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Ice-templated hierarchically porous carbon as electrode anode materials for lithium-ion battery

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Ice templating has been widely used to prepare a wide range of porous materials and nanostructures. The process is highly straightforward. By freezing a solution or suspension (both water and organic solvent can be used) and removing the frozen solvent crystals, a template structure can be produced. It is important to adjust the solution compositions and control the freezing conditions in order to generate the materials with desired structure or morphology. A directional freezing process by orientating crystal growth may be used to prepare a unique type of aligned porous materials.

Porous carbon can be used in many applications in adsorption, separation, catalysis and as energy materials. One route to prepare porous carbon is by carbonization of porous carbon-rich polymers. Although ice templating has been extensively used to prepare porous polymer or composites, the formation of porous carbon by this route is highly limited. In this presentation, we show that polyacrylonitrile (PAN, a widely used carbon precursor) can be dissolved in dimethyl sulfoxide (DMSO). The solution is directly frozen in liquid nitrogen and then freeze-dried to produce a porous monolith. Hierarchical porous nitrogen-rich carbon monolith can be prepared by the following thermal annealing and carbonization under nitrogen (J. Mater. Chem. A 2014, 2, 17787). Electrochemical evaluation of the carbon materials as anodes for the rechargeable lithium-ion battery revealed an impressive stable reversible capacity as high as 745 mA h g^{-1} at a current density of 50 mA g^{-1}. Incorporation of melamine (for further N-doping) and graphene into the carbon monoliths was achieved easily, and found to significantly enhance high rate performance – with a reversible capacity of about 300 mA h g^{-1} obtained at the ultra high current density of 10 A g^{-1}.

Keywords: ice templating, porous carbon, lithium-ion battery, anode materials

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