Carbonaceous anodes for Li ion batteries: how to match materials to applications.

Ortal Yariv lavi [a], Doron Aurbach [a]
[a] *Department of Chemistry, Bar-Ilan University, Ramat Gan 5290002 Israel*

E-mail: ortalyariv@gmail.com

Lithium ion batteries' degradation is highly affected by processes that occur at the negative electrodes. These include possible side reactions, trapping of Li ions (hence, irreversible loss of active Li ions) and fractures of the primary electrodes particles via exfoliation processes. Low irreversible capacity and long cycle life are two basic requirements for advanced anode materials in rechargeable batteries.

Graphite is most widely used as the anode material for Li-ion batteries due to its stable specific capacity, small irreversible capacity, and good cycling performance. Major disadvantages of graphite are its relatively low mechanical stability and poor performance at low temperatures (below – 15^0C). Graphite can easily undergo co-insertion of solvent molecules during intercalation of Li ions, what leads to its exfoliation and fast degradation. Consequently, graphite electrodes do not work well in ethereal solutions, because they cannot reach good enough passivation in them at potentials in which Li ion intercalation occurs.

Carbon materials can be classified into several groups: graphite which is an ordered, crystalline layered material, hard carbons which cannot be graphitized at high temperatures and soft carbons which are in fact disordered nano-graphitic materials that can become graphitic by heat treatment at high temperatures.

We demonstrate the stability and performance of four different carbonaceous materials: natural graphite, surface modified graphite, soft and hard carbons in several electrolyte solutions: EC-DMC, FEC-DMC, 2FEC-DMC, EC-DMC-VC (0.5–2%) with $LiPF_6$ as the electrolyte and diglyme/LiTFSI solutions. The main goal was to map the behavior of important components of Li ion batteries and to optimize electrodes/solutions that work well over a wide temperature range, from −30◦C to 45◦C. Standard binary electrolyte solutions such as EC-DMC suffer from low specific conductivity at low temperature, while solutions based on fluorinated carbonates such as FEC can work below −30 ^{0}C. Soft carbons has lower specific capacity than graphite (up to 250 mAh/g vs. 370 mAh/g respectively) but behave better at low temperatures. For instance, below -5 ^{0}C the specific capacity of soft carbons is higher than that of graphite. Hard carbon electrodes may suffer from higher initial irreversible capacity but they are mechanically stable, are not affected by co-intercalation and exfoliation phenomena. Thereby, they are very suitable to work in ethereal solutions, demonstrating with them specific capacities that can approach that of graphitic materials.

References:

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