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Controlling light emission improves organic solar cell performance

ICFO researchers have enhanced the performance of an organic solar cell by optimizing the fluorescence quantum yield (FQY), that is, by favoring light emission instead of heat dissipation after light absorption.
The study, published in ACS Energy Applied Materials, shows that FQY related to light emission inside the solar cell can be improved by engineering the interface between the light-absorbing and the charge-transporting layers, resulting in a measurable increase in the open-circuit voltage. This methodology is potentially applicable to other photovoltaic technologies.

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Organic solar cells (OSCs) use carbon-based materials instead of silicon to convert sunlight into electricity. Their flexibility, semi-transparency, and low-cost manufacturing make them attractive for applications such as wearables, smart windows, and building-integrated photovoltaics. But OSCs face a significant efficiency bottleneck due to large losses in **open-circuit voltage (Voc)**, the electrical potential difference between the two terminals of solar cells.

A team of ICFO researchers and members of the SOREC2 project, **Dr. Francisco Bernal-Texca**, **Chiara Cortese**, and **Dr. Mariia Kramarenko**, led by **UPC and ICFO Prof. Jordi Martorell**, have recently proposed a new strategy to significantly enhance the Voc. The team has addressed the **fluorescence quantum yield (FQY)**, a largely unexplored determinant of Voc, which the study, published in ACS Energy Applied Materials, demonstrates to be critical.

When a solar cell absorbs light, the energy of some electrons increases, that is, they become excited. The FQY reflects how efficiently the electrons' extra energy is re-emitted as light rather than lost as heat, which often occurs due to chemical defects at material interfaces. ICFO researchers have now demonstrated that **optimizing FQY can significantly increase the Voc;** its effects, contrary to traditional believe, are not negligible.

ï¿½A higher FQY indicates that the defect-pathways to heat have been reduced, allowing a much higher density of charge carriers to accumulate,ï¿½ explains Dr. Franc sco Bernal-Texca, first author of the article. ï¿½Since the electrical potential increases s the carrier concentration grows, improving the FQY directly increases the Voc, moving the

device closer to its maximum theoretical limit,ï¿½ he add
. To reach this conclusion, the team fabricated a fully operational solar cell rather than ju
t testing individual organic ingredients, and showed that the FQY is ten times higher in t
e former. They then applied an ultrathin (5 nm) lithium fluoride (LiF) layer on top of the electr
n transport layer made of ZnO, which further enhanced the FQY by 18%, leading to **Voc gain as large as 12 millivolts**. Spectroscopic analysis revealed that **LiF acts as a protective sealant that passivates chemical defects**, preventing electrons from being caught in trapping states and wasted as heat. Finally, the researchers developed a theoretical model that correlates the increase in Voc to the rise in FQY, agreeing with the experimental data.
According to Prof. Jordi Martorell, lead researcher of the study: ï¿½**The presented methodology has the potential to be applied to any type of solar cell and opens a door to surpassing the established limits of solar energy conversion.**ï¿½ For now, it has alrea
y revealed that even small improvements in light emission can have a measurable impact
n the overall voltag

Reference:

Francisco Bernal-Texca, Chiara Cortese, Mariia Kramarenko, and Jordi Martorell, Nongeminate Radiative Recombination and Voc in Organic Solar Cells Enhanced by a Charge Transporter/Absorber Interface Change, ACS Applied Energy Materials **2025** 8 (24), 17863-17870
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Scheme showing the process followed to build the final solar cell, which consists of stacking six organic layers. Credit: Francisco Bernal-Texca.

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Artistic image of the resulting solar cell with its six layers. Credit: Francisco Bernal-Texca.