Comparison of Metallic Li/Na and Alloying-Based Anodes for High Energy Density Li/Na Batteries

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The demand for rechargeable batteries based energy storage is growing significantly due to the rapid economic development, especially the grand revolution of electric vehicles. Currently Li-ion batteries dominate the market, however, the high cost, limited capacity and lack of Li resources largely limit the promise of Li-ion batteries for future use. In the search of alternatives of energy storage devices, advanced Li-ion batteries and Na-ion batteries that utilize low-cost, high-capacity, long-lifespan and safe electrodes, especially anodes, have been intensively researched.

Metallic Li and Na have been considered as the "Holy Grail" anode for Li/Na batteries, but their practical application has been greatly challenged by the uncontrolled Li/Na dendrite formation. A 3D porous Ni@Cu current collector, prepared by a particular simple and rapid hydrogen bubble dynamic template (HBDT) electrodeposition method, has effectively suppressed the dendritic Li/Na deposition enabling stable Li and Na metal anodes [1]. Moreover, the $LiNO_3$ additive in the electrolyte helps to create a thin and stable solid electrolyte interphase (SEI) layer improving the Coulombic efficiency and cycle life.

Nanostructured Si anode has been intensively researched for Li-ion batteries due to its high capacity for Li-ion storage. However, its commercial introduction still faces great challenges. A scalable and high mass loading Si-only anode has been produced by directly depositing Si nanoparticles on a current collector without processing. It achieves a remarkable areal capacity at high current rates and high cycling stability for Li-ion batteries (up to 4 mAh cm^{-2} and ~ 1.5 mAh cm^{-2} at 0.8 mA cm^{-2} and 1.6 mA cm^{-2}, respectively) taking advantages of a one-off and locally protective SEI layer [2].

Though Si has the highest capacity for Li-ion storage, its capability of storing Na-ion is less-favourable [3]. P has the highest capacity for Na-ion storage but undergoes rapid degradation due to the large volume change and low electronic conductivity. A facilely synthesized Sn_4P_3-P@graphene composite exhibits a high and stable capacity retention of >550 mAh g^{-1} over 1000 cycles at 1 A g^{-1} and unrivalled rate capability (~315 mAh g^{-1} at 10 A g^{-1}) [4].

In conclusion, the anodes for high energy density Li/Na batteries requires high specific capacity, stable SEI formation, high Coulombic efficiency and long cycle life. Moreover, the commercialization has to be enabled by low material cost and scalable manufacturing.

References:

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