High performance all-solid-state batteries with slurry coated $LiNi_{0.8}Co_{0.1}Mn_{0.1}O_2$ composite cathode and Li_6PS_5Cl electrolyte: effect of binder content

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The synthesis of solid electrolyte with high ionic conductivity and the design of electrode interface with excellent compatibility are critical to realize the bulk-type application of all-solid-state battery. In order to realize the superior electrochemical performances, argyrodite Li_6PS_5Cl is a promising solid electrolyte in all-solid-state battery due to high ionic conductivity and electrochemical stability. Meanwhile, the solution reprecipitation is a valid process providing intimate ionic contact between electrode and electrolyte to mitigate the interface incompatibility. In this work, we report the preparation of composite cathodes for all-solid-state battery using conventional binder-containing slurries. The composite electrode is fabricated by a wet-slurry process with dissolving active material ($LiNi_{0.8}Co_{0.1}Mn_{0.1}O_2$), solid electrolyte ($Li_6PS_5Cl$), binder (ethyl cellulose) and conductive additives (carbon black) in anhydrous ethanol. This all-solid-state battery exhibits comprehensively enhanced electrochemical performance, including the reversible capacity, cycling stability and rate capability. The detailed working mechanism of composite cathode in all-solid-state battery also has been systematically investigated. The interesting findings of this work are as follows:

(1) Li_6PS_5Cl can be employed as promising solid electrolyte with their incomparable advantages of low cost, easy processability, high ionic conductivity and electrochemical stability, which will be beneficial to enhance the cycling stability and higher energy densities.

(2) Ethyl cellulose with good chain flexibility and chemical stability can serve as a polymeric binder to ensure the uniformity of the active material in pulping and reinforce the contact of the solid interface and structural robustness in all-solid-state battery.

(3) The composite cathode containing 1 wt.% of ethyl cellulose exhibits high reversible capacity (111.7 mAh g-1 at 30 °C), superior capacity retention (89.7% after 100 cycles), and enhanced rate capability (38.8 mAh g-1 at 1 C).

This work demonstrates that the fast ion migration and stable interface between active particles and solid electrolyte enabled by optimum content of chemically compatible binder are critical to the electrochemical performance of all-solid-state lithium-ion batteries.

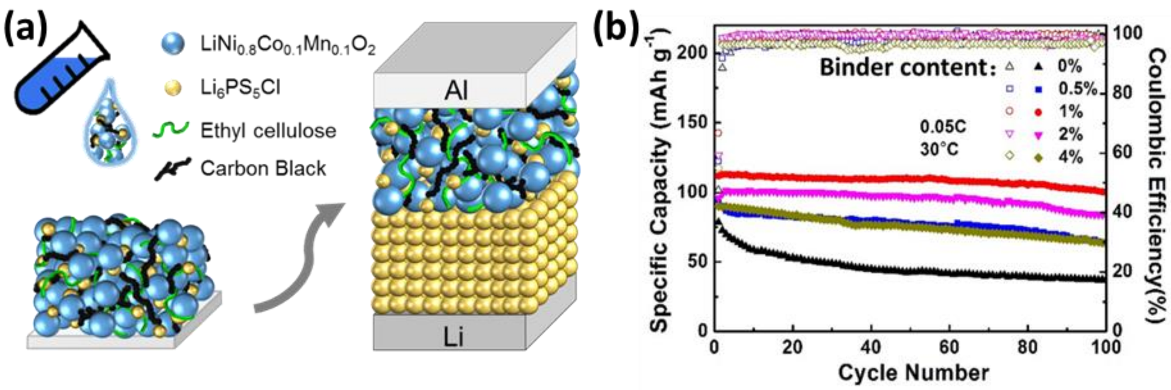

Figure 1 (a) Fabrication illustration of the all-solid-state batteries, (b) cell cycling performance with different binder content.