Glass-Based Electrodes for Lithium/Sodium-Ion Batteries

An invited talk

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There are many ways to enhance the performances of Li-ion batteries (LIBs). In recent years, substantial effort has been made in developing both electrodes and electrolyte for high-performance LIBs. However, there is still a huge room for LIBs to be further developed to keep up with the accelerating evolution of energy technology during the current green transition. Five years ago, we proposed the order/disorder engineering concept to improve the electrochemical properties of electrodes for LIBs [1,2]. This concept here refers to four aspects: 1) Designing a glass system that can undergo partial disorder-to-order transition during charge/discharge; 2) Generating micro/nano crystals in glass, i.e., fabricating glass-ceramics; 3) Making crystals electrochemically active by amorphization; 4) Transforming glass into high potential state through charging/discharging.

In this context, I present four case studies to demonstrate the enhancing effect of order/disorder engineering on electrochemical performances of electrodes. **First**, the vanadium-tellurite (VT) glasses were synthesized as LIB anode materials. It was found that nanocrystals formed in VT glass anode during charge/discharge cycling, leading to enhancement of both cycling stability and electronic/ionic conductivities [2]. **Second**, $NaFePO_4$ with maricite structure, which is electrochemically inactive for sodium-ion storage, was amorphized as cathode for NIBs by ball-milling. The induced disorder caused much improved sodium storage with an initial capacity of 115 mA h g^{-1} at 1 C and enhanced cycling stability [3]. **Third**, the Al-metal-organic framework (Al-MOF)/graphene composite was synthesized as LIB anode [4]. It was found that lithiation/delithiation induced an order-disorder transition in Al-MOF. This transition resulted in a capacity increase from 60 to 400 mA h g^{-1} at the current density of 100 mA g^{-1}. **Fourth**, we invented the first MOF glass anode for LIBs, which exhibited two-fold enhancement of the specific capacity after 1000 cycles of charging/discharging [5]. Such glass anode exhibited much higher lithium storage capacity (306 mA h g^{-1} at 2 A g^{-1}) than the crystalline anode. The microscopic mechanism of such capacity enhancement has been revealed by structural analyses [5]. The above findings suggest that glass is a promising material for developing superior LIBs and NIBs.

References

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