Área: MAT
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Development of downshifting filters based on Eu^{3+} complexes: Enhancing photon absorption and UV-stability of perovskite solar cells

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Highlights

A downshifting filter composed of Eu^{3+} complex with β-diketone in a PMMA polymer matrix converts UV light into visible light, promoting a power conversion efficiency (PCE) enhancement up to 2% in perovskite solar cells (PSCs).

Resumo/Abstract

PSCs have emerged as promising alternatives due to their high efficiency and low production costs. Their large-scale commercial implementation will significantly contribute to the energy transition and to the establishment of a low-carbon economy. The crystalline structure of perovskite follows the ABX_3 formula, where usually: X represents anions (Cl^-, Br^-, or I^-); B corresponds to the Pb^{2+} cation; and A is a monovalent cation, such as Cs^+, or an organic cation of similar size (**Figure 1**). Despite their potential, these devices face critical challenges, including instability under humidity, oxygen, and ultraviolet (UV) radiation, factors that induce degradation and lead to efficiency loss. [1] An energetically favorable strategy to mitigate these issues involves incorporating downshifting optical filters (DSF) in PSCs, which convert UV photons into visible light rather than simply blocking it. The DSF absorbs high-energy UV photons and emits lower-energy visible photons,[2] compatible with PSCs optimal absorption range. This mechanism is particularly advantageous, as PSCs exhibit a wide bandgap, predominantly absorbing visible light, whose energy does not degrade the material as fast as the UV radiation. The DSF developed in this work consists of the $[Eu(hfa)_3(tppo)_2]$ complex dispersed in a polymeric matrix of poly(methyl methacrylate) (PMMA), where $[Eu(hfa)_3(tppo)_2]$ is responsible for the rate reduction conversion. The single-crystal structure of the complex reveals a distorted square antiprism geometry (D_{4d}), as shown in **Figure 2A and B**. The hexafluoroacetylacetone (hfa) and triphenylphosphine oxide (tppo) ligands act as sensitizers for the Eu^{3+} ion, optimizing emission in the $^5D_0 \rightarrow {}^7F_2$ band, with a maximum at 617 nm, as observed in the spectrum in **Figure 2C**. Application of DSF to PSCs fabricated resulted in an PCE enhancement ranging from 0.3% to 2%, depending on filter homogeneity (absence of optical defects, such as microvoids). The current-density of the devices followed the same improvement trend. Future studies will focus on evaluating the operational stability of the devices, as UV protection provided by the DSF may extend their lifespan.

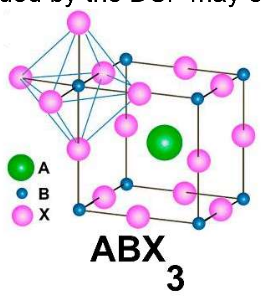

Figure 01: Perovskite Structure.

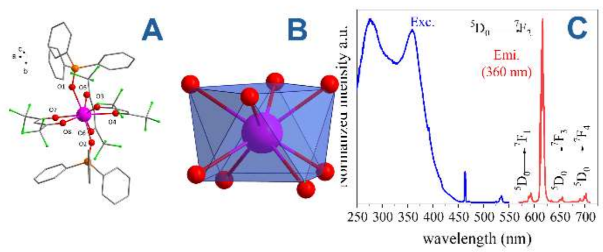

Figure 02: Crystal structure of the $[Eu(hfa)_3(tppo)_2]$ complex (A); geometry of the complex (B); Excitation spectrum in blue, emission spectrum in red (C).

References:
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