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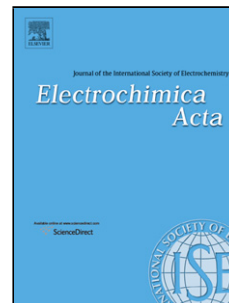
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# Nitrogen-Doped Graphene: Effects of nitrogen species on the properties of the vanadium redox flow battery

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**Abstract:** Nitrogen-doped graphene nanosheets (NGS), prepared by a simple hydrothermal reaction of graphene oxide (GO) with urea as nitrogen source were studied as positive electrodes in vanadium redox flow battery (VRFB). The synthesized NGS with the nitrogen level as high as 10.12 atom% is proven to be a promising material for VRFB. The structures and electrochemical properties of the materials are investigated by scanning electron microscopy, X-ray photoelectron spectroscopy, cyclic voltammetry and electrochemical impedance spectroscopy. The results demonstrate that not only the nitrogen doping level but the nitrogen type in the NGS are significant for its catalytic activity towards the  $[\text{VO}]^{2+}/[\text{VO}_2]^+$  redox couple reaction. In more detail, among four types of nitrogen species (pyridinic-N, pyrrolic-N, quaternary-N, oxidic-N) doped into the graphene lattice, quaternary-N play mainly roles for improving the catalytic activity toward the  $[\text{VO}]^{2+}/[\text{VO}_2]^+$  couple reaction.

**Keywords:** Vanadium redox flow battery; graphene sheets; nitrogen doping ; electrode

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