Supplementary information

**Stable perovskite solar cells using tin acetylacetonate based electron transporting layers**

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**Fig. S1. EDXS-STEM analysis.** HAADF scanning TEM images and corresponding elemental mapping of Sn, O, Cl and Br of the tin oxide films deposited on a carbon support grid.
Fig. S2. HR-TEM images of Acac, Cl$_2$ and Br$_2$ annealed at 180 °C.
Fig. S3. SEM cross-sectional images for the complete cells. The thickness of the ETL layer is higher for Cl$_2$/Perovskite and Br$_2$/perovskite than Acac/perovskite and c-TiO$_2$/perovskite.
Fig. S4. Absorbance (a) and XRD patterns (b) of the perovskite film on the FTO/ETLs.
Fig. S5. Top-view SEM images of the perovskite films formed on c-TiO$_2$, Acac, Cl$_2$ and Br$_2$ films, respectively.
Fig. S6. Top-view images SEM of c-TiO$_2$, Acac, Cl$_2$ and Br$_2$ on FTO, respectively, taken at a small area. Films are annealed at 180 °C 1 h.
Fig. S7. Top-view SEM images of Acac, Cl₂ and Br₂ films on FTO/c-TiO₂ substrates (left), and perovskite top-surface images on each ETL. An Acac solution in DMF turns into a turbid solution in a few hours while solutions show no color or transparency change.
Fig. S8. Typical $J-V$ curves of perovskite solar cells with c-TiO$_2$/Br$_2$ electron transporting layers prepared at 160 °C.
Fig. S9. pH test of the colloidal SnO$_2$ 15% in water (AlfaAesar). The result indicates the colloidal solution is in a highly basic condition with pH=11~12.
Fig. S10. A J-V curve of the planar-type perovskite mini-module.
Fig. S11. External quantum efficiency (EQE) of the champion cell.
Fig. S12. SEM top-view images of the perovskite films with one-step (a) and two-step method (b).
Fig. S13. Long-term stability of the champion cell.

Storage condition:
- RH: ~30%
- Without encapsulation
- In the dark
Fig. S14. A certificate of the solar cell measured at the Newport.
Fig. S15. Box plot for device PCE for Cl₂, Br₂ and m-TiO₂ BETL configurations.