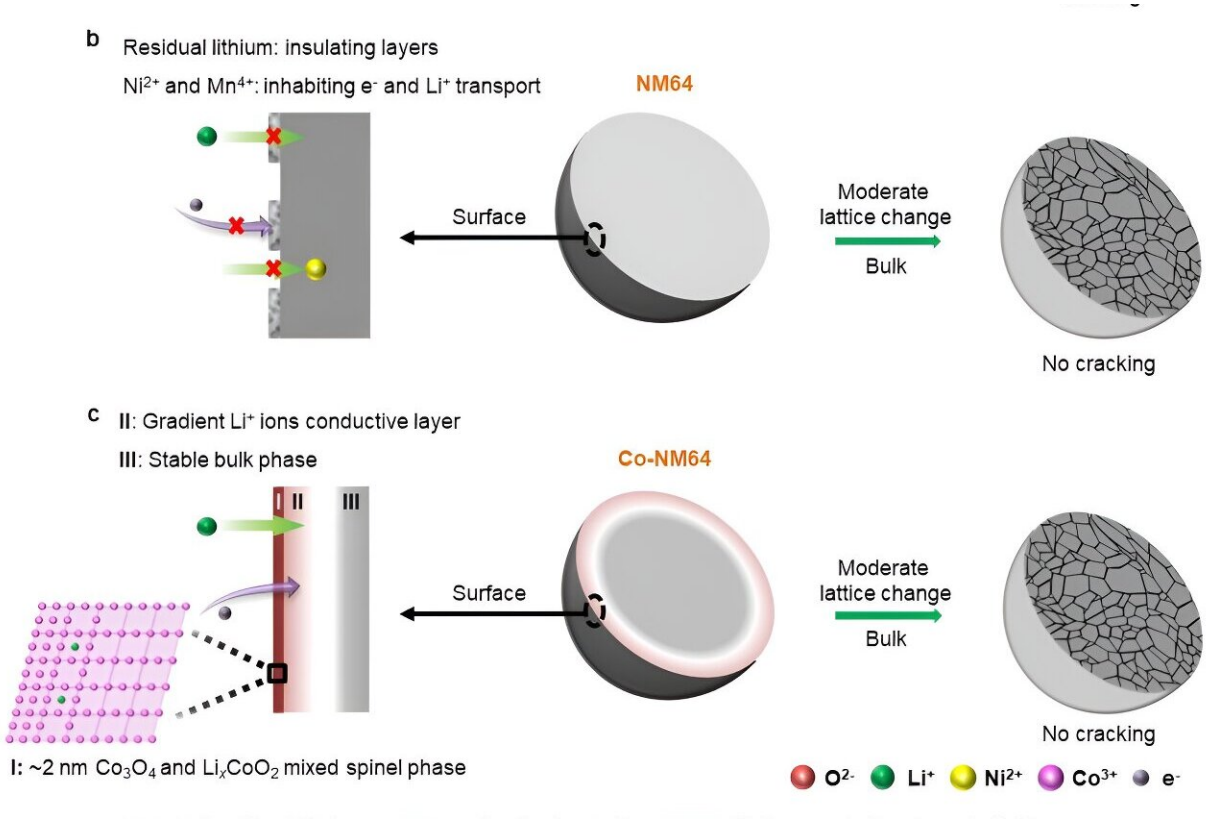
Rational layered oxide cathode design achieves low-cobalt, high-performance lithium-ion batteries

July 2 2024



Schematic illustration of the dynamics and stability evolution mechanisms for $LiNi_{0.6}Co_{0.2}Mn_{0.2}O_2$ (NCM622) (a), $LiNi_{0.6}Mn_{0.4}O_2$ (NM64) (b) and Co-modified $LiNi_{0.6}Mn_{0.4}O_2$ (Co-NM64) (c). Credit: Science China Press

Researchers from Hunan University have designed a layered oxide cathode for rechargeable lithium-ion batteries that achieves fast-charging performance, long life, and high safety using only an ultra-low amount of cobalt. The study was published in the journal *National Science Open*.

In recent years, lithium-ion secondary batteries have played a crucial role in the rapid increase of electric vehicles worldwide. Typically, lithium-ion battery cathodes contain cobalt to ensure fast-charging capabilities.

However, the surging demand for cobalt and its limited supply have significantly increased the cost of lithium-ion battery materials. The primary challenge has been to reduce cobalt usage while maintaining fast-charging performance.

To address this issue, the researchers synthesized a rational structure composed of a robust conductive protective layer, gradient Li^+ ions conductive layer and stable bulk phase by optimizing the distribution of cobalt in high-nickel layered oxide cathode particles.

Analysis showed that the robust conductive protective layer, gradient Li^+ ions conductive layer significantly enhanced the ionic and electronic conductivity of the material. Consequently, this structure exhibited excellent rate performance (fast-charging) even with an ultra-low amount of cobalt.

Additionally, the bulk phase with moderate cation mixing and the surface conductive protective layer effectively ensured material stability, achieving outstanding cycling stability and safety. In terms of battery performance, the designed cathode has doubled in rate performance (5 C) and retained 90.4% capacity after 300 cycles at high voltage in the full cell. These advantages suggest that the designed cathode has great potential for practical applications.

"Our study provides strong evidence that rational structural design can significantly reduce cobalt content while maintaining high rate performance and long life in batteries," said Professor Lu of Hunan University, the study's senior author. "This offers new insights for developing low-cost, high-performance lithium-ion battery materials."

Furthermore, for cathode materials with good structural stability but poor kinetic performance, the study demonstrates that simultaneously designing surface crystal structure and bulk phase is an effective way to ensure excellent electrochemical performance at a lower cost.

More information: Qiusheng Zhang et al, Surface Cobaltization for Boosted Kinetics and Excellent Stability of Nickel-rich Layered Cathodes, *National Science Open* (2024). DOI: 10.1360/nso/20240010

Provided by Science China Press