

Metal-organic framework derived nanoparticles embedded in carbonaceous matrices for lithium and sodium batteries

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Metal organic framework (MOF)-derived materials are promising for lithium- and sodium-ion batteries owing to their high theoretical capacity and widespread abundance of the transition metals involved. However, they usually suffer from severe structural changes upon repeated cycling and, in some cases, poor electrical conductivity, leading to unsatisfactory cycling stability and rate capability. Herein, we present the performance of two different MOF-derived electrode materials embedded in carbonaceous matrices for use as Li and Na storage or anode-less Li or Na metal batteries. The iron sulfide-carbon composite, synthesized from the Fe-MIL-88NH₂ MOF, is composed by ultrafine Fe₇S₈ nanoparticles (<10 nm in diameter) embedded in a heteroatom(N, S, and O)-doped carbonaceous framework (Fe₇S₈@HD-C) was obtained via a simple and efficient one-step sulfidation process. The composite electrodes show rather promising long-term cycling stability and rate capability for sodium storage in glyme electrolyte (930 mAh g⁻¹ for lithium and 675 mAh g⁻¹ for sodium at 0.1 A g⁻¹), while an improved rate capacity and long-term cycling stability (800 mAh g⁻¹ after 300 cycles at 1 A g⁻¹) for lithium can be achieved using conventional carbonates. The (MOF)-derived copper-carbon (Cu@C) composite was developed as a sodiophilic layer to improve the Coulombic efficiency (CE) and cycle life upon Na metal plating. The Cu particles can provide abundant nucleation sites to spatially guide Na deposition and the carbon framework offer void volume to avoid volume changes during the plating/stripping process enabling “anode-less” sodium batteries using Al-Cu@C as anode and NVP/C as cathode demonstrate promising CE as high as 99.5%, and long-term cycling life.