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Nitrogen-doped $\text{Ti}_3\text{C}_2\text{T}_x$ MXene electrodes for high-performance supercapacitors

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Abstract

A new type of nitrogen-doped two-dimensional MXene ($\text{N-Ti}_3\text{C}_2\text{T}_x$) was synthesized by post-etch annealing $\text{Ti}_3\text{C}_2\text{T}_x$ in ammonia as a promising electrode material for supercapacitors. The concentrations of nitrogen can be rationally controlled to produce $\text{N-Ti}_3\text{C}_2\text{T}_x$ materials with 1.7 - 20.7 at.% of nitrogen by simply tuning the annealing temperatures from 200 °C to 700 °C. The introduction of nitrogen as a heteroatom in the $\text{Ti}_3\text{C}_2\text{T}_x$ structure leads to a remarkable increase of the c-lattice parameter of MXene sheets from 1.92 nm in $\text{Ti}_3\text{C}_2\text{T}_x$ to 2.46 nm in N-doped ones upon ammonia treatment at 200 °C. More interestingly, the resultant doped MXene materials under optimized condition exhibited drastically improved electrochemical capacitances of $192 \text{ F}\cdot\text{g}^{-1}$ in 1 M H_2SO_4 and $82 \text{ F}\cdot\text{g}^{-1}$ in 1 M MgSO_4 electrolyte, which are remarkably higher than those of the un-doped $\text{Ti}_3\text{C}_2\text{T}_x$ materials ($34 \text{ F}\cdot\text{g}^{-1}$ in 1 M H_2SO_4 and $52 \text{ F}\cdot\text{g}^{-1}$ in 1 M MgSO_4).

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