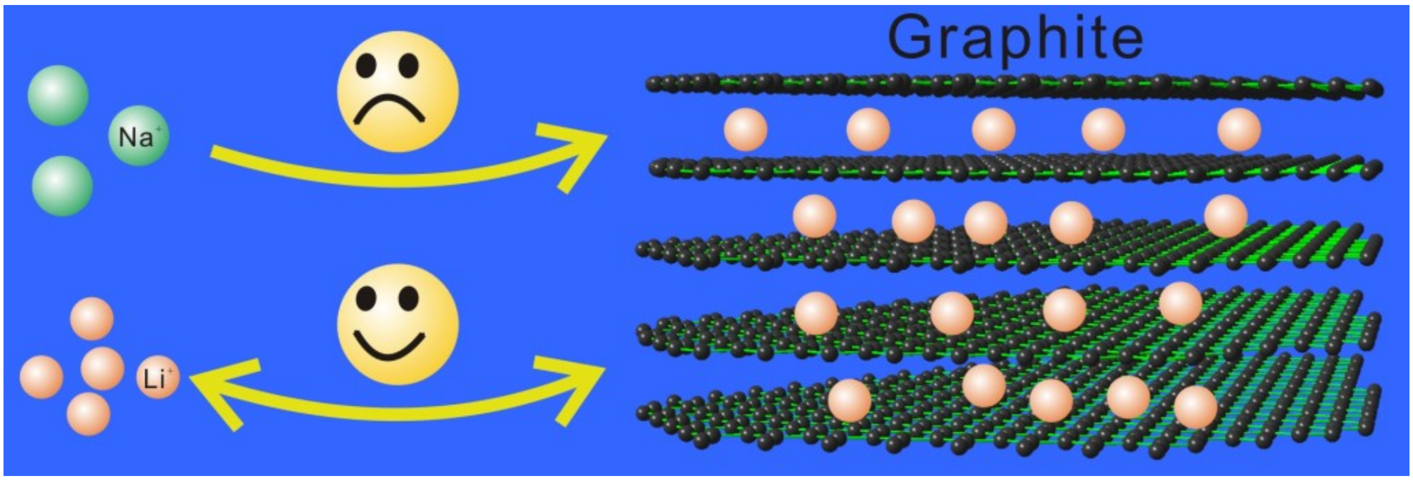
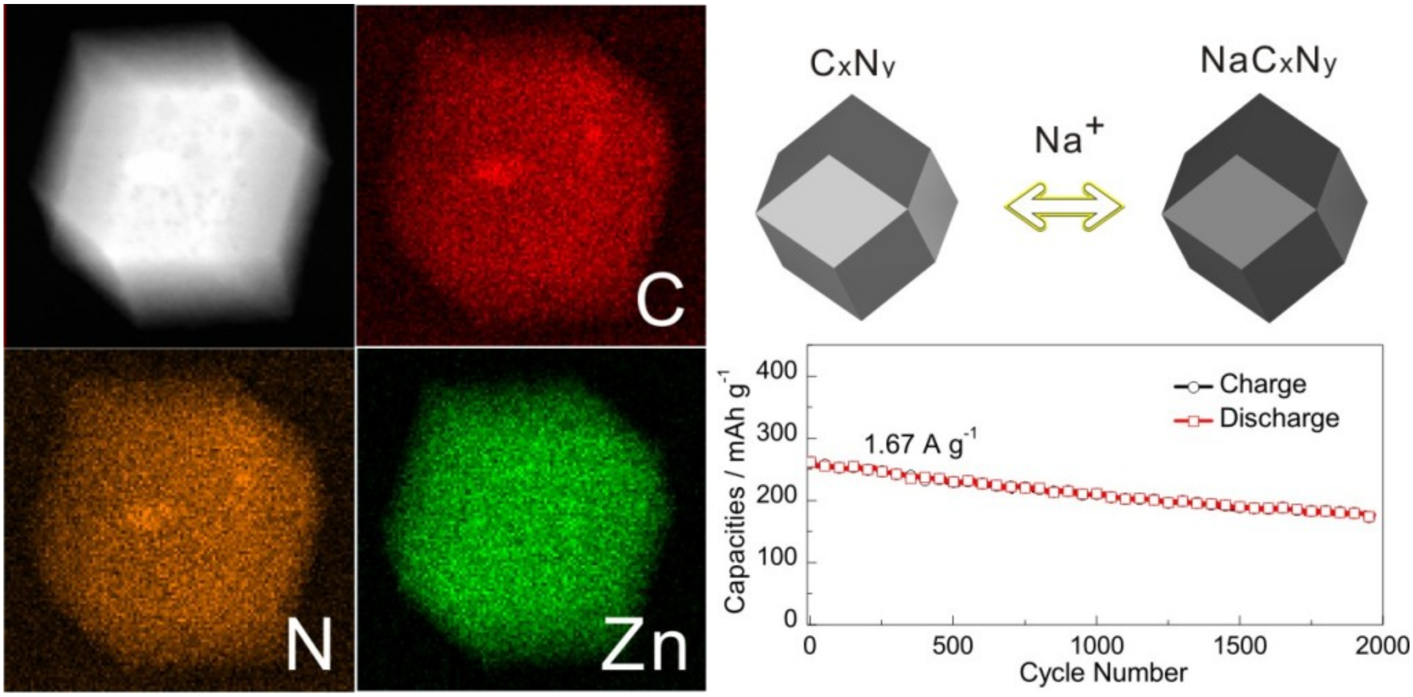
An amorphous carbon nitride composite: a better choice for Na-ion batteries

