

Insights into Novel Solid Materials, their Recyclability and Integration

into Li Polymer Batteries for EVs. Future research directions in this field.



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RESORCINOL-FORMALDEHYDE CARBON XEROGELS AS LITHIUM-ION BATTERY ANODE MATERIALS: INFLUENCE OF POROSITY ON CAPACITY AND CYCLING BEHAVIOUR

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Abstract

Carbon xerogels are promising candidates in the development of new high performance C-based anode materials for Li-ion batteries. Indeed, their specific capacities widely exceed that of conventional graphitic structures, and they can be intercalated/deintercalated in a low-cost electrolyte based on propylene carbonate (PC), which has an excellent conductivity at low temperatures. In addition, such carbonaceous materials show very small changes of volume during the charge/discharge, providing a long cycle life of such an anode. Nevertheless, hard carbons also exhibit quite high irreversible capacity losses due to their intrinsic high microporosity and, compared to graphite, a poor rate performance related to slow diffusion of Li in the internal structure[1]. To reduce these disadvantages, the structural and textural characteristics need to be carefully controlled.

Porous carbon xerogels can easily be prepared from resorcinol-formaldehyde aqueous mixtures, which are polymerized, dried and pyrolysed. The porosity of these xerogels is mainly governed by the pH of the precursor solution as well as by the drying procedure. Globally, these materials are composed of microporous nodules delimiting meso- or macroporous voids, the size of which is adjusted via the synthesis pH. Too a high microporosity can induce considerable irreversible capacity losses and too small mesopores may hinder the proper chemical diffusion of lithium ions within a bulk electrode material. The latter is often a rate-limiting step and optimized transport pathways could be provided by creating large mesopores or even macropores within the

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microporous carbon [3].

Here we report on the preliminary electrochemical characterization of porous carbon xerogels prepared by vacuum drying procedure. By adjusting the pH of the precursor solution, the materials obtained develop low to high values of specific surface areas and exhibit homogeneous pore sizes that range from several microns to several nanometers. The electrochemical performance of these materials as electrode compounds was tested by galvanostatic charge-discharge of 16-mm disc electrodes assembled in CR2016 coin cells or of 13-mm disc electrodes in home-made Swagelok-type cells.

The first results show that all the samples show quite a high irreversible capacity during the first cycle; this irreversible capacity is proportional to the specific surface area. Its value nevertheless remains quite low for the low-surface area macroporous sample. The latter also shows the best reversible capacity after the second cycle, with values approaching that of commonly used graphite. For example, when cycled at a rate of C/20 for 10 cycles, this sample showed a capacity of 320 mAh/g; the value was kept at 200 mAh/g when increasing the rate up to C/5. The long-term cycling performance was investigated by cycling the anodes at C/20 and C/5. Again, the macroporous sample behaves best, with superior capacity retention and invariable discharge capacity of ~175 mAh/g after more than 100 cycles. The electrochemical properties of carbon xerogels was evaluated in the conditions which are used typically for graphite (cycles in the potentials range from 0.003 to 1.5 V vs. Li⁺/Li). A higher reversible capacity of 400 mAh/g could be obtained for the macroporous sample using a discharge with plating of Li as described in [4], but this method could not be accepted in the case of Lithium-ion batteries.

These first results show that carbon xerogels are very promising candidates as anode materials for Li batteries, providing the textural characteristics are carefully controlled. The ongoing work is dealing with the establishment of possible relationships between textural features and electrochemical performance in order to shed light on the requirements that will dictate the best synthesis procedures.

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