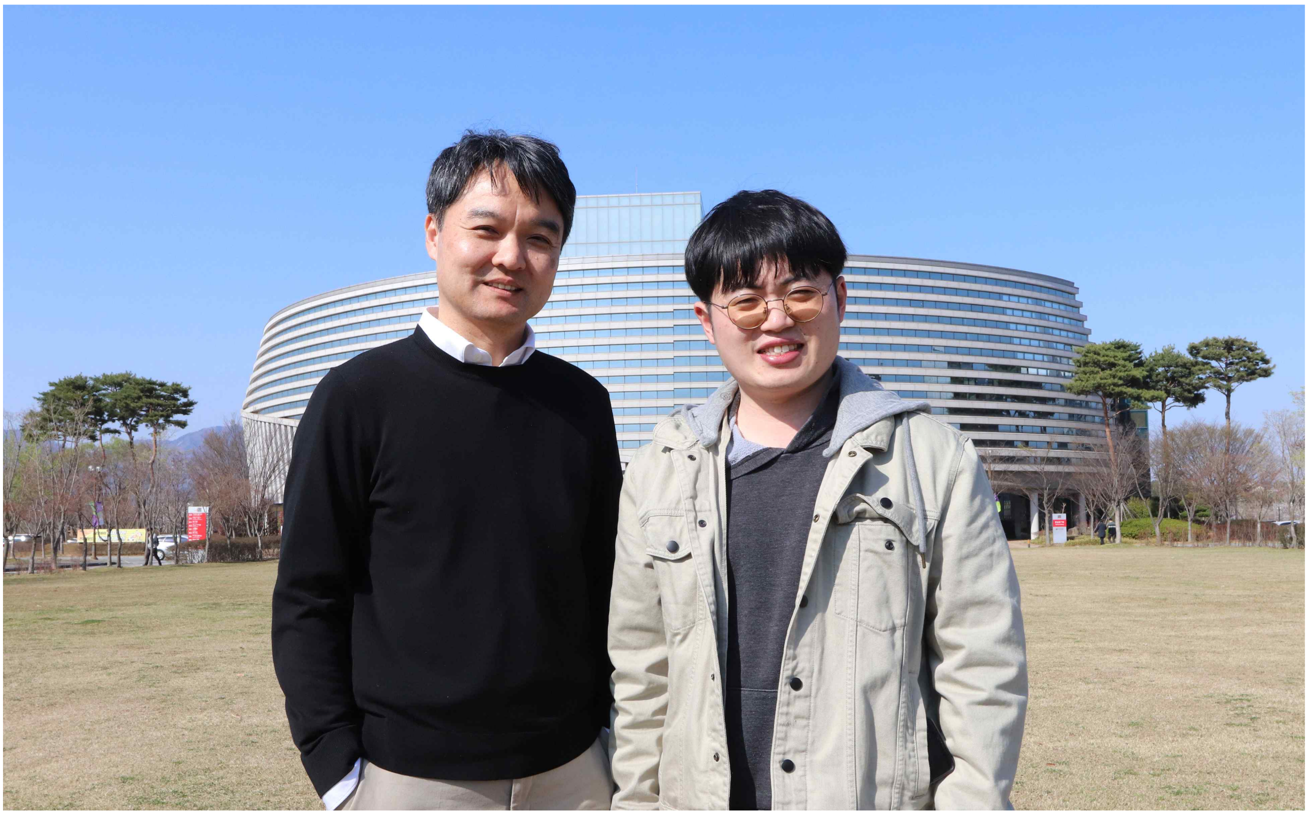
# Decreased crystallinity and increased conductivity 30 times! Development of new conductive polymer thermoelectric device

**- Breaking the conventional wisdom of increasing crystallinity... Lowering thermal conductivity by 60% and increasing thermoelectric properties by 6 times**



▲ (From left) GIST Department of Chemistry Professor Sukwon Hong and Ph.D. student Jinhwan Byeon

Thermoelectric devices that generate power using the Seebeck effect*, in which power is generated due to temperature differences, are attracting attention as cutting-edge energy devices because they can produce power from heat discarded by industries and the human body.

Since rare elements such as expensive bismuth (Bi), tellurium (Te), lanthanum (La), and antimony (Sb) are mainly used as materials for thermoelectric devices, carbon-based inexpensive conductive polymer thermoelectric devices that can replace them are attracting attention.

