Preparation and electrochemical properties of silicon embedded in N, P-dual-doped carbon matrix as anode for lithium-ion batteries

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The disadvantages, such as low electrical conductivity, lithium-ion diffusivity and significant volume expansion of the silicon anode during charge/discharge processes, have severely limited its cycling and rate performance. We proposed a simple method for encapsulating silicon nanoparticles in a nitrogen, phosphorus dual-doped porous carbon matrix, with nitrogen, phosphorus dual-doped carbon derived from phytic acid-doped polyaniline (PANi) hydrogel. Furthermore, the void layer was designed to allow for the volume expansion during silicon lithiation. Scanning electron microscopy and transmission electron microscopy observation indicated that silicon nanoparticles are embedded in the carbon matrix with the presence of a void between the silicon and carbon. The nitrogen adsorption–desorption isotherm showed that the composite featured the hierarchical microporous–mesoporous structure, which was the result of the cross-linking role of phytic acid in PANi; the composites possessed a high specific area of 226.6 m²/g. The doping level of nitrogen and phosphorus in the composites were 4.7% and 1.2%, respectively. The electrochemical tests indicated that the composite had a much better cyclability with a specific capacity of 639.8 mAh/g after 100 cycles at a current density of 400 mA/g, which was higher than that of silicon encapsulated in a nitrogen-doped carbon. This was attributed to the special porous structure, and the nitrogen, phosphorus dual-doping in carbon materials facilitated the lithiation of silicon anode.

Keywords: silicon, carbon coating, nitrogen, phosphorus, doping

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