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An unexpected look at high-rate properties of electrode materials for Lithium-ion batteries

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Lithium-ion batteries (LIBs) are now commonly used as power supplies of various purposes, from consumer electronics to hybrid and electric vehicles. In automotive applications, high power densities of lithium-ion batteries are of great value enabling one to ensure the starting acceleration. The power density is significantly governed by the diffusion of lithium ions into (and within) the grains of an electrode material. It is therefore considered that obtaining electrode materials in a nanosized form may allow for attaining greater charge/discharge rates than in the case of the electrode materials of a large particle size. However, the dependence of the power density on the particle size is not convincingly justified yet.

The high-rate capabilities of electrode materials for LIBs are reviewed and analyzed. Theoretical predictions of the limiting discharge rates of LIBs are made in terms of the Frenkel kinetic theory. The unexpected definition of an ideal electrode material is suggested: it should consist of nonaggregated, nanosized, perfect single crystals, and a balance between high rate properties and capacities should be determined not only by the size of crystals but also by their perfectness and ability to aggregation. It is stressed that the known values of the lithium ion diffusion in a perfect single crystal ensure the full discharge time of a battery of ca. 0.2 s. This means that nanodimensionality itself cannot be a prerequisite of high-rate properties of electrode materials, as their perfectness is a key value for attaining high discharge rates.

Biography:

Sviatoslav A. Kirillov is acting director of Joint Department of Electrochemical Energy Systems, Kyiv, Ukraine. He received his PhD from Institute of General and Inorganic Chemistry, Kyiv, and obtained DSc degree (habilitation) from Moscow State University. In 1992−2000, he was a holder of several visiting professorships in Greece (Patras University, Institute of Chemical Engineering and High-Temperature Chemical Processes, Patras, University of Thessaly). His research interests embrace interactions and dynamics in disordered systems, synthesis, characterization and testing of materials for electrochemistry, adsorption and catalysis. He authored in of about 200 papers, over 10 books and chapters in books, and 6 patents.