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ARTICLE

Supporting Information

Improving TiO_2 Electron Transport Layer in Perovskite Solar Cell by Acetylacetonate-based Additives

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Author Contributions
+H. Wang and Q. Chen contributed equally to this work.
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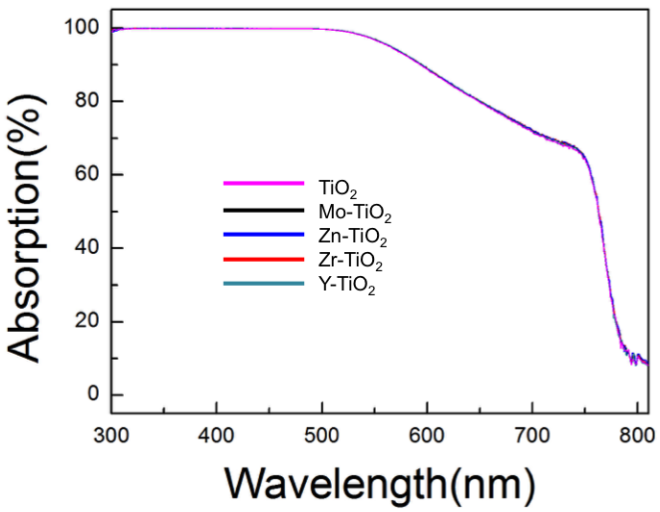

Figure S1 Absorption spectra of the perovskite absorber layer on modified TiO_2 ETLs by various additives.

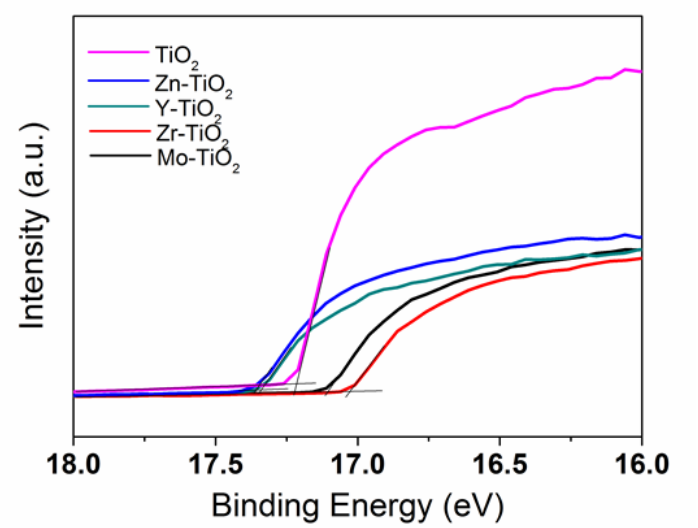

Figure S2 Photoemission cutoff obtained via UPS for TiO_2 with and without additives, and the obtained Fermi level for ETL materials are: TiO_2 (4.0 eV), to Zn-TiO_2 (3.85 eV), Y-TiO_2 (3.9 eV), Zr-TiO_2 (4.18 eV) and Mo-TiO_2 (4.1 eV) respectively.