As lithium ion batteries continue being used worldwide from consumer electronics to electric vehicles, the reserves of lithium resources keep declining. Sodium-ion batteries represent a potential candidate to power the next generation of portable electronics and store power from solar and wind energy. Sodium is more abundant than lithium, which makes sodium ion batteries have more advantages in costs. Unfortunately, Sodium ion is much bigger than lithium ion, which makes it more difficult for sodium ions to be inserted into the host materials. Graphite, the most successful anode material for lithium ion batteries, has exhibited the ultra-low Na^+ ions insertion capacity and sluggish diffusion kinetic due to their larger size and bulkier nature.



Although we could not change the size of sodium ions, we can design the structure of electrode materials which have larger space to receive sodium ions. We have demonstrated a porous amorphous carbon nitride (ACN) composite as anode for sodium ion batteries. To do this, we used a molecular design strategy to build 3D porous structure: First, we build cages through the metal ions and organic ligands. ZIF-8, as one of metal-organic frameworks (MOFs) which have been known for their extraordinarily high surface areas and tuneable pore size, is synthesized by copolymerization of Zn (II) with 2-methylimidazole links. Second, ZIF-8 is carbonized under N_2 atmosphere, which the high surface areas and porosity are retained. Moreover, heat treatment also improves the rigidity and conductivity of the materials. According to our characterization results after heat treatment, the ACN composite is mainly consisted of the amorphous carbon nitride and ZnO.



In terms of battery performance, due to the 3D porous structure, chemistry nature of carbon nitride and ZnO stabilizer in the composite, the ACN composite exhibits the excellent charge/discharge performance and cycling stability for sodium ion batteries. The ACN composite can deliver the reversible capacity of 430 mAh g^{-1} at 83 mA g^{-1}. It still can deliver 146 mAh g^{-1} even under an extremely high current of 8.33 A g^{-1}. There is only 0.016 % capacity degrading per cycle in the 2000 cycles at the current density of 1.67 A g^{-1} with coulombic efficiency of 100 %. Otherwise, the ACN composite exhibits good thermal stability with the low self heating rate (lower than 5.5 °C min^{-1}) and the high onset temperature (210 °C). We believe that this porous amorphous carbon nitride (ACN) composite will be a novel promising material in electrochemical energy storage applications.

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Publication

An Amorphous Carbon Nitride Composite Derived from ZIF-8 as Anode Material for Sodium-Ion Batteries.
Fan JM, Chen JJ, Zhang Q, Chen BB, Zang J, Zheng MS, Dong QF.
ChemSusChem. 2015 Jun 8