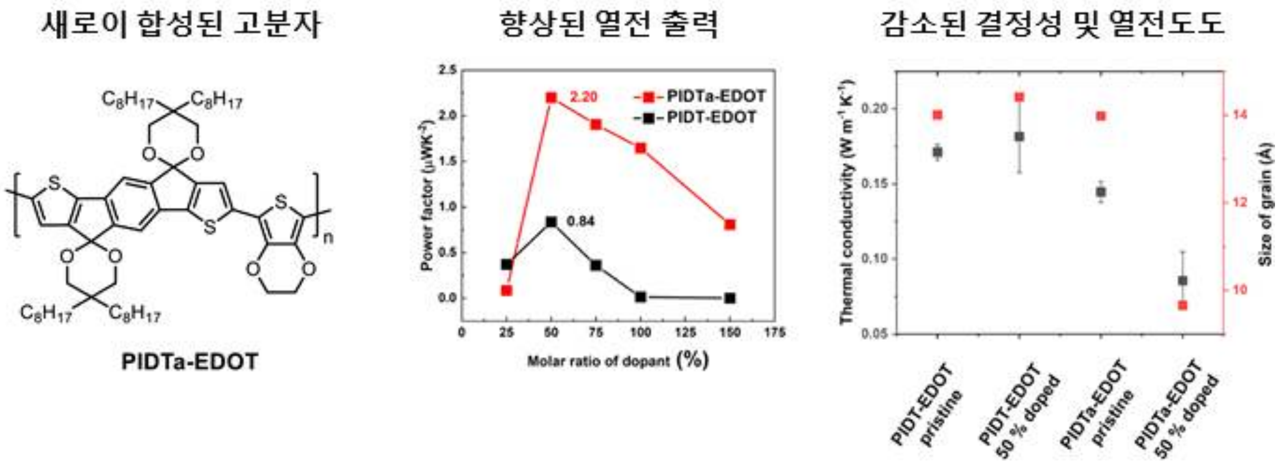
* Seebeck effect: An effect in which electric power is generated by moving electrons from a place with a higher temperature to a place with a lower temperature when a difference in temperature is given to two points in a material.

GIST (Gwangju Institute of Science and Technology, Acting President Raekil Park) Department of Chemistry Professor Sukwon Hong's research team developed a conductive polymer thermoelectric device that reduces thermal conductivity by lowering crystallinity and simultaneously increases electrical conductivity and thermoelectric characteristics, contrary to the direction of previous research.

The research team used a conductive polymer composed of a new type of molecule with an acetal functional group that can be doped through the formation of a Lewis acid-base complex*.

* Lewis acid-base complex: A complex formed when electrons move from a Lewis base, an electron donor, to a Lewis acid, an electron acceptor.

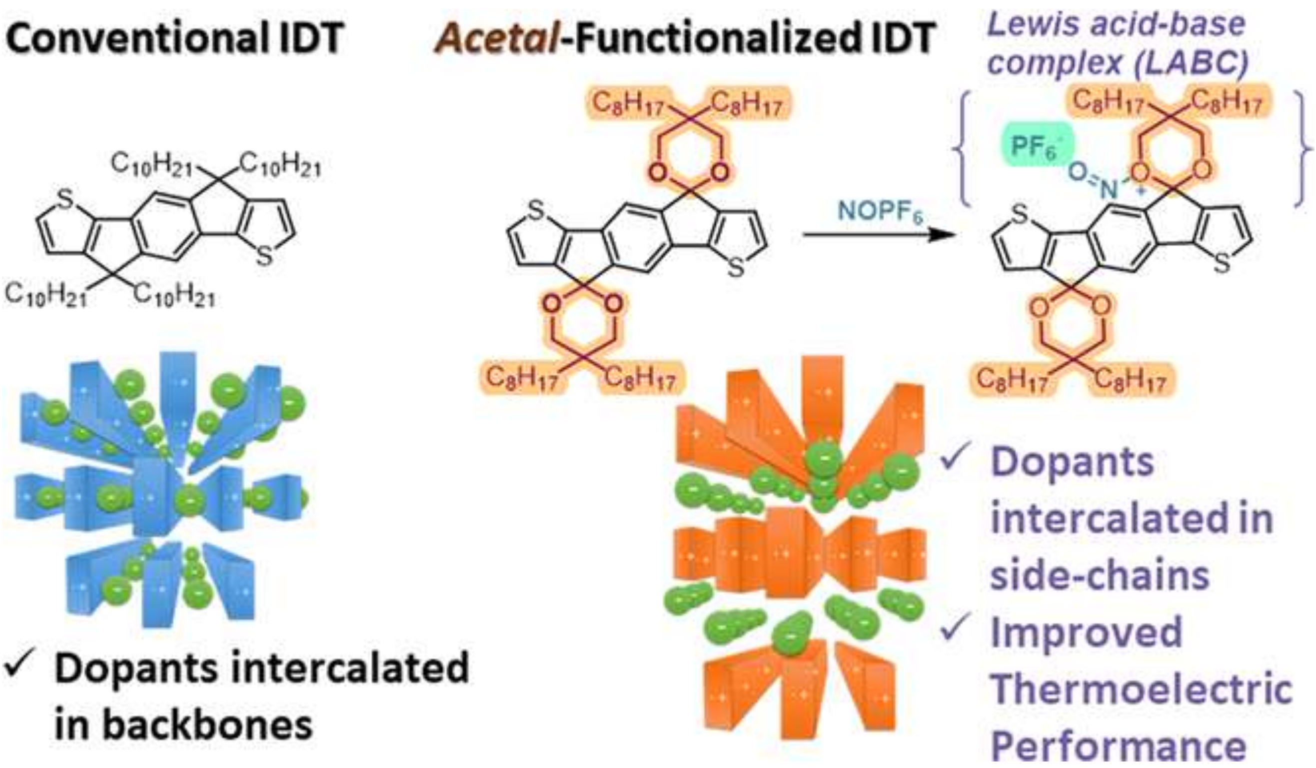
Existing research on conductive polymer thermoelectric devices has focused on improving conductivity and thermoelectric performance by inducing hard crystallinity such as metal materials. However, when the crystallinity is improved, the thermal conductivity also increases, resulting in a decrease in thermoelectric performance.




