Functionalized NbS_2-based solid-state electrolyte for flexible supercapacitors

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Highly efficient and durable flexible solid-state supercapacitors (FSSSCs) are emerging as low-cost devices for portable and wearable electronics because of the elimination of leakage of toxic/corrosive liquid electrolytes and their capability to withstand elevated mechanical stresses [1,2]. Nevertheless, the spread of FSSSCs requires the development of durable and highly conductive solid-state electrolytes, whose electrochemical characteristics must be competitive with those of traditional liquid electrolytes [3,4]. Here, we propose a novel composite solid-state electrolyte prepared by incorporating metallic two-dimensional (2D) group-V transition metal dichalcogenides (TMDs), namely liquid-phase exfoliated functionalized niobium disulfide (f-NbS_2) nanoflakes, into sulfonated poly(ether ether ketone) (SPEEK) polymeric matrix [5]. The terminal sulfonate groups in f-NbS_2 nanoflakes interact with the sulfonic acid groups of SPEEK by forming a robust hydrogen bonding network [6]. Consequently, the composite solid-state electrolyte is mechanically/chemically stable even at the degree of sulfonation of SPEEK as high as 70.2%, at which the mechanical strength is 38.3 MPa and the proton conductivity is maximized to 94.35 mS cm^{-2} at room temperature. Beyond the intrinsic properties of the solid-state electrolyte, the performance of FSSSC is strongly determined by the electrical connection between electrode materials and the electrolyte. In this context, the binders, used in the electrode material formulation to produce mechanically robust electrodes, must guarantee a close contact between the solid-state electrolyte and electrode active materials for effective double-layer formation [7]. To elucidate the importance of the interaction between the electrode materials (including active materials and binders) and the solid-state electrolyte, solid-state supercapacitors were produced using either SPEEK or polyvinylidene fluoride as proton-conducting and non-conducting binders, respectively. The use of our solid-state electrolyte in combination with proton-conducting SPEEK binder results in a solid-state supercapacitor with a specific capacitance of 115.724 F g^{-1} at 0.02 A g^{-1}, optimal rate capability (75.94 F g^{-1} at 10 A g^{-1}), and electrochemical stability over galvanostatic charge/discharge cycling.

References

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