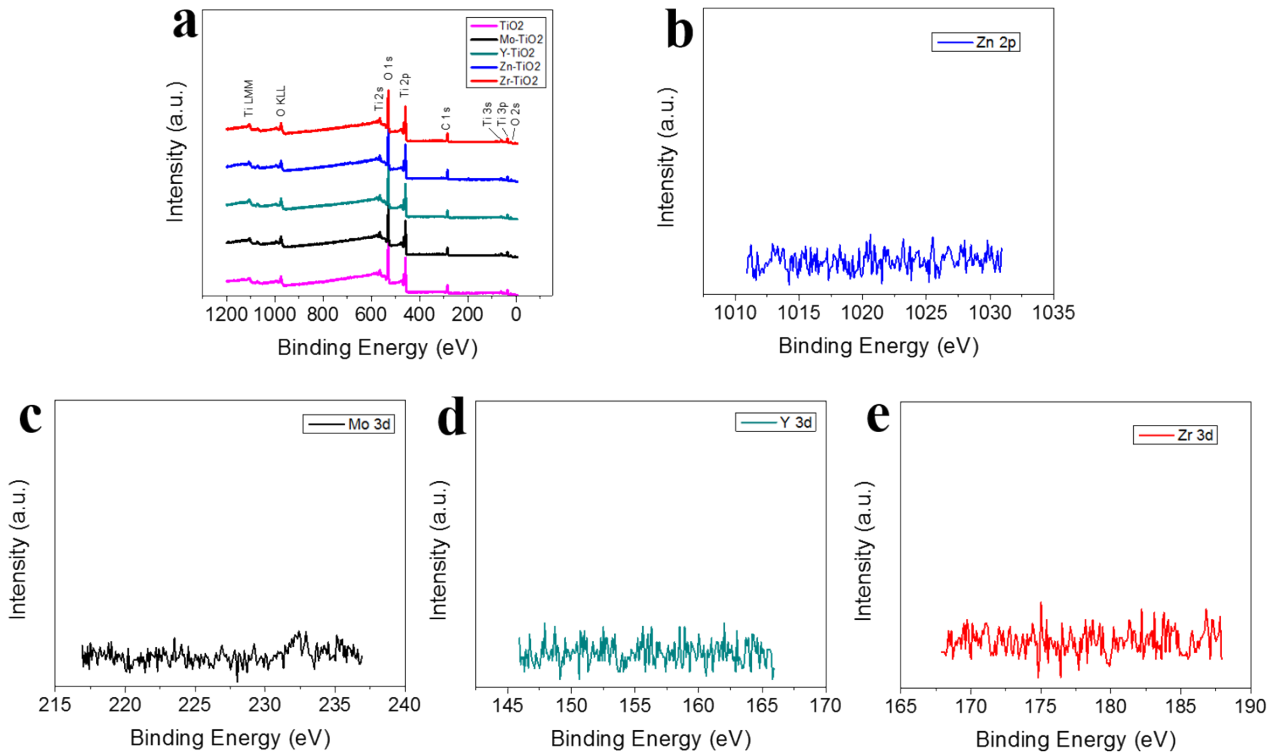

Figure S3 XPS analysis for TiO_2 with and without additives, a) the survey spectra of all the electron transport materials; b) a detailed scan of Zn 2p for Zn-TiO_2 film; c) a detailed scan of Mo 3d for Mo-TiO_2 film; d) a detailed scan of Y 3d for Y-TiO_2 film; e) a detailed scan of Zr 3d for Zr-TiO_2 film. The absence of the signal from the additives indicates a low incorporation concentration.

