**Biomass-derived hard carbon materials for sodium-ion storage**

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Hard carbon holds a great promise for sodium-ion batteries (NIBs). To enable this technology practically viable, it is important to understand sodium ion behavior when electrochemically interacting with hard carbon. Studies have shown that a voltage-capacity curve typically shows two regions: a high-potential sloping region and a low-potential plateau region. Early studies attributed these two regions to different charge storage mechanisms: the high-potential region is due to sodium ion intercalation between graphene sheets, whereas the low-potential region is attributed to filling of voids by sodium ions. Recent studies have demonstrated contradictory conclusions or a completely different charge storage mechanism: the initial sloping region is exclusively attributed to pseudoadsorption of sodium ions on defective sites, contributing a significant amount of charge storage to the total capacity, while the low-voltage plateau region is due to intercalations of sodium ions between graphene sheets. In addition, a very-low voltage region is considered pore filling. This inconsistency in understanding sodium ion storage mechanism in hard carbon needs as led to recognise the importance of capacitive charge storage and defective sites in carbon for charge storage. Nevertheless, it seems there are at least three possible mechanisms occurring when sodium ions electrochemically interact with hard carbon: 1) interlayer intercalation, which may also include a contribution from defects and heteroatoms; 2) sorption at open pore surfaces and defective sites (vacancies, heteroatoms, functional groups); and 3) sodium clustering (or plating) at voltage close to zero.

In this talk, I will discuss our recent research data on electrochemical properties of biomass-derived hard carbon electrode materials, as well as primary understanding of sodium ion behaviour when electrochemically interacting with biomass-derived hard carbon materials.