Among all kinds of cathode materials, layered Ni-rich $LiNi_{1-x-y}Co_xAl_yO_2$ materials are considered as promising candidates with advantages of high capacity and low cost. However, there still remain some crucial issues to be solved including unsatisfactory thermal stability and relatively rapid capacity fading during cycling. Optimizing synthesis process and surface coating are two major strategies to alleviate the above issues. Herein, on the one hand, we report an easy co-precipitation synthesis of microspherical $Ni_{1-x-y}Co_xAl_y(OH)_2$ precursors employing AlO_2^- as the Al source to guarantee the co-precipitation of Ni^{2+}, Co^{2+} and Al^{3+}.[1,2] As cathode materials for LIBs, both $LiNi_{0.8}Co_{0.15}Al_{0.05}O_2$ and $LiNi_{0.9}Co_{0.07}Al_{0.03}O_2$ exhibit high discharge capacity, good cycling performance and remarkable rate capability. The improved performance might be attributed to the combination of the high Ni component, well layered structure with low degree of Li^+/Ni^{2+} mixing, and uniform microspheres with homogeneous distribution of Ni, Co, and Al. On the other hand, we report a one-step dry coating of amorphous SiO_2 or $Zr(OH)_4$ on spherical $LiNi_{0.915}Co_{0.075}Al_{0.01}O_2$ (NCA) cathode materials.[3,4] 0.2 wt% SiO_2-coated NCA shows a specific capacity of 181.3 mA h g^{-1} with a capacity retention of 90.7% after 50 cycles at 1 C. 0.5 wt% $Zr(OH)_4$-coated NCA delivers a capacity of 197.6 mA h g^{-1} at the first cycle and 154.3 mA h g^{-1} after 100 cycles with a capacity retention of 78.1% at 1 C. Such superior electrochemical performance is mainly ascribed to the surface coating layer of amorphous SiO_2 or $Zr(OH)_4$, which effectively suppresses side reactions between NCA and electrolytes, decreases the SEI layer resistance, and retards the growth of charge-transfer resistance. All these works on the modification of layered Ni-rich cathode materials will further promote their commercial application in LIBs.

References

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Figures

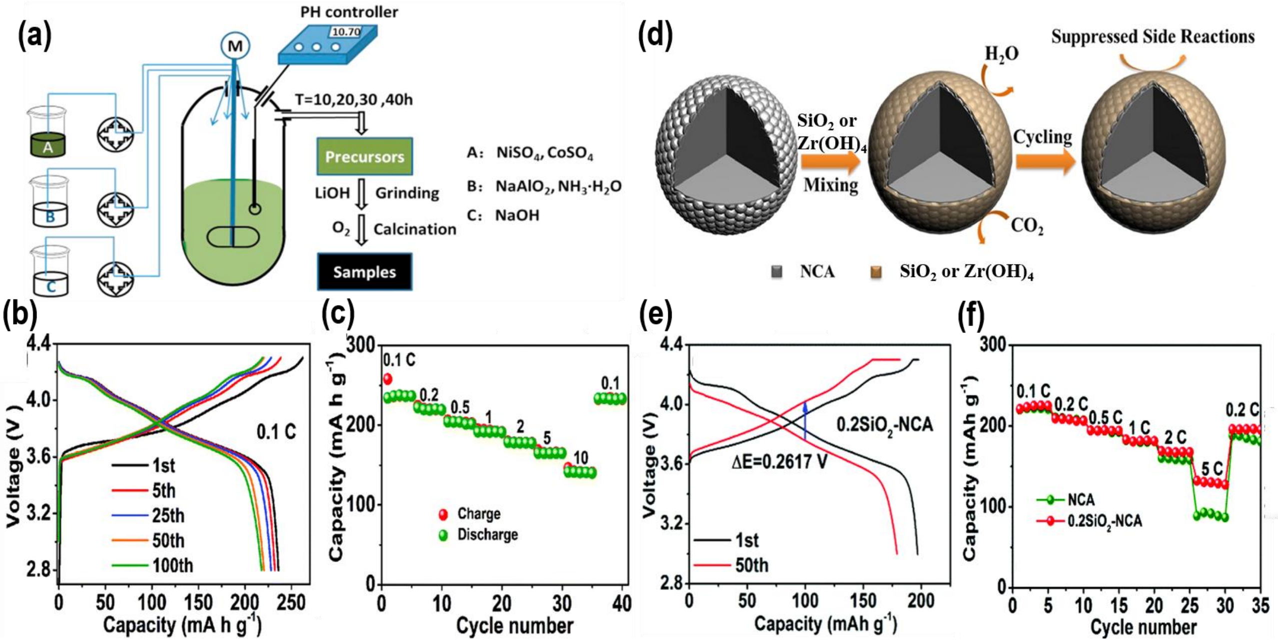

Figure 1: (a) Schematic illustration of the preparation process of spherical $LiNi_{1-x-y}Co_xAl_yO_2$. (b) Charge and discharge profiles at selected cycles at 0.1 C and (c) rate performance at various rates of the as-prepared $LiNi_{0.9}Co_{0.07}Al_{0.03}O_2$. (d) Schematic diagram for the effects of SiO_2 or $Zr(OH)_4$ coating layer on the surface of NCA. (e) Typical charge and discharge profiles of 0.2 wt% SiO_2-coated NCA and (f) rate capability of pristine NCA and 0.2 wt% SiO_2-coated NCA.