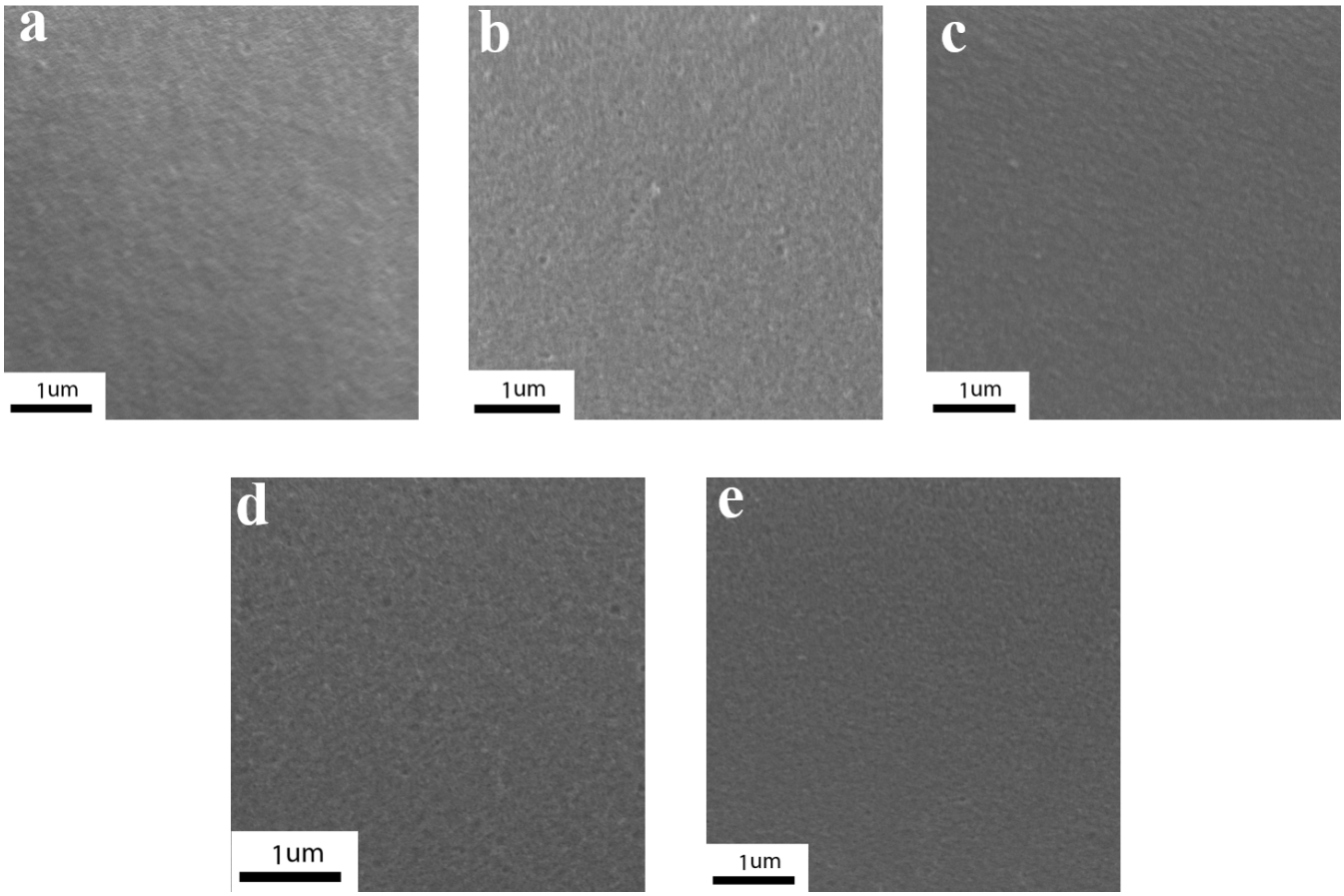

Figure S4 SEM images of TiO_2 with and without additives, a) TiO_2 film; b) Zn-TiO_2 film; c) Y-TiO_2 film; d) Zr-TiO_2 film; and e) Mo-TiO_2 film. Different electron transport materials exhibit similar morphology in terms of the film conformity and grain size.

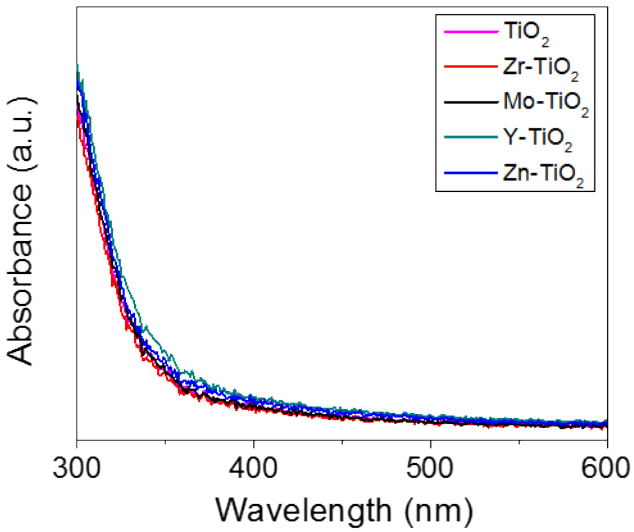

Figure S5 UV-Vis absorption of TiO_2 with and without additives. All the electron transport materials exhibit similar bandgaps around 3.6 eV.

