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Heteroatom Doped Binary Metal Oxide Modified Carbon as a Bifunctional Electrocatalysts for all Vanadium Redox Flow Battery

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Abstract : As one of the most promising electrochemical energy storage systems, vanadium redox flow batteries (VRFBs) have received increasing attention owing to their attractive features for largescale storage applications. However, their high production cost and relatively low energy efficiency still limit their feasibility. For practical implementation, it is of great interest to improve their efficiency and reduce their cost. One of the key components of VRFBs that can greatly influence the efficiency and final cost is the electrode, which provide the reactions sites for redox couples (VO^{2+}/VO_2 + and V^{2+}/V^{3+}). Carbon-based materials are considered to be the most feasible electrode materials in the VRFB because of their excellent potential in terms of operation range, good permeability, large surface area, and reasonable cost. However, owing to limited electrochemical activity and reversibility and poor wettability due to its hydrophobic properties, the performance of the cell employing carbon-based electrodes remained limited. To address the challenges, we synthesized heteroatom-doped bimetallic oxide grown on the surface of carbon through the one-step approach. When applied to VRFBs, the prepared electrode exhibits significant electrocatalytic effect toward the VO^{2+}/VO_2 + and V^{3+}/V^{2+} redox reaction compared with that of pristine carbon. It is found that the presence of heteroatom on metal oxide promotes the absorption of vanadium ions. The controlled morphology of bimetallic metal oxide also exposes more active sites for the redox reaction of vanadium ions. Hence, the prepared electrode displays the best electrochemical performance with energy and voltage efficiencies of 74.8% and 78.9%, respectively, which is much higher than those of 59.8% and 63.2% obtained from the pristine carbon at high current density. Moreover, the electrode exhibit durability and stability in an acidic electrolyte during long-term operation for 1000 cycles at the higher current density.

Keywords : VRFB, VO^{2+}/VO_2 + and V^{3+}/V^{2+} redox couples, graphite felt, heteroatom-doping
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