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Professor Eunji Lee's research team identifies the three-dimensional structure of polymer nanowires and photovoltaic layers that will improve the stability of organic solar cells

- GIST (President Seung Hyeon Moon) – A research team led by Professor Eunji Lee of the School of Materials Science and Engineering has developed a technique for improving the stability of organic solar cells by manufacturing conductive polymer nanowire into the photoactive layer. Transmission electron microscopy * confirmed that the stability is due to the photovoltaic layer.

* Transmission electron microscopy: a tomography technique for obtaining detailed 3D structures of sub-cellular macro-molecular objects

- Organic solar cells based on conductive polymer materials are attracting attention as next generation solar cells because they are lighter, more flexible, and cheaper to manufacture than conventional inorganic-based solar cells. However, despite the development of a high efficiency organic solar cell, its initial efficiency rapidly decreases when it is used under actual sunlight, which is a great obstacle to commercialization.

- The inherent metastable state and deterioration phenomenon of organic materials in contrast to inorganic materials are important issues to be considered in the development of organic solar cells. In particular, the physical and chemical deterioration of the photoactive layer due to light or oxygen permeation causes large aggregation of the material of the electron and the electron acceptor, thereby reducing the bonding interface between the two materials, which hinders electron transport and reduces efficiency. However, the morphological structure changes of the photoactive layer has not been understood due to lack of proper analytical tools.
 - The inherent metastable state and deterioration phenomenon of organic materials in contrast to inorganic materials are important issues to be considered in the development of organic solar cells. In particular, the physical and chemical deterioration of the photoactive layer due to light or oxygen permeation reduces the bonding between the two materials.
- The research team produced nanowires with a thickness of about 10 nm by inducing crystallization of poly(3-hexylthiophene) * conductive polymers in solution and manufacturing photoelectric thin films with heterogeneous joint structures by mixing them with derivatives. In order to maximize the photoelectric conversion efficiency without heat treatment or post-treatment using solvents, the phase separation of the electron donor and acceptor satisfying the exciton diffusion length was induced. The morphological structure and the change of efficiency according to light irradiation were confirmed by comparing them with normal blended photoactive layer thin films.

* Poly(3-hexylthiophene): the most investigated material in bulk heterojunction organic solar cells because it has a simple chemical structure, reasonable spectral absorption, good semiconducting properties, high chemical stability, and wide commercial availability

- In the case of normal blended photoactive layers, large phase separation of each material was observed after irradiation for 40 hours and showed a performance degradation of more than 40% compared with the initial efficiency. On the other hand, the

nanotube-based photoactive layer suppresses penetration by oxygen or water due to the strong bonds between the polymers inside the nanowire. Even after irradiation, the initial three-dimensional structure of the percolation pathway was maintained and the performance was only 15% lower than the initial efficiency. The correlation between the morphological structure of the photoactive layer and the degradation of the efficiency of the organic solar cell was quantitatively determined by three-dimensional electron tomography and computational simulation.

- Professor Eunji Lee said, "This research is significant because the analysis has identified the deterioration mechanism of the photovoltaic layer, which causes efficiency reduction, as well as how to improve stability by manufacturing conductive polymer nanowire into the photoactive layer of the organic solar. Based on this, we will reevaluate the long-term stability of existing high efficiency organic solar cell, improve them, and contribute to commercialization."

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