June, 2025
Yazaki Corporation

Development of binder-free electrode materials using carbon nanotubes
Lifespan doubled, fast charging and discharging

YTC America Inc., a U.S. subsidiary of Yazaki Corporation, has developed an electrode material for energy storage devices based on carbon nanotubes (hereinafter referred to as CNT) that does not contain polymer binders (hereinafter referred to as binder-free electrode material).
Compared to conventional electrode materials, this newly developed electrode material was shown to successfully cut the internal electrical cell resistance (hereinafter referred to as internal resistance) in half and significantly extend the lifespan of energy storage devices.

Background and history of research and development of new materials

With the advancement of electrification and AI technology towards the realization of a carbon-neutral society, the use of large-capacity, high-power energy storage devices, such as lithium-ion batteries and supercapacitors, as rechargeable energy sources and power leveling devices, is expected to expand. These energy storage devices are all composed of electrodes that include polymer binders. Polymer binders, which are electrically insulating, increase internal cell resistance, limit charging and discharging speeds, and restrict power performance. Additionally, the degradation of polymer binders due to repeated charging and discharging shortens the lifespan of energy storage devices. To address these issues, we have developed binder-free electrode materials using conductive CNTs instead of electrically insulating polymer binders.

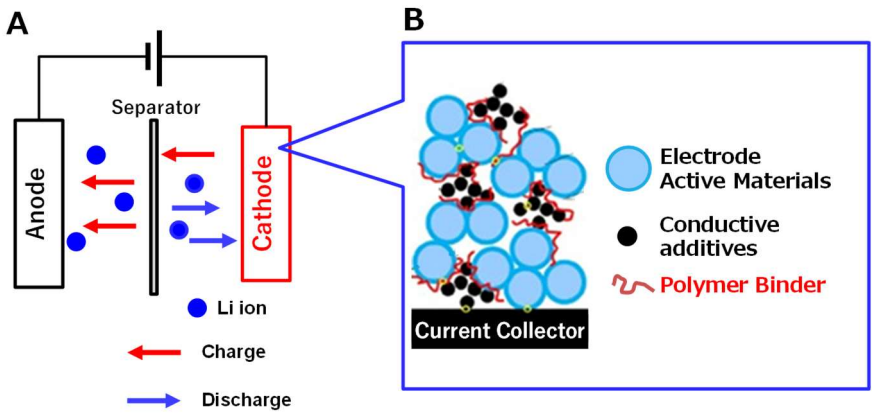

Figure 1: Schematic diagram showing the lithium-ion battery configuration (A) and the conventional electrode composition (B)

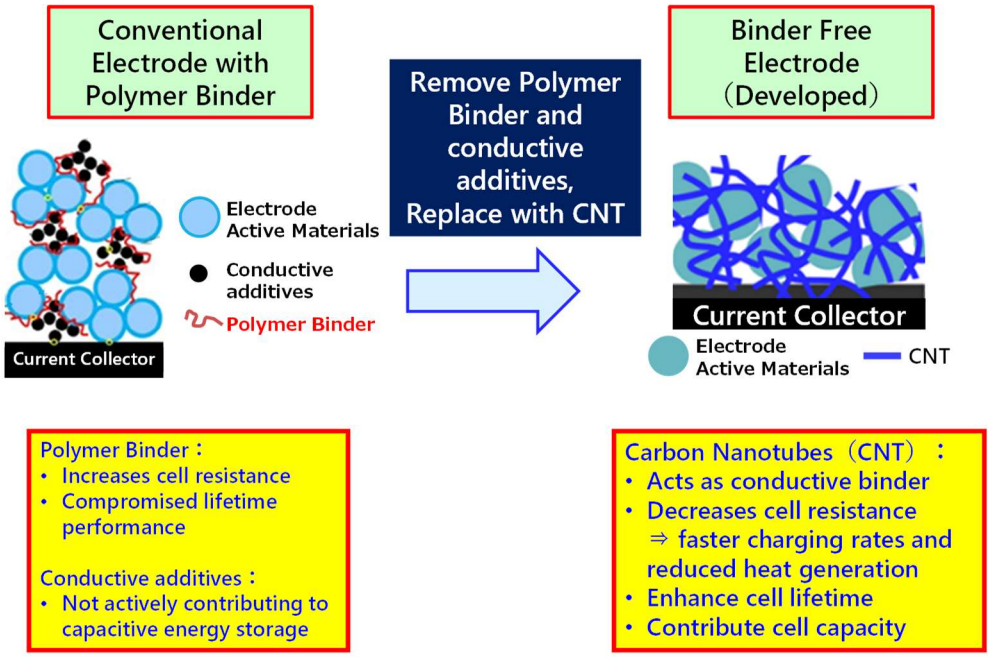

Figure 2: Conventional electrode with polymer binder (left) and binder-free electrode (right)

