Sodium-ion battery is a low cost energy storage device, which are similar in some ways to lithium-ion batteries. In both systems, Na/Li ions are shuttled between the battery’s positive and negative electrodes during charging and discharging. Taking into account recent concerns about a possible lithium shortage with the spread of battery cost, safety, and raw material abundance. Due to the increased size and heavier weight of the Na atom compared to the Li atom, the volumetric energy density and specific energy density obtainable for the sodium-ion battery would be significantly less than those obtainable with the lithium-ion battery. However, Na-ion batteries would be interesting for very low cost systems for grid storage, which could make renewable energy a primary source of energy rather than just a supplemental one.

There are mainly three types of anode materials for sodium-ion batteries including carbon materials, alloy-based materials such as Sn, Sb, and P and insertion type sodium metal oxide materials. Alloy-based anode materials such as Sn, Sb, and P show high theoretical capacity of 847 (Na9SbNa), 660 (Na2Sb), 2,596 (Na3P) mAh g⁻¹ towards sodium, but with more than 300% volume expansion. The theoretical capacity and the expansion ratio were shown in Figure 1. It can be found that the expansion ratio for Sodium based anode materials is more serious than Lithium based anode materials due to the bigger size of Na⁺ ions leading to poor cycle life. Several studies have shown that this massive volume expansion can lead to poor cycle life. Capacity fade can be caused by pulverization of the active particles or degradation of the electrode coating. Based on our previous experience in LIBs [1], the capacity fade of alloy-based negative electrodes is very sensitive to the choice of binder. A good binder must ideally maintain adhesion of the electrode to the current collector, maintain ionic contact, and facilitate the formation of a stable interface with the electrolyte. Komaba et al. [2] reported that Sn electrodes with high capacity (500 mAh g⁻¹) for more than 20 cycles were achieved by choosing appropriate binder and electrolyte additives. Qian et al. [3] reported that a Sn/C nanocomposite using CMC as binder can deliver a reversible capacity of 610 mAh g⁻¹, a rate capability at a very high current of 2000 mAh g⁻¹ and a long-term cycling stability with 94% capacity retention over 100 cycles. Darwiche et al. [4] found that commercial micrometric Sn demonstrates good cycling performances for Na, with a capacity of 600 mAh g⁻¹ (theoretical capacity 610 mAh g⁻¹) up to 160 cycles and with a coulombic efficiency of 98% when using carboxymethyl cellulose (CMC) as binder and fluoroethylene carbonate (FEC) as an additive. Qian et al. [5] and Kim et al. [6] reported that an amorphous phosphorus composite with carbon could deliver a high capacity of 1764 mAh g⁻¹ at the current density of 250 mA g⁻¹ using CMC as binders and 1890 mAh g⁻¹ at current density of 143 mA g⁻¹ using PAA as binder, respectively. Great effort has to be made to further develop appropriate low-cost active materials for SIBs. However, great efforts have to be made to find appropriate active materials for anodes of SIBs with cheaper price and environmental friendliness.

Here, we will present our work on anode materials for sodium ion battery. The materials include carbon based materials, Sn-based materials and red phosphorous based composites with high specific capacity and excellent capacity retention [7-9].

![Figure 1. Theoretical specific capacity and volume expansion ratio of different anode materials for sodium battery.](image)

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**Reference**


