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KTiPO4F: The Negative Electrode Material for Potassium Batteries

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Abstract : Lithium-ion batteries (LIBs) play a pivotal role in achieving the key objective “zero-carbon emission” as countries agreed to reach a 1.5°C global warming target according to the Paris agreement. Nowadays, due to the tremendous mobile and stationary consumption of small/large-format LIBs, the demand and consequently the price for such energy storage devices have been raised. The aforementioned challenges originate from the shrinkage of the major applied critical materials in these batteries, such as cobalt (Co), nickel (Ni), Lithium (Li), graphite (G), and manganese (Mn). Therefore, it is imperative to consider alternative elements to address issues corresponding to the limitation of resources around the globe. Potassium (K) is considered an effective alternative to Li since K is a more abundant element, has a higher operating potential, a faster diffusion rate, and the lowest stokes radius in comparison to the closest neighbors in the periodic table (Li and Na). Among all reported materials for metal-ion batteries, some of them possess the general formula AMXO4L [A = Li, Na, K; M = Fe, Ti, V; X = P, S, Si; L= O, F, OH] is of potential to be applied both as anode and cathode and enable researchers to investigate them in the full symmetric battery format. KTiPO4F (KTP structural material) has been previously reported by our group as a promising cathode with decent electronic properties. Herein, we report a synthesis, crystal structure characterization, morphology, as well as K-ion storage properties of KTiPO4F. Our investigation reveals that KTiPO4F delivers discharge capacity > 150 mAh/g at 26.6 mA/g (C/5 current rate) in the potential window of 0.001-3 V. Surprisingly, the cycling performance of C-KTiPO4F//K cell is stable for 1000 cycles at 130 mA/g (C current rate), presenting capacity > 130 mAh/g. More interestingly, we achieved to assemble full symmetric batteries where carbon-coated KTiPO4F serves as both negative and positive electrodes, delivering >70 mAh/g in the potential range of 0.001-4.2V.

Keywords : anode material, potassium battery, chemical characterization, electrochemical properties
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