Sodium ion battery diagram

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Sodium-ion batteries (NIBs, SIBs, or Na-ion batteries) are several types of rechargeable batteries, which use sodium ions (Na+) as their charge carriers. In some cases, its working principle and cell construction are similar to those of lithium-ion battery (LIB) types, but it replaces lithium with sodium as the intercalating ion. Sodium belongs to the same group in the periodic table as lithium and thus has similar chemical properties. However, in some cases, such as aqueous batteries, SIBs can be quite different from LIBs.

SIB cells consist of a cathode based on a sodium-based material, an anode (not necessarily a sodium-based material) and a liquid electrolyte containing dissociated sodium salts in polar protic or aprotic solvents. During charging, sodium ions move from the cathode to the anode while electrons travel through the external circuit. During discharge, the reverse process occurs.

Due to the physical and electrochemical properties of sodium, SIBs require different materials from those used for LIBs.[12]

In 2015, researchers demonstrated that graphite could co-intercalate sodium in ether-based electrolytes. Low capacities around 100 mAh/g were obtained with relatively high working potentials between 0 - 1.2 V vs Na/Na+.[17]

Graphene Janus particles have been used in experimental sodium-ion batteries to increase energy density. One side provides interaction sites while the other provides inter-layer separation. Energy density reached 337 mAh/g.[18]

Carbon arsenide (AsC5) mono/bilayer has been explored as an anode material due to high specific gravity (794/596 mAh/g), low expansion (1.2%), and ultra low diffusion barrier (0.16/0.09 eV), indicating rapid charge/discharge cycle capability, during sodium intercalation.[19] After sodium adsorption, a carbon arsenide anode maintains structural stability at 300 K, indicating long cycle life.

Researchers from Tokyo University of Science achieved 478 mAh/g with nano-sized magnesium particles, announced in December 2020.[24]

Some sodium titanate phases such as Na2Ti3O7,[25][26][27] or NaTiO2,[28] delivered capacities around 90-180 mAh/g at low working potentials (< 1 V vs Na/Na+), though cycling stability was limited to a few hundred cycles.

Some other materials, such as mercury, electroactive polymers and sodium terephthalate derivatives,[31] have also been demonstrated in laboratories, but did not provoke commercial interest.[15]

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Numerous research groups investigated the use of Prussian blue and various Prussian blue analogues (PBAs) as cathodes for Na+-ion batteries. The ideal formula for a discharged material is$Na_2M[Fe(CN)_6]$, and it corresponds to the theoretical capacity of ca. 170 mAh/g, which is equally split between two one-electron voltage plateaus. Such high specific charges are rarely observed only in PBA samples with a low number of structural defects.