

GIST develops next-generation battery technology with twice the range and enhanced safety... Fully charged in 12 minutes

- Research team led by Research Institute for Solar and Sustainable Energies Director KwangSup Eom... Creates lithium metal battery that simultaneously suppresses dendrite formation and volume expansion through a 3D structural design that induces lithium to stack uniformly from the bottom

*- Presents potential for commercialization in electric vehicles and ESS... Published in the international academic journal **Energy & Environmental Materials***



▲ (From left) Research Institute for Solar and Sustainable Energies Director KwangSup Eom (Department of Materials Science and Engineering Professor), and Dr. Jinhyeon Jo

As the adoption of electric vehicles expands, there is a growing demand for batteries that allow for longer driving distances on a single charge and shorter charging times.

Lithium-ion batteries, currently widely used in electric vehicles and smartphones, face difficulties in dramatically improving performance because the amount of lithium ions that graphite, the anode material, can store has nearly reached its limit.

** lithium-ion battery (LIB): A commercial battery technology that uses carbon-based materials, such as graphite, instead of lithium metal as the anode, storing and releasing energy as lithium ions move between the anode and cathode during the charging and discharging process. Possessing relatively high energy density, stability, and a long lifespan, it is currently the most widely used battery for electric vehicles, smartphones, laptops, and energy storage systems (ESS).*

** anode: An electrode that stores and releases lithium ions during the charging and discharging process; it is a key component that determines the battery's energy density and lifespan.*

The Gwangju Institute of Science and Technology (GIST, President Kichul Lim) announced that a research team led by Research Institute for Solar and Sustainable Energies Director KwangSup Eom (Department of Materials Science and Engineering Professor), has developed a technology to improve the charging speed and stability of lithium metal batteries by utilizing a 3D structure coated with an electrically conductive polymer on its surface.

For electric vehicles (EVs), it is important to store electricity and use it reliably when needed. Lithium-ion batteries, which are currently widely used in EVs and other applications, have the advantage of being able to store a large amount of energy relative to their size and weight.

Lithium metal batteries, which are attracting attention as next-generation batteries, can theoretically achieve an energy density approximately twice as high as conventional lithium-ion batteries. However, they present a problem in that "lithium dendrites"* can form during the charging and discharging process, where lithium does not accumulate evenly on the surface of the negative electrode but grows into sharp, tree-branch-like structures.

These dendrites can penetrate the battery's internal separator*, causing the positive and negative electrodes to come into direct contact and trigger a "short circuit" where electricity flows all at once. Simultaneously, they cause volume expansion, significantly degrading the battery's lifespan and safety.

** lithium dendrites (Li-dendrite): A crystal structure in which lithium does not accumulate evenly on the surface of the negative electrode during the charging and discharging process of a lithium metal battery but grows into a sharp, tree-branch-like shape. It can damage the separator inside the battery, causing a short circuit between the positive and negative electrodes and significantly reducing the battery's lifespan and safety.*

** separator: A very thin insulating film that prevents the positive and negative electrodes from coming into direct contact with each other inside the battery. It is a key component that determines battery safety because it helps the battery operate normally by allowing only lithium ions to move without allowing electricity to pass through.*



▲ Dr. Jinhyeon Jo is conducting an experiment to coat a three-dimensional structure with a polymer in a glove box.

Focusing on the fact that the location and manner in which lithium accumulates determine battery performance, the research team designed a three-dimensional structure (SP-PPy@pPVDF) that induces lithium to accumulate uniformly from within the structure.

They created a structure with many internal voids using 'polyvinylidene fluoride (PVDF),' a lightweight and highly durable polymer material, and coated it with 'polypyrrole,' a polymer that conducts electricity only partially.

** polypyrrole: A polymer material that conducts electricity only partially, it helps lithium accumulate evenly during the charging and discharging process rather than pooling in one area. This ensures stable internal battery reactions, improving*

both safety and lifespan. In particular, it is a functional material that creates an environment where lithium adheres well, effectively suppressing the growth of lithium dendrites even under ultra-fast charging conditions.



▲ (From left) Research Institute for Solar and Sustainable Energies Director KwangSup Eom (Department of Materials Science and Engineering Professor), and Dr. Jinhyeon Jo are conducting an experiment in the laboratory.

This structure regulates current flow to induce lithium to stack neatly from the bottom in a "bottom-up" manner, simultaneously suppressing dendrite formation and volume expansion.

As a result, it has increased energy storage density by more than double compared to conventional lithium-ion batteries and significantly improved the volume expansion issue.

Furthermore, it has achieved ultra-fast charging performance by drastically shortening charging time, enabling a full charge in approximately 12 minutes. In addition, stable performance was secured even under high-speed charging conditions (5C*, approximately 12 minutes of charging), which were difficult with existing structures.

