TITANATE SYSTEMS FOR SODIUM STORAGE

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Room temperature sodium-ion batteries (NIBs) are expected to play a significant role in the future as an alternate battery technology to lithium-ion batteries, especially in applications where the weight and size of a battery are not crucial parameters. In this context, implementation of NIBs as large scale electrical energy storage (EES) devices for handling the intermittent nature of power generation from power plants running on renewable sources such as solar and wind will be especially attractive. Factors such as globally abundant sodium reserves and the identification of some newly discovered high energy density NIB cathodes[1] could make NIBs feasible for future EES. However, such high performance NIB cathodes would need an equally capable anode. In this talk, we will present our results on the sodium storage characteristics and performance of some phases within the sodium titanate family operating as low voltage NIB anodes. In particular, we will discuss three separate NIB anodes from this family which have individually attractive features for different EES applications.

The first such anode, $Na_2Ti_6O_{13}$, demonstrates an ultra-long cycle life of 5,000 cycles with a fast response time of 30 C (2 min).[2] We will discuss the cause of this excellent performance through structural studies. Its capacity close to 50 mAh/g at an average voltage of 0.85 V *vs* Na/Na^+ may be attractive for regulating the minute-by-minute fluctuations of power generated from solar/wind farms, where a fast response time is most important rather than storage capacity. The second such NIB anode involves the two mole sodium storage per mole of the $Na_2Ti_3O_7$ phase. This $Na_2Ti_3O_7 \leftrightharpoons Na_4Ti_3O_7$ sodium storage pathway has an attractively high capacity of 178 mAh/g with a very low charge plateau at 0.4 V *vs* Na/Na^+.[3] We will discuss our attempts at stabilizing its cycling performance through electrochemical and synthesis-related approaches. The third NIB anode discussed will be the recently discovered $Na_2Ti_3O_7 \leftrightharpoons Na_{3-x}Ti_3O_7$ pathway ($x \leq 1$) which exhibits a moderate-high capacity of 89 mAh/g with the lowest voltage redox activity for any non-carbon based NIB anode at 0.2 V *vs* Na/Na^+.[4] We will discuss its sodium storage mechanism and show its excellent performance punctuated with a response up to 80 C (45 s) with a decent cycle life till 1,500 cycles. Furthermore, we will discuss our analyses on the unreliability of sodium metal acting as a counter electrode with special considerations to the possibility of erroneous data interpretations in sodium half cells[5] with some specific examples.

References

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