TECHNICAL BULLETIN

Battery-grade boric acid for lithium-ion battery cathodes

For more than 150 years, U.S. Borax has been at the forefront of borate technology, research, and development—continuously finding better ways™ to provide the refined borates that the world needs. With a state-of-the-art laboratory and focus on specialty products, our European subsidiary—Borax Français—is a global leader in innovation. In recent years, significant advancements have been made in utilizing borates for advanced e-mobility applications, particularly in lithium-ion batteries for electric vehicles (EV).

U.S. Borax, part of Rio Tinto, is committed to helping customers achieve and improve their advanced technology goals. Our Coudekerque site has been operational in the Hauts-de-France region since 1902. As a long-standing member of the Coudekerque-Branche community, the site is deeply embedded in the region's social and industrial fabric.

Our products

Borates are mined, refined, and shipped from our California mine to Coudekerque, where a second refining process produces high-value specialty borates for various industries, including agriculture, pharmaceuticals, nuclear, and industrial manufacturing. Borax Français is currently investing in modernizing its facilities and developing new products, particularly for the cathode active material (CAM) sector.

Under the *Optibor*® brand, U.S. Borax offers a range of boric acid grades that meet the specific needs of the lithium-ion battery industry.

Purity is available in two distinct grades:

1. **Technical-grade boric acid:** Refined borates produced through the primary refining consuming boron minerals as feedstock
2. **Ultra-high-purity boric acid known as *Optibor* BQ (battery quality):** Refined through a secondary process at our Coudekerque site, that consumes technical grade boric acid as feedstock, operated under a rigorous quality assurance system. This process significantly reduces impurities such as alkalis, magnetic materials, sulfates (SO_4), and chlorides (Cl).

With the add-on improvement project set for completion by the end of 2025, both purity grades will be available in super-fine form while maintaining ultra-low magnetic impurity levels. Customizable particle sizes, such as D50 options, will be offered for direct supply to cathode manufacturers.

Lithium-ion batteries

Boron and its compounds have been extensively studied throughout the history and development of lithium-ion batteries (LiB), playing a role in various LiB components. For more details, please refer to the paper written by our technical team: "Examining the Benefits of Using Boron Compounds in Lithium Batteries: A Comprehensive Review of Literature"[1].

In commercialization, boron has been used for decades in electrolytes to enhance the stability of the solid electrolyte interface (SEI) in LiBs. Recently, with the growth of the EV industry and development of LiB technology, there has been growing research into the application of boric acid in both graphite anodes and nickel-cobalt-manganese (NCM) cathodes, as evidenced by the increasing number of patents related to boron in these components. Notably, we see that NCM cathode manufacturers around the world commonly use boric acid to enhance cycling capacity.

Lithium-ion batteries cathodes

Recognizing the limited information available, we conducted R&D studies to support interested cathode makers exploring boric acid use. In collaboration with the National Taiwan University of Science and Technology, we conducted a laboratory program using a solvent to dissolve boric acid to precisely control dosage and ensure homogeneity of boric acid mixing and application. Following the wet preparation method, boric acid was applied to NCM83 cathodes through doping and coating, and lithium iron phosphate (LFP) cathodes through coating only.

Preparation method	Wet mixing – using solvent		
Application method	Doping	Coating	Coating
Cathode chemistry	p-NCM83 $Ni_{0.83}Co_{0.12}Mn_{0.05}(OH)_2$	NCM $LiNi_{0.83}Co_{0.12}Mn_{0.05}O_2$	LFP

Our results show that doping on p-NCM effectively enhances cycling capacity by 8-10%. The impact on coulombic efficiency and cycling performance varies with different doping temperatures.

For coating NCM, our findings clearly demonstrated the benefits of applying boric acid to commercial cathodes, with the level of improvement dependent on dosage, coating temperature, and boric acid purity.

- **Dosage:** Increasing the boric acid dosage enhances performance, but exceeding the optimal level reduces benefits, likely due to excessive reactions with the cathode
- **Coating temperature:** Temperature plays a critical role; it needs be high enough to enable boron integration while low enough to prevent structural deformation, such as disordered layers and cation mixing
- **Boric acid purity:** Optimizing dosage and coating temperature can enhance cycling capacity by 5%. Using ultra-high-purity, BQ grade boric acid produced by Borax Français further improved performance by an additional 5%.

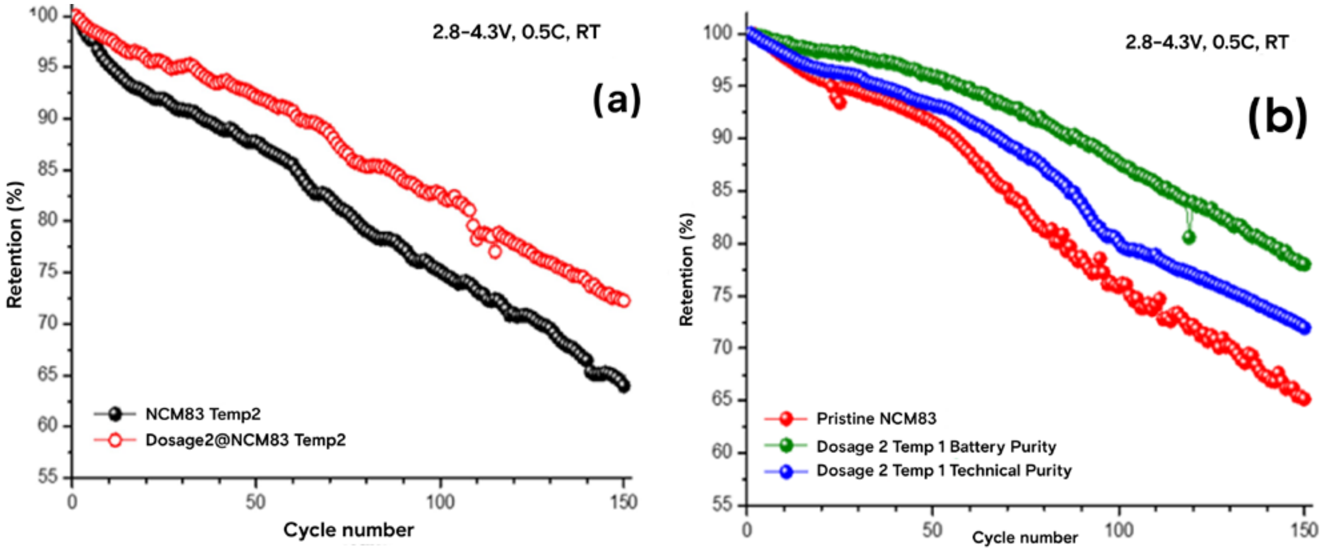

Figure 1. (a) Capacity retention of NCM83 cathodes with boric acid applied through doping and (b) NCM cathodes with boric acid coating. High-purity boric acid further enhances performance by an additional 5%.

For LFP cathodes, the coating application of high-purity boric acid has shown interesting results in stabilizing the cycling capacity curve over extended cycles. Research on its effectiveness and optimization is still ongoing.

Reference

Zheng, Changlin (Allen). 2022. Examining the Benefits of Using Boron Compounds in Lithium Batteries: A Comprehensive Review of Literature. Batteries 8, no. 10: 187.