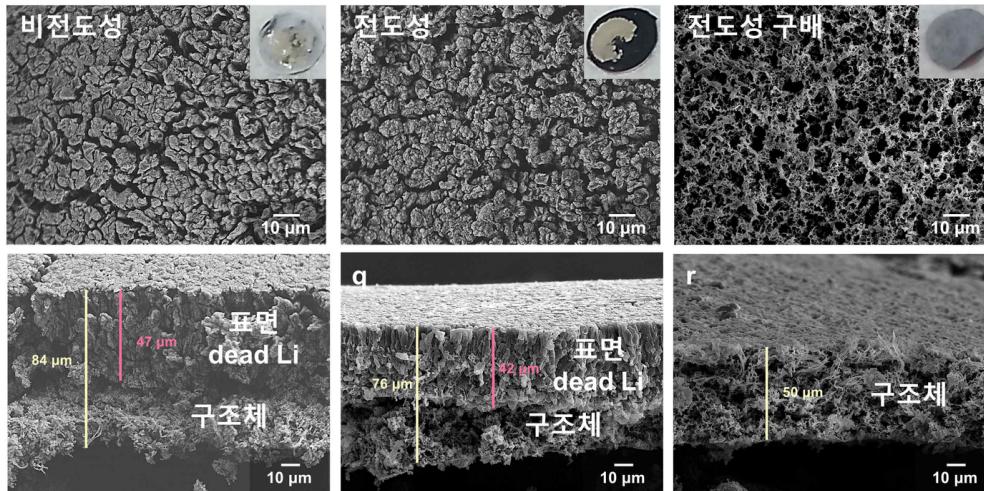
While the performance of conventional copper current collector-based lithium anodes or general porous structures deteriorates rapidly after about 80 charge-discharge cycles, the structure designed by the research team maintained 94.7% of its initial capacity even after more than 200 repeated uses.

No volume expansion was observed during the charge-discharge process, proving its stability even in high-speed charging environments.

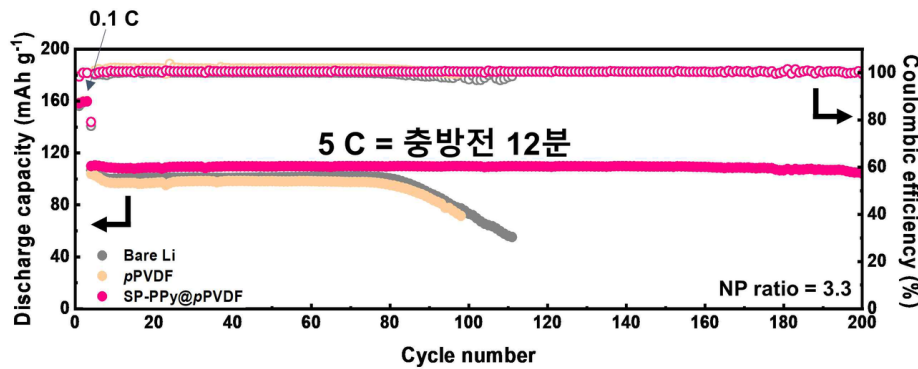
Furthermore, this technology enables the simultaneous implementation of polymer coating and surface insulation using only a simple solution process, making it advantageous for large-area production. It is particularly significant in that it can be applied to various fields, such as electric vehicle batteries, energy storage systems (ESS), and batteries for air mobility, thereby increasing the potential for future commercialization.

** C-rate: An indicator representing the charging and discharging speed of a battery; 1C signifies a full charge in 1 hour, while 5C signifies a full charge in approximately 12 minutes.*

- 리튬 도금 형상 변화



- 완전 셀 성능 향상



▲ Comparison of lithium metal growth patterns and battery performance with and without a conductive gradient coating. A lithium-friendly polypyrrole (PPy) is coated on the surface of the structure, and a "conductive gradient" structure is applied, designed to allow electricity to flow internally while insulating the exterior. Thanks to this, lithium grows evenly, reducing the problem of sharp, prickly accumulation (top). When the battery made in this way was tested under ultra-fast conditions (5C) where it is charged in 12 minutes, it lasted more than twice as long as a conventional lithium metal anode and maintained stable performance even after 200 charge-discharge cycles (below).

Professor KwangSup Eom said, "This research is significant in that it presents a structural solution that can simultaneously resolve the problem of dendrite formation and the resulting volume expansion during the charge-discharge process, which has been pointed out as a chronic problem of lithium metal batteries."

He added, “If lithium metal batteries, which possess more than twice the energy storage density of currently used lithium-ion batteries, are commercialized, it is expected to develop into a technology capable of doubling the driving range of electric vehicles and air mobility and enabling ultra-fast charging in approximately 12 minutes.”

This research, supervised by Research Institute for Solar and Sustainable Energies Director KwangSup Eom (Department of Materials Science and Engineering Professor, corresponding author), and conducted by Dr. Jinhyeon Jo (first author), was supported by the Mid-Career Researcher Support Program of the Ministry of Science and ICT and the National Research Foundation of Korea.

The research results — [Architecture of Semiconductive Macroporous Polymer Scaffold to Realize Ultra-Fast Charging in Lithium Metal Batteries](#) — were published online on March 29, 2026, in *Energy & Environmental Materials*, a prestigious international academic journal in the fields of materials science and energy.

Meanwhile, GIST stated that this research achievement was considered to have both academic significance and potential for industrial application, and that discussions regarding technology transfer can be conducted through the Technology Commercialization Office (hgmoon@gist.ac.kr).