Baikowski®

Solution partner for
FINE MINERALS

ADVANCED MATERIALS FOR BATTERIES

4N Alumina & Nano-Zirconia Solutions

> Batteries are devices that **store and convert chemical energy into electrical energy**. They have many applications in various fields, such as electronics, medical devices, transportation, and renewable energy. For the time being, batteries for electric vehicles (EVs) and hybrid electric vehicles (HEVs), which are expected to play a key role in the transition to a low-carbon economy, are considered as one of the most important challenge.

> There are different types of batteries, such as lead-acid, nickel-metal hydride, lithium-ion, and solid-state batteries, each with their own advantages and disadvantages. In order to enhance the performance, safety, and longevity of these batteries, researchers and manufacturers have been exploring together new materials and technologies.

How High Purity Alumina help address battery challenges?

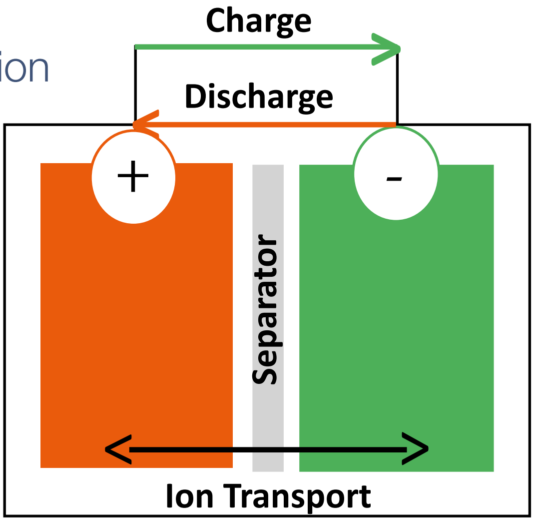
> If High Purity Alumina (HPA) has improved the performance and safety of lithium-ion batteries by coating the separator, cathode and anode materials, preventing side reactions and thermal runaway, it has also a role to play in overcoming the limitations of solid-state batteries.

> Solid state batteries are considered as one of the most promising candidates for the next generation of car batteries, as they offer higher energy density, longer cycle life, better safety, and lower environmental impact than conventional liquid-electrolyte batteries.
They are using solid electrolytes instead of liquid or gel electrolytes, which eliminates the risk of leakage, flammability, and degradation. However, they also face some challenges, such as high low ionic conductivity, interfacial instability, and and poor compatibility with electrodes.

> High purity alumina (HPA) can be used as **a separator** to prevent the contact between anode and catode**,** as well as to **enhance the electrolytes ionic conductivity and electrochemical performance.**

1. How batteries work?

1.1 Battery components and energy production



> A battery consists of two electrodes, an **anode** (negative) and a **cathode** (positive), and an **electrolyte** that allows the movement of ions between them.

> When the battery is connected to an external circuit, electrons flow from the anode to the cathode and the other way around during the charging and discharging process, generating an electric current.

> This process can be repeated hundreds or even thousands of times, giving the battery its rechargeable character.

1.2 Energy storage process

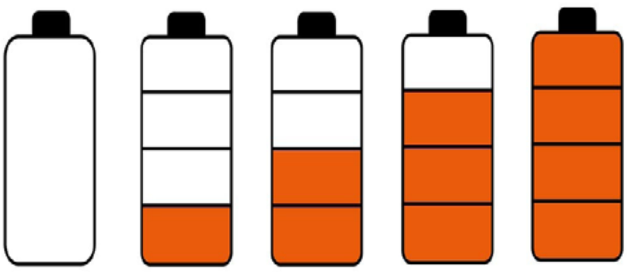
> The transfer of ions and electrons alone is not enough to store electrical energy. In addition, there must be a difference in electric potential between the two electrodes. This is created thanks to the so-called oxidation-reduction processes.

> Thus, during charging, the extraction of the ion and the electron from the positive electrode corresponds to an oxidation of the latter, which leads to an increase in the electric potential. Conversely, the incorporation of the ion and of the electron on the negative electrode side corresponds to a reduction of the latter, therefore to a drop in potential.

> **The voltage** measured between the terminals of the cell is the potential difference between the cathode and the anode. It increases during charging and decreases during discharge, typically varying between 4.2 V and 2.5 V, with an average around 3.7 V, often indicated on the battery.

