Stabilizing Halide Perovskites In Polar Electrolytes for Photoelectrochemical Solar Fuel Production and CO_2 Capture

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Halide perovskite (HaP) solar cells, known for their high voltage efficiency (>70%) and a conduction band minimum with low electron affinity, hold significant potential as photocathodes for cost-effective solar fuel generation. However, their instability in aqueous environments, where they readily dissolve, poses a formidable challenge. To mitigate this, ultrathin Al_2O_3 layers (< 10 nm), applied via atomic layer deposition, serve as protective barriers against water penetration, albeit with the drawback of electronic insulation. To facilitate selective electron transport through these insulating encapsulation layers, linear conjugated organic molecules, termed "molecular relays," are incorporated. The electronic properties of these molecular relays are verified through conductive probe atomic force microscopy, energy level alignment analysis, and photo-electrodeposition of metal particles (Pt and Ag) from ethanolic solutions. Furthermore, a feasibility study of utilizing this composite structure for CO_2 capture was conducted, leveraging the unique characteristics of bromide perovskite-based photoelectrodes. Encapsulated HaP photoelectrodes, when immersed in CO_2-saturated aqueous electrolytes, demonstrated a photocurrent of approximately 100 $\mu A/cm^2$ at around -0.32 V versus Ag/AgCl. This work presents a robust approach to enhance the stability of HaP materials in polar, protonic electrolytes, paving the way for their application as photoelectrodes in solar fuel production and CO_2 capture systems.