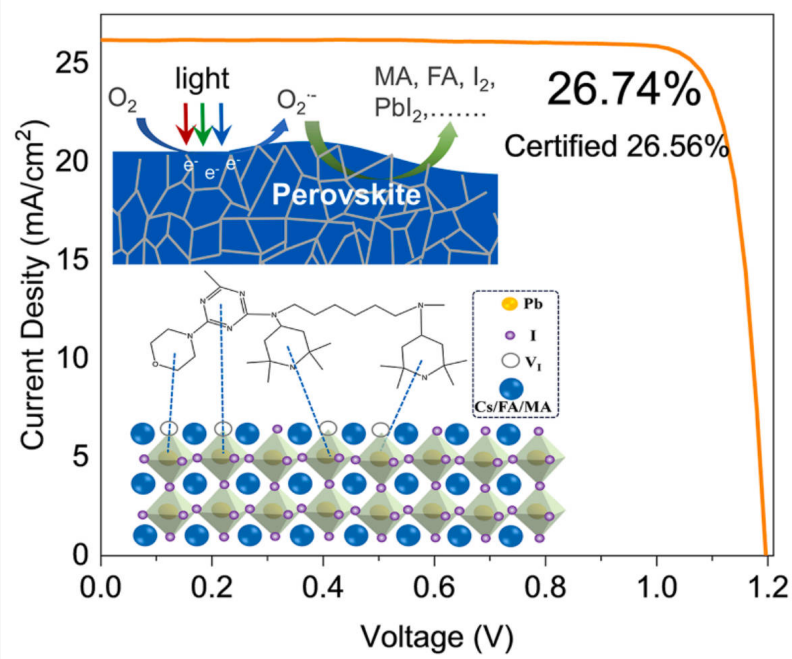
# A molecular shield against light: Stabilizing perovskite solar cells at record efficiency

GA, UNITED STATES, February 3, 2026 /EINPresswire.com/ -- Perovskite solar cells have reached power conversion efficiencies comparable to established photovoltaic technologies, yet their vulnerability to light-induced degradation continues to hinder practical deployment. This study introduces a chemical stabilization strategy that suppresses the radical reactions responsible for photo-driven decomposition in perovskite materials. By integrating a multifunctional hindered amine into the perovskite layer, the approach simultaneously scavenges reactive oxygen species and passivates electronic defects. As a result, the solar cells achieve both exceptionally high efficiency and markedly improved operational durability under illumination. The work demonstrates that controlling light-activated chemical pathways at the molecular level can reconcile efficiency and stability—two long-standing, competing challenges in perovskite photovoltaics.



Hindered amine stabilization suppresses light-induced degradation while enabling record-efficiency perovskite solar cells.

Metal-halide perovskite solar cells are attractive for next-generation photovoltaics due to their low fabrication cost and rapidly rising efficiencies. However, exposure to light and oxygen generates superoxide radicals that attack organic cations and disrupt the perovskite lattice, leading to rapid performance loss. While encapsulation and optical filtering can mitigate environmental damage, they do not address degradation originating inside the perovskite crystal or at defect-rich interfaces. Moreover, trap states at grain boundaries often accelerate radical formation and non-radiative recombination. Based on these challenges, there is a pressing need to develop strategies that directly suppress light-induced chemical degradation while simultaneously reducing defect density within perovskite films.

Researchers from Hebei University of Technology, Kunming University of Science and Technology, Macau University of Science and Technology, and Chimie ParisTech report a new stabilization approach for perovskite solar cells in eScience, published (DOI: 10.1016/j.esci.2025.100451) in January 2026. The team demonstrates that incorporating a hindered amine light stabilizer into inverted perovskite solar cells effectively blocks photo-induced decomposition pathways. The resulting devices deliver a certified power conversion efficiency above 26% while maintaining performance under prolonged light exposure, offering a promising route toward durable, high-performance perovskite photovoltaics.

The proposed hindered amine stabilization strategy operates through a dual mechanism. Under illumination, the hindered amine absorbs light energy and forms nitroxyl radicals that catalytically neutralize superoxide species generated within the perovskite layer. By removing these highly reactive radicals before they can attack organic cations or Pb–I bonds, the strategy suppresses the primary chemical trigger of light-induced degradation. Importantly, the radical-scavenging process is regenerative, allowing continuous protection during device operation.

In parallel, functional groups within the hindered amine molecule coordinate with under-coordinated lead ions and iodine vacancies at grain boundaries and surfaces. This chemical interaction passivates electronic trap states, enlarges perovskite grain size, smooths film morphology, and reduces non-radiative recombination. Spectroscopic and electrical analyses confirm lower trap densities, longer carrier lifetimes, and improved energy-level alignment at device interfaces.

Together, these effects enable inverted perovskite solar cells fabricated under ambient conditions to reach a champion efficiency of 26.74%. Unencapsulated devices retain over 95% of their initial efficiency after more than 1,000 hours of continuous light aging, demonstrating a rare combination of record efficiency and operational stability.

“This work shows that light instability in perovskite solar cells is not an unavoidable materials problem, but a chemically addressable one,” the researchers note. By targeting both reactive radicals and interfacial defects, the hindered amine approach offers a unified solution rather than a collection of incremental fixes. The authors emphasize that the strategy is compatible with existing device architectures and scalable fabrication methods, making it particularly relevant for translating laboratory advances into commercially viable photovoltaic technologies.

The demonstrated stabilization strategy could significantly accelerate the commercialization of perovskite solar cells, especially for applications requiring long-term exposure to sunlight, such as building-integrated photovoltaics and tandem solar modules. Beyond perovskites, the concept of combining radical scavenging with defect passivation may be applicable to other light-sensitive optoelectronic materials. By reframing stability as a controllable chemical process rather than a structural limitation, this work opens new pathways for designing durable, high-efficiency solar technologies that bridge the gap between laboratory performance and real-world deployment.

DOI
10.1016/j.esci.2025.100451

Original Source URL
https://doi.org/10.1016/j.esci.2025.100451

Funding information
This work was supported by the Science and Technology Development Fund, Macau SAR (No. 0009/2022/AGJ). The National Natural Science Foundation of China (52462031, U21A2076, 62274018). The S&T Program of Hebei (24464401D). The Natural Science Foundation of Hebei Province (E2024202086, E2024202300). The Central Guidance on Local Science and Technology Development Fund of Hebei Province (226Z4305G). Hebei Province Higher Education Science and Technology Research Project (JZX2024030). Shijiazhuang Basic Research Project at Hebei-based Universities (241790847A).

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