Novel approach to synthesize sodium manganese oxide with P- and O- type mixed phases : a study on the natural formation of sodium carbonate and its activation method

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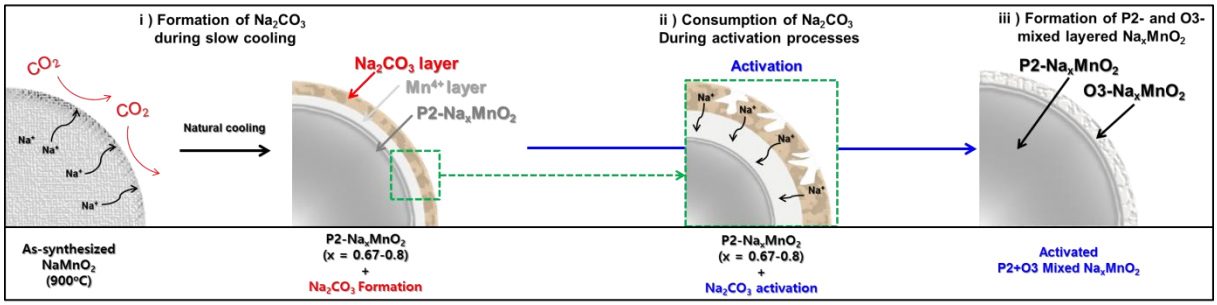
Sodium manganese oxide (Na_xMnO_2) is a representative cathode material for sodium ion batteries. Because of the preferred coordination of sodium ions in the MnO_2 layer, sodium manganese oxide can be constructed into either P2 or O3 structure.[1] Among them, sodium manganese oxide with the P2 structure exhibits better electrochemical performances compared to not only the O3 structure, but also other sodium ion cathode materials. However, the low sodium content of its initial state is one of its biggest limitations as a cathode material. Furthermore, many reports showed that the initial charge capacity of the P2 phase is lower than its theoretical capacity. Despite this, in-depth studies into the low initial charge capacity of the P2 phase have been so far absent.[2]

At the same time, the formation of sodium carbonates on the surface of layered Na ion cathodes looks typical and more severe compared to that on layered lithium ion cathodes. This carbonate formation may be due to the reaction between atmospheric CO_2 and sodium ions on the surface of the cathode materials.[3] The formation of surface sodium carbonate is detrimental because it is electrochemically inactive and generally consumes significant amount of sodium ions during its formation. Our study indicated that the formation of sodium carbonate is one of the major causes for the deterioration of their electrochemical performance, including initial charge capacity, coulombic efficiency etc. We hypothesise that the formation of sodium carbonate alters the oxidation state of manganese on the surface, leading to lower electrochemical activity during its first charge. Therefore, we attempted to study the natural formation of sodium carbonate on the surface of sodium manganese oxide and suggest novel ways to enable the activation of the electrochemically inactive sodium carbonate, so as to achieve higher initial charge capacity.



References:
[1] C. Delmas, C. Fouassier, P. Hagenuller, Physica B+C 99 (1980) 81-85.
[2] M. H. Han, E. Gonzalo, G. Sing, T. A. Rojo, Energy Environ. Sci. 8 (2014) 81-102.
[3] J. W. Kim, D. Lee, H. G. Lee, ISIJ Int. 41 (2001) 116-123.