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On the use of carbon nanotubes in prototyping the high energy density Li-ion batteries

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Energy storage technology based on lithium-ion electrochemical systems makes it possible to manufacture batteries with high specific energy and power densities. Over the past decades such batteries have been the most widely used ones in applications related to electric vehicles, portable electronics, and robotics.
The main area of research aimed at improving the specific parameters of lithium-ion batteries is associated with the synthesis and study of new electrode materials and electrolytes providing higher specific lithium capacities and higher voltage. Moreover, lithium-ion battery specific parameters can be significantly improved by reducing the mass contribution of inactive components, as well as by controlling the microstructure of the electrode layers.
The technological aspects of fabrication of high areal capacity LFP-based electrodes using the carbon nanotubes as conductive additives were considered. The influence of electrode slurry rheological properties and electrode composition on its areal (mAh cm-2), volumetric (mAh cm-3) and gravimetric (mAh g-1) capacity and C-rate performance has been studied.
The electrodes with 1% of the CNTs demonstrate a higher specific capacity compared with electrodes containing 5-15% of carbon black. However, increase in the CNT content up to 10% significantly lowers electrode volumetric capacity, which is even lower than for the electrodes with carbon black.
SANS measurements revealed that the CNT network embedded in the electrode layer provides its greater wettability by an electrolyte compared to carbon black used as conductive additive. This results in better electrode C-rate performance.
During fabrication of thick electrodes, it is necessary to take into account the rheological properties of the electrode slurry. Our results revealed that increase in the CNT mass content of more than 5% significantly complicates the process of their dispersion in a solvent and fabrication of thick homogeneous layers becomes problematic.
Electrode calendaring improves the electrode volumetric capacity. In our case, the optimal compression rate is of 10% at a roll temperature of 100°C.
It was demonstrated that using the CNTs as conductive additives opens prospect for fabrication of electrodes with areal capacity more than 5 mAh cm-2.
The practical applicability of the considered electrode technology was approved on the pouch cell prototype with specific energy density of 150 Wh kg-1/295 Wh l-1.
The results of electrochemical measurements showed that an increase in the CNT mass fraction in the electrode composition leads to an increase in its C-rate performance. However, for the formation of thick and dense electrodes with a high areal capacity, it is necessary to take into account the rheological properties of the electrode slurry as well as the fact that during drying the electrode coating undergoes shrinkage due to evaporation of a solvent. Thus, it is important to maintain a balance between the mass ratio of the electrode components and their total content in a unit of solvent.

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