Borates in batteries

Global efforts to reduce emissions and the need for improved energy storage for mobile applications are promoting rigorous research efforts in new battery technologies. While lithium-ion batteries have emerged as the principal technology, improvements in performance and safety are necessary for broader market adoption. Commercial and experimental applications of boron-based materials to improve both anodes and electrolytes indicate substantial benefits to batteries.

Surface treatment:

When used to modify the surface of graphite, treatment with borates at <1000 °C results in promising improvements in rate capability, life cycle, and capacity [1-4]. High rate capability is essential in high power applications i.e., power tools and hybrid electric vehicles. Increased capacity improves the amount of charge a battery can hold and is important in improving driving range. When applied to the anode or used in electrolytes borates likely improve the surface interface, a critical layer that forms during cycling [5]. In several studies, borates have proven beneficial to the formation of the solid electrolyte interphase (SEI) [6-8].

Graphite anodes are susceptible to lithium deposition and dendrite formation at high charge rates which can short out the cell and cause safety issues [10]. Borate surface coating may protect it from lithium deposition leading to better safety characteristics.

Borate surface coating on graphite may improve the stability of the SEI by participating in formation chemistry or altering morphology [4].

The SEI forms a boundary between electrode and electrolyte. In this component of the cell, complex and potentially beneficial electrochemical reactions are expected, whereas reactions occurring outside of this interface are often self-destructive and lead to performance decay [9].

Mechanism:

Upon further investigation with scanning electron microscopy, there is no evident change in morphology with borate treatment. Surface area and pore structure analysis indicate borate melts into pore structures and defect sites on the surface of graphite. Reactions during the formation of the SEI are likely influenced by the presence of borate, improving the capacity, rate capability and life of the battery.

Borates lead to improvements in a variety of battery applications including: surface treatment of graphite anodes, catalyzing the synthesis of graphite and as electrolyte additives.

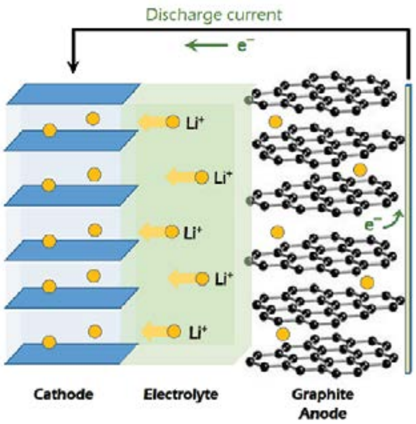

Figure 1 schematic diagram of a lithium ion battery

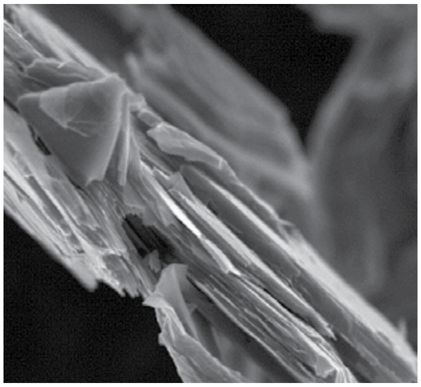

Figure 2 Scanning electron microscopy of borate treated graphite

[Graphitization Catalyst] – Synthetic graphite is made from various materials including coal tar pitch, petroleum coke, and various other conbonaceous products. High temperature heat treatment of graphite contributes to a highly ordered crystalline graphite structure. High temperature graphitization is an expensive and energy intensive process requiring temperatures in the 3000 °C range.

Borate addition prior to graphitization improves electrochemical properties and lowers temperatures required for graphitization [11]. In addition to increasing crystallinity, boron is thought to incorporate into the lattice structure of graphite at higher temperatures, initiating greater alignment and changing electronic structure. When residing in the graphite lattice, boron can act as an electron acceptor leading to a specific capacity of 437 mAh/g, higher than the theoretical maximum for pure graphite (372 mAh/g) [12].

Electrolytes – Borate compounds, including lithium bis(oxalato)borate (LiBOB) and related compounds are widely used in commercial Li-Ion batteries. The decomposition reactions of the anode and cathode are substantially decreased by incorporation of borate compounds into the SEI, greatly improving battery life, performance, and safety [13] [6].

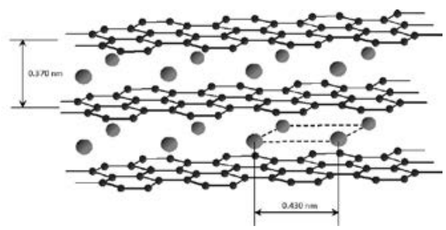

Figure 3 Lithium intercalation into graphite layers, adapted from an illustration in [3].

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- People who make a difference: Experts in borate chemistry, technical support, and customer service
- Solutions that make a difference: Strategic inventory placement and long-term contracts with shippers to ensure supply reliability

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