> The other indication given is the **capacity** in milliampere hours (mAh), typically between 2000 and 3000 mAh for small batteries such as those of mobile phones, or in ampere-hours (Ah), for larger batteries (typically between 50 and 60 Ah).

The stored energy or the specific energy is the product of the average voltage times the capacity and is expressed in watt-hours (Wh).



1.3 Battery parameters

> An accumulator, whatever the technology used, is essentially defined by three sizes :

Accumulator sizes		
	Unit	**Description**
Specific energy density (or volume)	Wh/kg or Wh/l	Corresponds to the quantity of energy stored per unit mass (or volume) of accumulator.
Specific power density	W/kg	Represents the power (electrical energy supplied per unit of time) that the accumulator mass unit can deliver.
Cyclability	Number of cycles	Characterizes the lifetime of the accumulator, that is to say the number of times it can restore an energy level greater than 80% of its nominal energy, this value being the value most often requested for portable applications.

2. The two main types of batteries

> There are different types of batteries, the most common and widely used is the **lithium-ion battery (liquid or gel electrolyte)**. As advancements in battery technology progressed, there is a growing interest in exploring alternatives with higher energy density and improved safety, driving research and development efforts towards **solid state batteries.**

2.1 Liquid or gel electrolyte batteries

> This battery uses a **liquid electrolyte**, usually a mixture of organic solvents and lithium salts, and electrodes made of metal oxides or phosphates (cathode) and graphite, Li metal or silicon (anode).

> The lithium ions move through the liquid electrolyte which have some drawbacks, such as flammability, leakage, limited voltage stability, and poor performance at low or high temperatures.

> To overcome these challenges, solid-state batteries, which use a solid electrolyte instead of a liquid one, have been developped.

2.2 Solid-state batteries

> **A solid electrolyte** can be made of ceramics, polymers, or composites, and provide higher safety, energy and power density, as well as longer cycle life than liquid electrolytes.

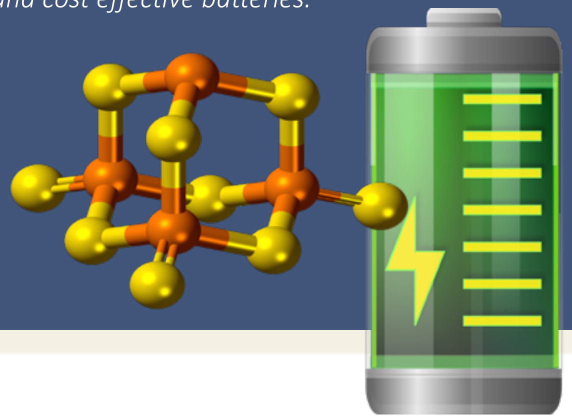
> This solid electrolyte acts as a separator between the electrodes, preventing short circuits and dendrite formation. The electrodes can also be made of different materials, such as lithium metal or sulfides, which can increase the capacity and voltage of the battery.

> Nevertheless, solid-state batteries require higher temperatures and pressures to form good contact between the electrodes and the electrolyte, which can increase the cost and complexity of manufacturing

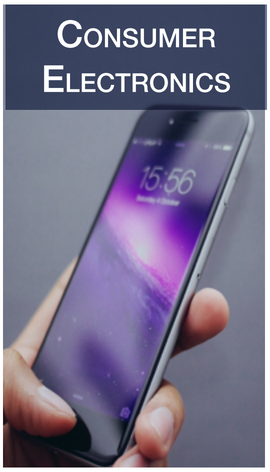
> They also have lower ionic conductivity than liquid electrolytes, which can limit the rate capability and power output of the battery.

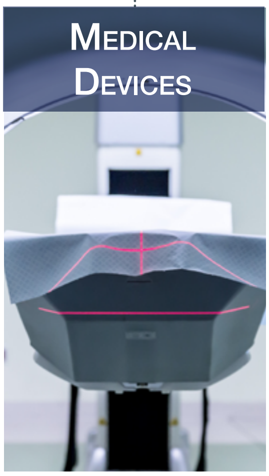
*Researchers are looking for **alternative to lithium** such as sodium and sulfur to avoid the use of critical materials and to improve battery performance.*

Whatever the technologies, progress remains to be made in order to increase energy storage capacity to meet the continued demand of growing markets and meet the challenges of providing "sustainable" and cost effective batteries.



