Nanostructured Electrode Materials for Rechargeable Sodium Ion Batteries

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Abstract

Growing costs and limited resources of lithium (Li) has triggered substantial scientific interest to find alternatives. In this respect, the research on sodium (Na) ion batteries hasbeen intensely revived, mostly motivated by the high natural abundance of Na.[1] Therefore an important effort is being made in developing high capacity materials for sodium-Ion batteries, which are inherently eco-efficient and environmentally friendly, in combination with feasible approaches to low-cost production and recyclability. This talk will discuss new concepts, chemistries and architectures for advanced Na ion secondary battery systems.

In the first part, quinones, which are a facinating type of battery material comprising a high theoretical capacity, fast reaction kinetics and a large structural diversity, are discussed. Different types of quinones are considered for nonaqueous and aqueous organic Na-ion batteries. Despite many advantages, mainly dissolution of the active material has hampered their successful application as battery materials.[2] This work presents recent advances using pigments containing benzoquinone units, for example, anthraquinone (AQ) in comparison to perylentetracarboxylicdiimide (PTCDI) as active material for Na ion battery electrodes. Thermally evaporated layers of AQ and PTCDI on carbon paper substrates are used as electrode composites, whereby the nanostructured carbon adds potential advantages, mainly its large surface area, ordered porous network, large pore volume, good electrical conductivity and low cost.

The second part of this talk reports on the sodiation and desodiation characteristics of anodically grown, self-organized titanium dioxide (TiO_2) nanotubes. It is found that carbon treated, anatase TiO_{2-x}-C nanotubes demonstrate substantial self-improving Na storage capacities as cycling proceeds, leading to high specific capacities. Subsequent kinetic analysis reveals a pseudocapacitive contribution which dominates the Na storage process at fast sodiation rates. This pseudocapacitance in TiO_{2-x}-C nanotubes is found to enable exceptionally high-rate capabilities, with high specific capacities at elevated current rates of up to 20C.[3]

Keywords: *nanostructured, electrode materials, sodium ion, batteries, organic, inorganic*

References

[1] M. D. Slater, D. Kim, E. Lee, C. S. Johnson, Adv. Funct. Mater. 2013, 23, 947.
[2] D. Werner, D. H. Apaydin, E. Portenkirchner, Batter. Supercaps 2018, 1, 160.
[3] E. Portenkirchner, D. Werner, S. Liebl, D. Stock, A. Auer, J. Kunze-Liebhäuser, ACS Appl. Energy Mater. 2018, 1, 6646.

Biography

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