Table S1: The hysteresis study of the devices based on TiO_2 electron transport materials with and without additives.

Sample	Voc (V)	Jsc (mA/cm^2)	PCE (%)	FF (%)
Reference	1.047	20.30	16.39	77.15
Standard	1.048	20.54	16.59	77.06
Standard (rev)	1.027	20.51	15.46	73.38
Y-TiO_2	1.017	20.29	15.46	74.91
Y-TiO_2(rev)	1.007	19.52	14.66	74.59
Mo-TiO_2	0.995	20.12	15.21	76.01
Mo-TiO_2(rev)	0.955	20.30	13.85	71.41
Zr-TiO_2	1.041	19.83	15.69	76.03
Zr-TiO_2(rev)	1.024	19.66	14.78	73.40
Zn-TiO_2	1.046	19.84	15.91	76.67
Zn-TiO_2(rev)	1.027	19.40	14.86	74.58

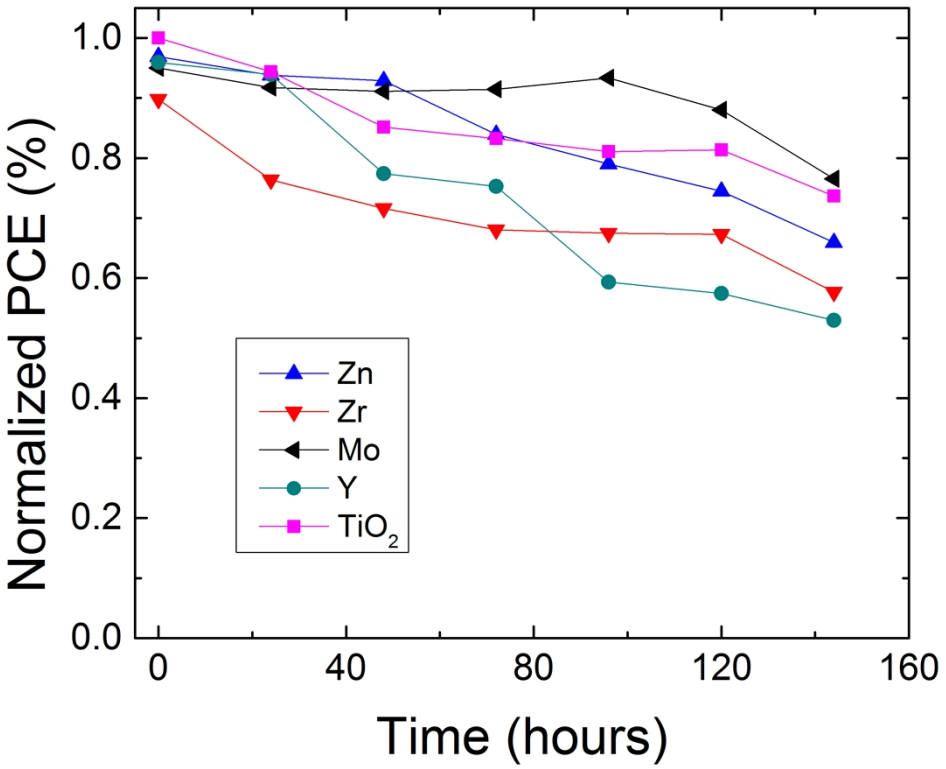

Figure S6 Stability study of devices based on TiO_2 with and without additives. The stability of perovskite solar cells shows a random trend, where the devices based on Mo-TiO_2 exhibit improved stability, while others show a decreased stability when compared to standard devices. Further studies on underlying degradation mechanisms is under investigation.