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Hybrid TiO_2-TiAcAc/SnO_2 Electron Transporting Layer Enable High V_{OC} in Carbon-based Perovskite Solar Cells

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Abstract

Carbon-based perovskite solar cells (C-PSCs) are attracting considerable attention in the field of photovoltaic technology due to their potential for cost-effective production and exceptional long-term stability. However, a key barrier to their growth is the limited power conversion efficiency (PCE). This study demonstrates an approach to improve the PCE of C-PSCs by introducing a hybrid TiO_2+TiAcAc/SnO_2 electron transporting layer through a low-temperature process (≤150°C). The technique involves incorporating titanium diisopropoxide bis(acetylacetonate) (TiAcAc) into TiO_2 and modifying the interface between the electron transporting layer (ETL) and perovskite by using an ultrathin SnO_2 film. The addition of TiAcAc effectively closes the voids among the TiO_2 nanoparticles, resulting in a more compact TiO_2 coating. Consequently, the inclusion of TiAcAc in TiO_2 leads to an augmentation of the open circuit voltage (V_{OC}) to 1.10V. Moreover, an ultrathin SnO_2 film is applied to passivate the interface between TiO_2+TiAcAc and the perovskite layers. This results in an increased fill factor (FF) by reducing interface defects. Therefore, the device with an active area of 0.09 cm^2, utilizing a TiO_2+TiAcAc/SnO_2 ETL and fabricated under ambient conditions with a relative humidity of 35%RH, achieves a maximum PCE of 16.00%, with an open-circuit voltage (V_{OC}) of 1.09V, a short-circuit current density (J_{SC}) of 20.34 mA cm^{-2}, and a fill factor (FF) of 72.00%. It is expected that this work will offer an effective approach to raise the photovoltaic performance of the C-PSCs.

Keywords

Carbon-based Perovskite Solar Cells, Electron Transporting Layer, Tio_2, TiAcAc, SnO_2