Key points of R&D

The technology we have developed allows the use of organic solvents or aqueous solvents without using any surfactants or dispersants typically required for the dispersion of CNTs. This prevents adverse effects on performance due to residual components and simplifies the manufacturing process. When the formulated CNT dispersion slurry is mixed with electrode active materials such as NMC (lithium-nickel-manganese-cobalt oxide) or activated carbon, it effectively entangles around the active material, maintaining the electrode shape, thus eliminating the need for commonly used polymer binders and conductive materials (conductive additives). Additionally, since polymer binders are not included, solvents that impact cost and the environment, such as N-methyl-2-pyrrolidone (NMP), are not required.

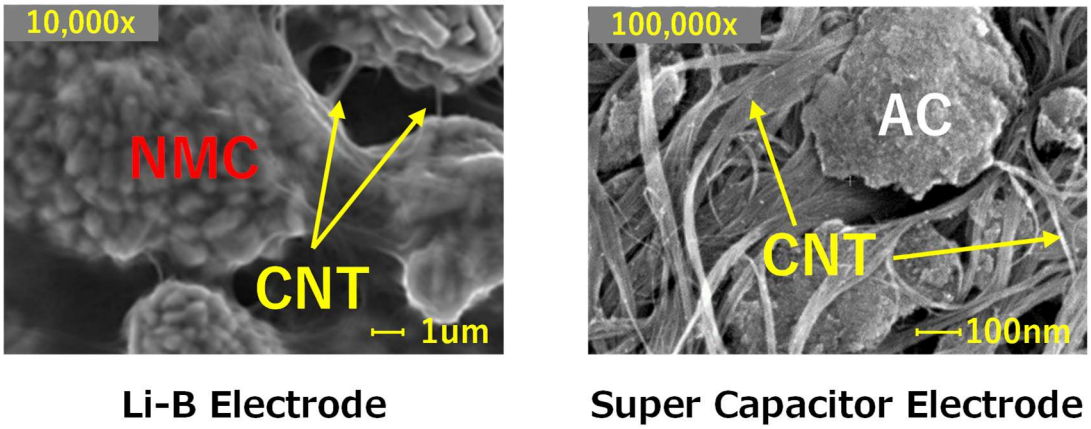

Figure 3: Electron micrograph of a binder-free electrode

Features of binder-free electrode materials

- Utilizes high-purity, high-quality CNT materials
- Surfactant-free, dispersant-free and polymer binder-free
- Dispersible in organic and aqueous solvents
- Can be prepared in a wide range of viscosity

Based on these features, we have demonstrated the coating of electrodes of various thicknesses using conventional roll-to-roll coating equipment.

Improving the performance of lithium-ion batteries using binder-free electrodes

A lithium-ion battery combining a binder-free LTO (lithium titanate) anode and binder-free NMC (lithium-nickel-manganese-cobalt oxide) cathode was demonstrated to exhibit a reduction in internal resistance by half and a doubled lifespan compared to conventional lithium-ion batteries containing polymer binders. Additionally, the capacity retention during rapid charging and discharging has improved more than twofold, at one-tenth of the rated charging time. Similar performance improvements were also confirmed when using other electrode active materials.

