Abstract

In this work, the effects of inorganic metal oxides nanoparticles in the active layer of normal and inverted architecture based hybrid organic solar cells (OSCs) with improved power conversion efficiency (PCE) were studied. The active layers primarily consist of poly (3-hexylthiophene-P3HT, [6,6]-phenyl-C60-butyric acid methyl ester-PCBM mixed with zinc oxide (ZnO), titanium dioxide (TiO_2) nanoparticles (NPs) individually and combined. A systematic replacement of PCBM was realized by introducing metal oxides nanoparticles ZnO and TiO_2 individually and combined, while maintaining a fixed amount of P3HT. The effect was investigated in various solvents, specifically chlorobenzene (CB), 1,2-dichlorobenzene (DCB) and xylene (X). The introduction of metal oxides nanoparticles was found to significantly increase the PCE of the devices. To understand the effects of metal oxides nanoparticles, various techniques such as electrical characteristics (J-V) under air mass (A.M) 1.5G with 100 mW/cm^2 illumination intensity, external quantum efficiency (EQE), field emission microscopy (FESEM), transmission electron microscopy (TEM), atomic force microscopy (AFM), ultraviolet-visible (UV-Vis) spectrophotometry, charge extraction by linearly increasing voltage (CELIV) and X-Ray diffraction were employed. A significant increase in charge mobility and EQE were observed for devices with metal oxides nanoparticles in the photoactive layer. Mixing of metal oxides NPs mostly introduced the red shift and increased the absorption in the visible region. The addition of metal oxides nanoparticles was also found to increase the film roughness of the active layer. The nanoparticles agglomerated as their ratio relative to PCBM increased and completely agglomerated with no fullerene derivative. The stability of inverted devices was much higher than normal devices.