3. Applications





4. How HPA overcomes battery technology limitations?

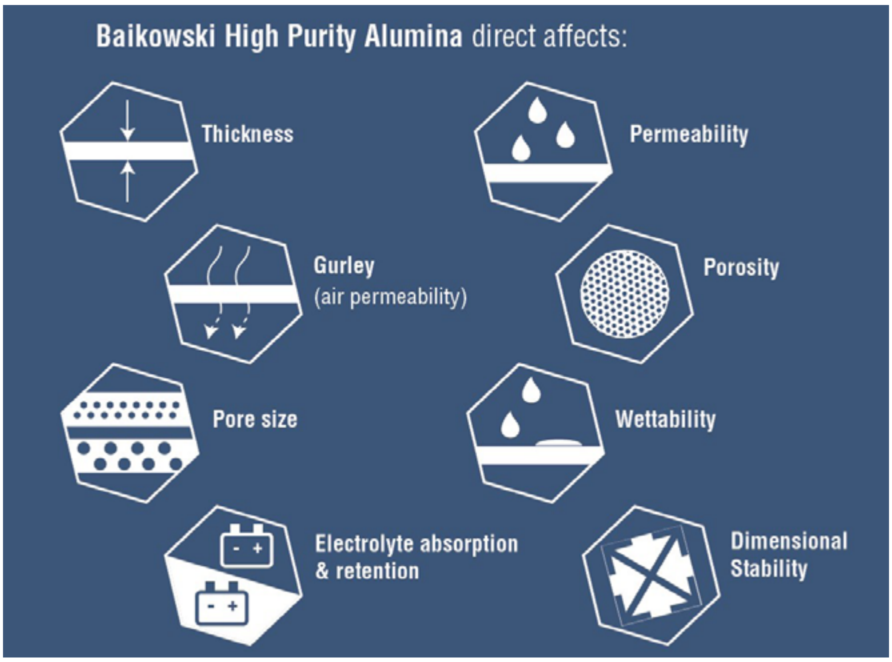
> **HPA coating** is a process that involves a thin layer of HPA on the surface of the electrodes and separator, which prevents short circuits, decomposition reactions, reduces long-term capacity fading, and leads to an enhanced overall battery performance.

> Indeed, HPA is a ceramic material that has high thermal stability, chemical resistance, and electrical insulation properties that can provide several benefits for batteries, such as:

- **Enhancing the safety and efficiency** of the battery by preventing short circuits and thermal runaway.

  Conventional separators made of polyolefin materials have low thermal stability, high shrinkage, and poor wettability that HPA coating enables to overcome.
- **Improving the structural stability of the electrodes** during charge-discharge cycles, especially for silicon-based anodes that tend to swell and degrade rapidly,
- **Reducing the first-cycle-capacity-loss of silicon anodes**,
- **Protecting the cathode from corrosion** and improve its conductivity, which can extend the battery life and enhance its performance.
- **Increasing the energy density and retention capacity of the battery**, which can translate to longer battery life and better overall performance.

> HPA properties can also be managed for battery needs : **thickness, permeability, gurley, pore size, dimensional stability, electrolyte absorption and retention.**



> Discover all [our solutions for batteries]

5. How can Baikoswki® R&D help design tailored HPA solutions for batteries?

> We assist you in selecting the most suitable alumina for your specific process requirements. Our offerings consider various factors, including particle size distribution, crystallographic phase, and other physical properties crucial for processability, such as viscosity, coating thickness, and packing density of the coated layer, consolidation of the layer at low temperature ...

> Depending on your needs, we offer different :

- **Purity ranges** among our Baikalox®products,
- **Ready-to-use slurries**, such as SLA products, with different pH levels compatible with your additives (binders and other components),
- **Nano-zirconia slurries** are also available for advanced applications,
- **Tailor-made solid or liquid formulations** to optimize packing density.

PRODUCT DESIGN

Through an active collaboration, we are committed to deliver customized solutions to enhance your process efficiency and product quality.

> Additionally, our R&D team goes beyond traditional analyses to provide you with comprehensive data, including :

- **TGA/DSC** curves for thermal analysis,
- **Viscosity** curves for flow properties,
- **Zeta potential or sedimentation** data for stability assessment,
- **SEM** for detailed microstructural analysis.

> Contact us and we will develop together the product that meets all your specific needs and requirements.

Your solution partner for fine minerals

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