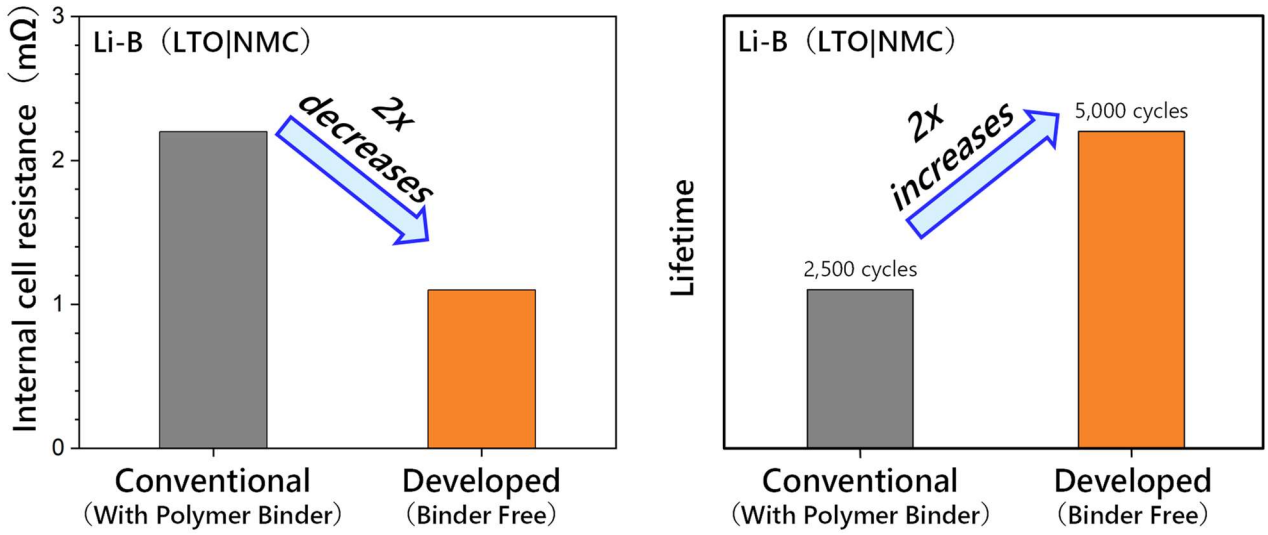

Figure 4: Internal resistance and lifetime comparison of conventional and binder-free electrodes

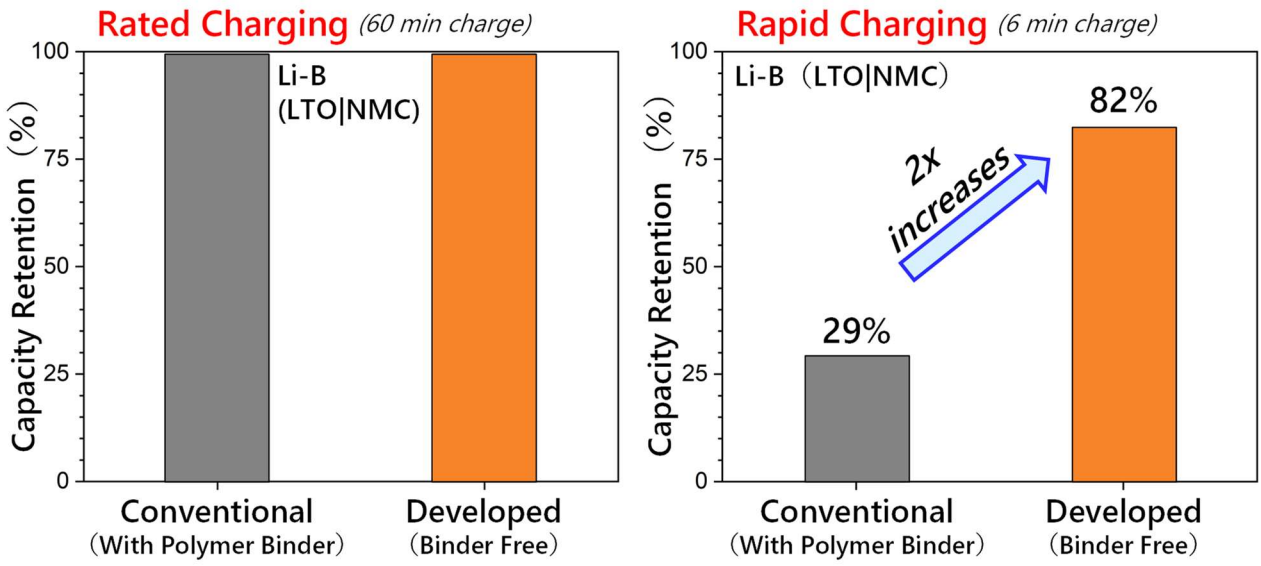

Figure 5: Comparison of capacity retention rates between conventional electrodes and binder-free electrodes

Improving Supercapacitor Performance Using Binder-Free Electrodes

A 400F supercapacitor combining binder-free electrodes of activated carbon was demonstrated to exhibit improved charging and discharging speeds due to the halved internal resistance, and its lifespan has doubled compared to commercially available supercapacitors using electrodes with polymer binders.

