CVD-coated carbon xerogels as Na-ion battery electrode materials

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Energy storage using batteries plays a key role for a more sustainable future. However, the demand increase requires better concepts in terms of critical material use and manufacturing processes. Those new concepts should help solving issues of material availability (in particular Li) and use of toxic or difficult-to-recycle materials (e.g. NMP as solvent and PVDF as binder). This study focuses on developing carbon materials for negative electrodes of Na-ion batteries that are prepared by a water-based process using a biosourced binder, xanthan gum.

A series of nanostructured hard carbons (carbon xerogels - CXs) were synthesized by pyrolysis of phenolic resins. Those hard carbons with various meso/macropore sizes (i.e. 50 nm, 1500 nm, 4000 nm and 5000 nm) consist of interconnected microporous nodules of various sizes; as such, it is foreseen that they cannot perform properly as Na-ion insertion materials due to their high specific surface area (> 600 m²/g), leading to high irreversibility at the first electrochemical cycle. Herein, we developed low-surface CXs, down to 3 m2/g, by masking the micropores of the CXs with a secondary carbon layer via carbon-coating by Chemical Vapor Deposition (CVD). In the meantime, the chainlike structure of the CXs remained intact, allowing them to still accommodate Na+ ions.

Uncoated and coated powders were used to produce electrodes using a water-based spray-coating process and water-soluble xanthan gum; the electrodes were then tested in half-cell configuration (i.e. vs Na metal). The CX with 5000 nm pore size showed reversible capacities up to 300 mAh/g at C/20 (18.6 mA/gcarbon) with irreversible losses at first cycle below 15%. However, its capacity retention at relatively high C-rates (C/5) was lower compared to other CXs with smaller meso/macropore sizes. In addition, the CVD coating increased significantly the insertion plateau at low voltage. Further research is going on with intermediate pore size CXs to find an optimum point for both elevated capacity and high C-rate behaviour, and to determine the exact role of the CVD-derived layer.