▲ A conductive polymer developed based on the above materials and confirmed improved thermoelectric power factor, reduced crystallinity and thermal conductivity.

The conductive polymer thermoelectric element developed by the research team has a 60% reduction in thermal conductivity compared to the previous one by lowering the crystallinity, despite the reduced crystallinity contrary to conventional wisdom. Due to improved pi-pi stacking*, it was possible to confirm a whopping 30 times higher conductivity and 6 times higher thermoelectric properties.

* pi-pi stacking: A structure formed by stacking aromatic compound skeletons of conjugated polymers facing each other.

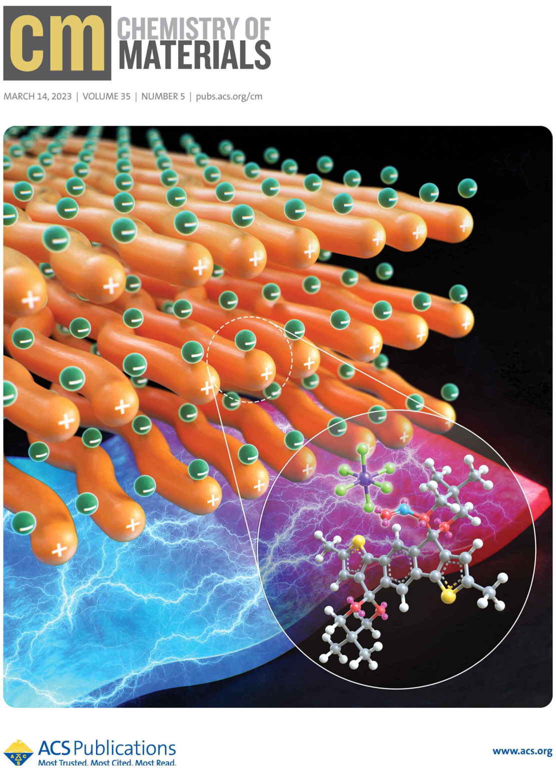


▲ A molecule that can be doped by forming a Lewis acid-base complex between acetal and Nitrosyl Hexaphosphate (NOPF6). Unlike conventional polymers, dopants are distributed on the side chains of polymers during doping, leading to improved pi-pi stacking.

This research result greatly improved the performance of inexpensive conductive polymer thermoelectric devices, raising the possibility of commercialization. In addition, it is expected to increase energy efficiency in society as a whole by recycling heat generated not only from high-tech devices such as electric vehicles, wearable devices, and robots, but also from industries such as factories and power plants.

Professor Sukwon Hong said, "In contrast to the previous research direction, a new research direction was proposed to increase the conductivity of conductive polymers by lowering the crystallinity. It is expected to greatly contribute to improving the performance and commercialization of conductive polymer thermoelectric devices."

This research was carried out as a climate change response project and a GIST Development Project supervised by the Next Generation Energy Research Institute with the support of the Ministry of Science and ICT. The results of the research were published online on March 2nd in the international journal ‘Chemistry of Materials’ and was selected for the cover article.



▲ Cover article

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