Effect of Hole Transporting Materials on the Performance of Perovskite Solar Cells in Air

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Abstract

Perovskite solar cell (PSC) has been intensively studied for improving the efficiency and stability for the past few years. Various Hole Transporting Materials (HTMs) have been reported in optimizing the performance of the PSC and the best efficiencies have been obtained using 2,2',7,7'-tetrakis (N,N'-di-p-methoxyphenylamine)-9,9'-spirobifluorene (Spiro-OMeTAD) as HTMs. However, Spiro-OMeTAD has several challenges related to cost, stability, handling and poor carrier mobility. In order to overcome these challenges, this study focuses on employing various organic / inorganic HTMs such as Spiro-OMeTAD, Poly -3-hexylthiophene (P3HT), Copper (I) iodide (CuI) and Poly(ethylenedioxythiophene):polystyrene sulphonate (PEDOT:PSS) in fabricating organic-inorganic hybrid PSC in air. A comparison study on several TiO_2 / $CH_3NH_3PbI_xCl_{3-x}$ / HTMs / Au PSCs with the above HTMs such as Spiro-OMeTAD, P3HT, CuI, PEDOT:PSS were carried out. The best efficiency of 8 % was obtained with CuI as HTM under Air Mass (AM) 1.5 conditions (100 mW cm^{-2}, 1 sun) in air separately. Here a novel pressing method was employed for incorporating CuI. An efficiency of 4.6 % was achieved with P3HT as HTM, whereas with Spiro-OMeTAD, the best efficiency of 5.6 % was achieved by doping Spiro-OMeTAD with lithium-bis-trifluoromethanesulfonyl-imide (LiTFSI) and tert-butylpyridine (TBP) under Air Mass (AM) 1.5 conditions (100 $mWcm^{-2}$, 1 sun) in air. Better efficiency achieved with CuI may be due to the novel method used for preparation, that leads to the efficient hole transport that minimizes the electron-hole recombination. In contrast, stability of P3HT based PSCs was observed to be superior than Spiro-OMeTAD based solar cells in air. PSCs with P3HT as HTM were air stable even after one month.

Keywords: Perovskie solar cells, Hole transporting materials, Pressing method, Copper (I) iodide, Spiro-OMeTAD, P3HT, Airstable