Disordered carbonaceous materials as high performance anode for Na-Ion Battery

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Though Li-ion batteries (LIBs) have encountered enormous success, lithium extraction is expensive and most lithium reserves are found in geopolitically unstable regions of the world. Therefore interest has recently grown to look for alternatives to LIBs, such as Na/ion batteries (SIBs), which represent promising alternatives mainly due to the advantages of abundance of Na in the earth crust and the possibility to use aluminum current collector for the negative electrode.[1]

Although several candidate positive electrode materials have been reported to date for SIB, a limited amount of negative anode candidate have been encountered with low intercalation voltage, high first cycle coulombic efficiency and good cycle stability.[2,3] Graphite is considered as the standard LIB anode due to its cheap and easy production, its high reversibility and relatively good energy density due to its low insertion potential of about 100mV. However, due to the 0.3V difference between Na and Li, insertion of Na^+ into graphite would occur at negative voltages vs Na, prohibiting its use for SIB. Only disordered soft- and hard- carbon offer significant insertion above Na plating voltage, with the best reports in hard carbons with more than 300mAh/g. [4,5] Based on the use of SAXS it has been demonstrated by Stevens and Dahn that the mechanism of hard carbon is related to the presence of microporosity,[6] although Bommier et al recently demonstrated that microporosity probed by gas adsorption is detrimental to the performance of hard carbons.[4]

Herein, we will present and discuss our recent progress and perspective in the study of disordered carbons as negative electrodes for SIB. Various disordered carbonaceous materials have been explored, non-graphitic carbon or hard- carbons (HC) as well as soft carbons (SC). These highly disordered carbons do not contain long-range ordered “ABAB” stacking that is seen in graphite but comprise turbostratic structures with defects and structural voids, which enable them with good performance for Na-ion storage.

The microstructure and the morphology of these carbons have been studied by coupling gas adsorption, powder X-ray diffraction (in-situ and ex-situ PXRD) and Small Angle X-ray Scattering (SAXS) measurements, which, by correlating with their electrochemical performance, had led us to new insights into the mechanism of sodium insertion into disordered SC and HC and identifying key-microstructural features to be considered for best electrochemical performance.

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