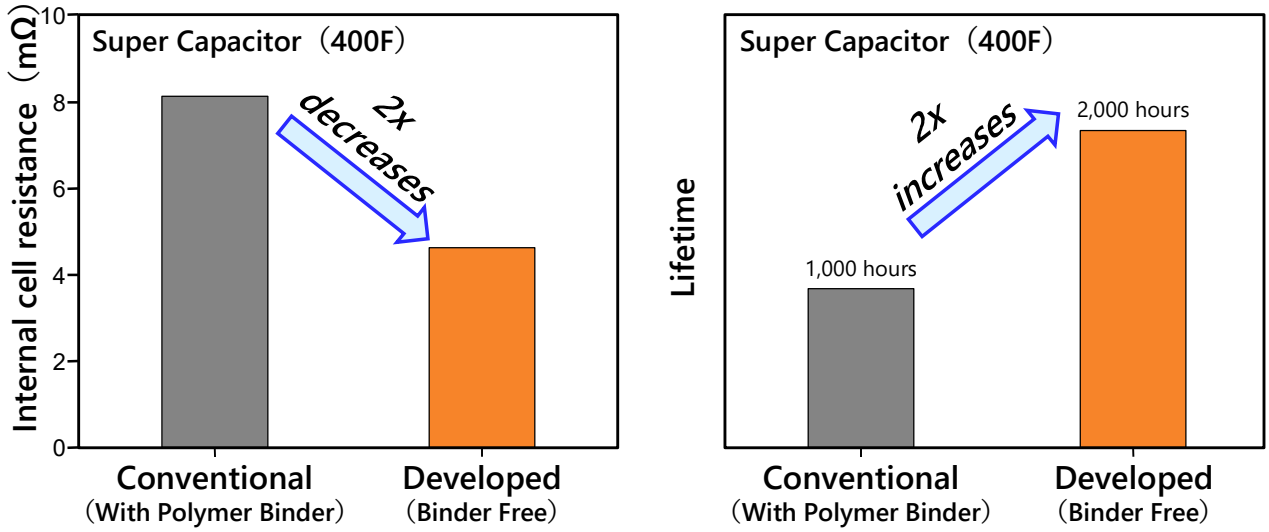

Figure 6: Internal resistance and lifetime comparison of conventional and binder-free electrodes

What to do next

To demonstrate the technical results at a practical level, we will seek collaboration with external partners and aim for practical application after 2027.

Terminology

- **Carbon Nanotubes (CNT)**: Nano-materials composed of carbon atoms arranged in a tubular structure.
- **Power Leveling Device**: A device that suppresses power consumption peaks and equalizes consumption over time.
- **Lithium-Ion Battery**: A secondary battery that stores and releases electrical energy by moving lithium ions between the cathode and anode.
- **Supercapacitor**: An energy storage device capable of rapid charging and discharging.
- **Polymer Binder**: A polymer-based adhesive used to bind electrode materials.
- **Internal Resistance**: The resistance encountered by the current flowing within a battery cell.
- **Power Performance**: The performance of a battery in supplying power.
- **Surfactant**: A substance that reduces the surface tension of liquids.
- **Dispersant**: A substance used to uniformly disperse powders in a liquid.
- **Organic Solvent**: A solvent used to dissolve organic compounds.
- **Aqueous Solvent**: A water-based solvent.
- **Electrode Active Material**: Materials used in electrodes that generate or store electrical energy.
- **Conductive Additive**: An additive used to enhance the conductivity of electrodes.
- **N-Methyl-2-pyrrolidone (NMP)**: An organic solvent with high dissolving power.
- **Capacity Retention Rate (Retention Rate)**: The ratio of discharge capacity to the nominal charge capacity, expressed as a percentage.

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