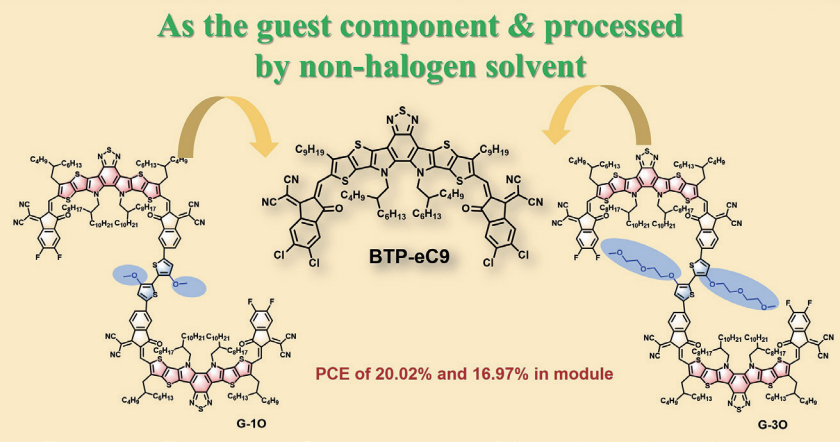
Novel Giant Acceptors Drive Eco-Friendly Organic Solar Cells Past 20% Efficiency

A research team led by Dr. GE Ziyi from the Ningbo Institute of Materials Technology and Engineering (NIMTE) of the Chinese Academy of Sciences has developed novel giant acceptors with an oxygenated linker, enabling the creation of highly efficient non-halogen-processed organic solar cells (OSCs), with a power conversion efficiency (PCE) up to 20.02%.

This study was published in *Advanced Materials* (doi: 10.1002/adma.202511584) on November 24, 2025.



The chemical structures of the designed guest component and BTP-eC9. (Image by NIMTE)

OSCs are distinguished by their lightweight nature, solution-processability, mechanical flexibility, and low-cost fabrication, making them a top candidate for next-generation photovoltaic technology. Conventional OSCs, however, rely on low-boiling-point halogenated solvents to achieve high efficiency. The high volatility of these solvents, though, poses a barrier to mass production. While alternative high-boiling-point non-halogenated solvents—such as toluene and o-xylene—are more suitable for scaling up production, they often lead to reduced efficiency due to inferior morphology.

To address this challenge, the research team used toluene (a less hazardous solvent) to design a simplified fabrication process, tailored for scalable organic photovoltaic production. They introduced two giant guest acceptors (oligomerized acceptors)—dubbed G-1O and G-3O, each with distinct oxygenated side chains—into PM6:BTP-eC9 blends. This modification extended the crystallization time of the blend, which suppressed excessive aggregation while promoting finer phase separation. These giant guest acceptors retain the advantages of Y-derivative acceptors, including precise molecular architectures, excellent photoelectric properties, and robust solution processability—all of which contribute to an optimized active layer morphology.

Compared to G-3O, whose longer oxygenated side chain induces uneven phase separation, the incorporation of G-1O—with its shorter side chain—improves molecular planarity, thus enabling a more homogeneous phase distribution. This, in turn, facilitates efficient charge transfer and mitigates voltage loss.

The ternary device based on G-1O achieved a PCE of 19.90%, outperforming the G-3O-based device, which only reached 17.90%. The team further enhanced the G-1O-based device's performance by applying a 100 nm anti-reflection coating (ARC) layer, pushing its PCE to 20.02%.

In addition, the researchers fabricated a 15.6 cm^2 large-area module using the PM6:BTP-eC9:G-1O system. This module exhibited a high PCE of 16.97% and contained no dead zones—findings that confirm the technology's scalability and eco-friendly processing advantages.

This work establishes a viable pathway for developing high-performance OSCs using non-halogenated solvents, underscoring their great potential for commercial photovoltaic applications.

(Source: NIMTE)

Copyright © 2025 by the Chinese Academy of Sciences and published by the journal *Bulletin of the Chinese Academy of Sciences*. This article is licensed and distributed under the Creative Commons Attribution-NonCommercial-NoDerivatives license 4.0 as given at https://creativecommons.org/licenses/by-nc-nd/4.0/.