ABSTRACT

Recently, the NASICON-type $Na_3V_2(PO_4)_3$ (NVP) has received as a promising cathode material for Na- as well as hybrid Li-ion batteries (HLIBs) due to its fast-ion diffusion coefficient, excellent cycleability, and superior thermal and electrochemical safety features. However, poor electronic conductivity and a relatively lower nominal voltage of NVP limit its use in new emerging storage applications (viz. EVs). To address these issues, various strategies have been adopted to synthesize NVP (and its modified varieties) to introduce stability in the structure, high ionicity in the anionic framework and shorten the transport path length for reactive species (electrons and ions). This has been accomplished by synthesizing doped variants of NVP such as aliovalent Ni-doped and highly electronegative F-doped NVP, fabricating porous carbon-coated and favourable nanostructure-designed NVP variants such as nanopetal-assembled flower-like and a mixture of rectangular and hexagonal prism-like morphologies, as well as compositing between NVP and $Na_3V_2O_2(PO_4)_2F$ (NVOPF) to provide the best combination of high capacity, nominal voltage and cycling stability. In addition, to further improve the rate performance and cycleability, hybridization between synthesized NVP-based materials with supercapacitive component (activated carbon) have been persuaded to fabricate bi-material cathodes. Thus, NVP@C/AC and NVOPF-NVP@C/AC bi-materials are demonstrated to be ultrafast and long-life cathodes for hybrid battery-supercapacitor (bat-cap) energy storage devices. The excellent electrochemical performances of the bi-material electrodes may be ascribed to the synergic interaction between battery and supercapacitor components, which can be correlated with the lowering of charge-transfer resistance and faster kinetics of reactive species in the bi-material electrodes. Finally, the electrochemical characteristics of these synthesized cathodes with non-Li metal-based anodes such as $Li_4Ti_5O_{12}$ (LTO) and nanocomposite carbon-coated LTO-TiO_2 (anatase)-TiO_2 (rutile) (LTO-A-R@C) are systematically investigated in a common Li-ion electrolyte (1 M $LiPF_6$ in EC+DEC). The electrochemical performances demonstrate that the fabricated HLIBs would be promising for high power, long-life, safe and stable advanced energy storage applications.

Keywords: $Na_3V_2(PO_4)_3$; Hybrid Li-ion battery; Nanostructuring; Doping; Bi-material electrode; Hybrid bat-cap; Rate; Cycleability