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Novel TiO2 Nanoparticles Decorated Graphene Electrodes for Lithium-Ion Batteries Investigated with Operando X-ray Diffraction

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Commercially available lithium-ion batteries (LIBs) show limitations for future large-scale applications, due to still low energy density, safety, slow charge/discharge rate and limited cycle-life. Battery recycling is also still an open problem, mostly bound to the use of toxic heavy metals. TiO2 is an abundant, low-cost and environmentally friendly electrode material, attractive for large scale energy-storage. However, TiO2 electrodes suffer from low electrical conductivity. Graphene can embed TiO2 nanoparticles, forming a conductive nanocomposite anode material for Li-ion batteries, with improved Li-ion and electron transport. Here, novel gram-scale graphene-based electrodes decorated with titanium dioxide (TiO2) anatase were investigated as anodes for LIBs.

Graphene employed for this work was obtained in large (grams) scale, through a thermal exfoliation of graphite oxide (TEGO) under dynamic vacuum. We managed to decorate TEGO with TiO2 anatase nanocrystals via a novel facile solvothermal synthesis employing titanium tetraisopropoxide as TiO2 precursor. Different stoichiometries of TiO2:TEGO have been synthesized, characterized with powder XRD, Raman and TEM; the electrochemical behavior was studied in half-cell configuration (CR2032 coin cells) via galvanostatic chronopotentiometry. The structural evolution of TiO2 nanocrystals was followed by means of operando synchrotron powder x-ray diffraction.

We found that graphene plays an important role, both as a substrate, favouring the almost pure TiO2 anatase nanocrystal growth, and as an efficient charge collector, thanks to its high electrical conductivity, contrasting the insulating nature of TiO2 and thus improving specific capacity of the electrode. In particular, electrodes with 99:1 TiO2:TEGO composition proved to be the most promising ones, showing a stable and reversible capacity of above 180 mAh/g at C/5 and high charge/discharge capability.

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