Fluorosilane Facilitates Highly-Efficient and More Stable Perovskite Solar Cells

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Abstract: Solution-processed organic-inorganic hybrid perovskite solar cells (PSCs) have exhibited excellent photovoltaic efficiency comparable to that of conventional silicon solar cells. Nevertheless, further research is still needed to tackle their non-negligible inferior long-term stability in particular when exposed to various environmental factors (e.g., moisture, oxygen, illumination, and ultraviolet (UV) radiation). To address the moisture-induced degradation issue, in this work, we investigate the possibility to design a superhydrophobic surface for perovskite thin films. Specifically, three different fluorosilanes are utilized to modify the perovskite film surface through vapor-assisted self-assembled process. The fluorosilane-decorated perovskite films exhibit outstanding tolerance to water with a water contact angle >110°, which is significantly larger than the water contact angle measured on the control sample without fluorosilane (< 90°). Furthermore, in comparison to the control sample, the decorated devices show higher power conversion efficiency reaching a PCE ≥ 22% and enhanced stability. Under identical degradation conditions, the optimized decorated perovskite solar cells exhibited only ~ 4% of PCE drop from its initial PCE after 100 hours storage in ambient humid air, while the control devices exhibited a significant PCE drop of 19%.

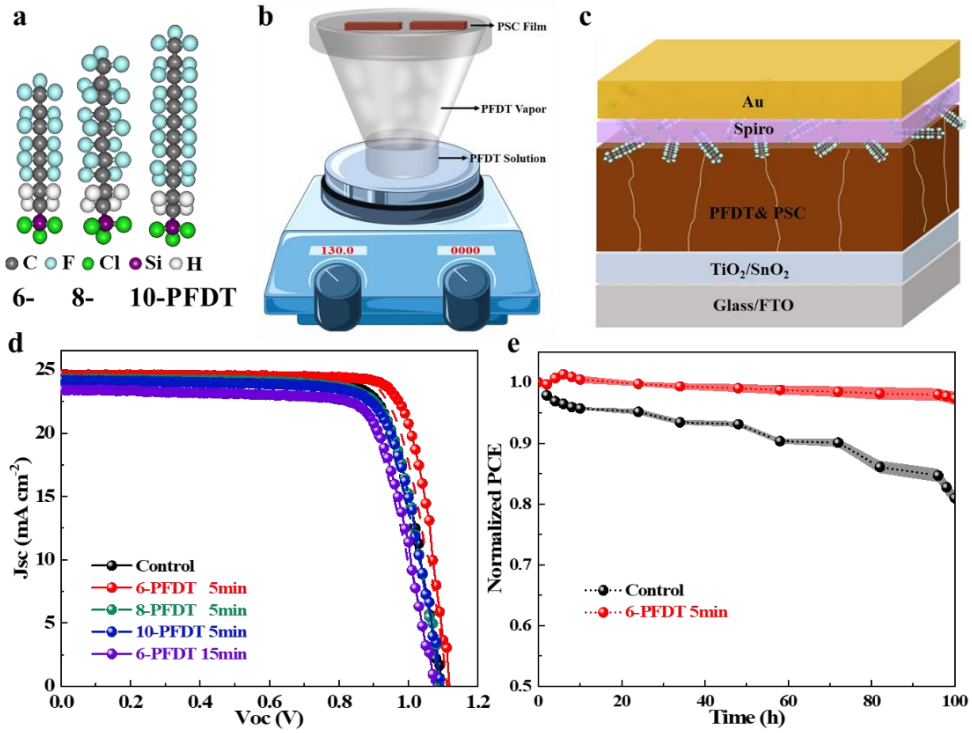

Figure 1. (a) Molecular structure of the three fluorosilanes (below termed as PFDT) with different perfluorocarbon chains. (b) schematic diagram of vapor assisted self-assembled process. (c) Schematic *n-i-p* device structure of PFDT-modified PSCs adopted in this work. (d) The *J-V* characteristics comparing solar cells without (control condition) and with different types of PFDT and different duration of PFDT vapor-treatment. *J-V* curves were measured in an Ar glovebox under simulated AM1.5G solar illumination operated at 1-sun (100 mW cm^{-2}). (e) The solar cells' PCE evolution measured on fluorosilane-decorated and non-decorated (control) devices storaged under ambient condition (~25°C, HR~40%).