Electronic Supplementary Material (ESI) for Physical Chemistry Chemical Physics.

Supporting information

Effects of $TiCl_4$ Treatment on Structural and Electrochemical Properties of a Porous TiO_2 Layer in $CH_3NH_3PbI_3$ Perovskite Solar Cells

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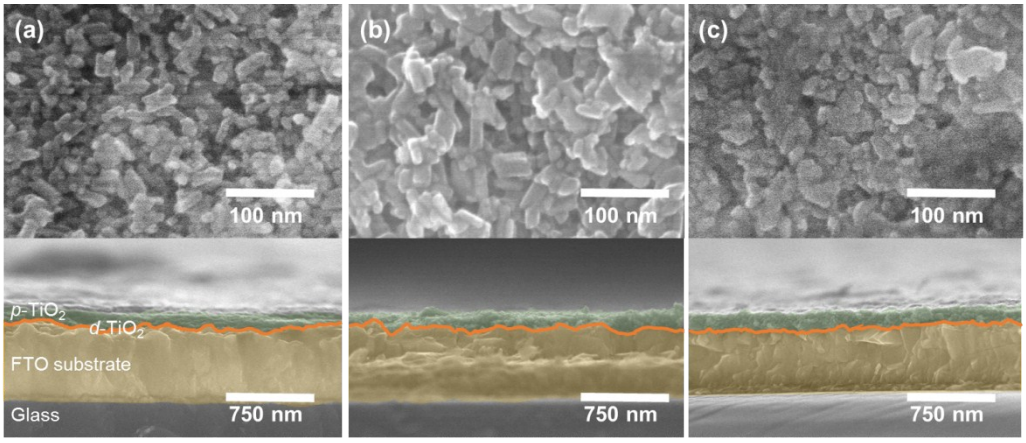

Figure S1. FE-SEM images of the surface morphology and cross section of (a) pTiO$_2$(0), (b) pTiO$_2$(50) and (c) pTiO$_2$(100), respectively. SEM images were recorded at an acceleration voltage of 20 kV.

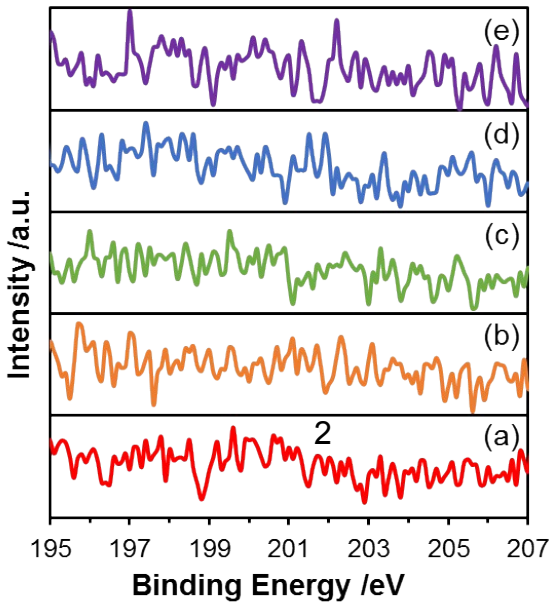

Figure S2. Cl 2p XPS of (a) pTiO$_2$(0), (b) pTiO$_2$(20), (c) pTiO$_2$(50), (d) pTiO$_2$(80) and (e) pTiO$_2$(100).

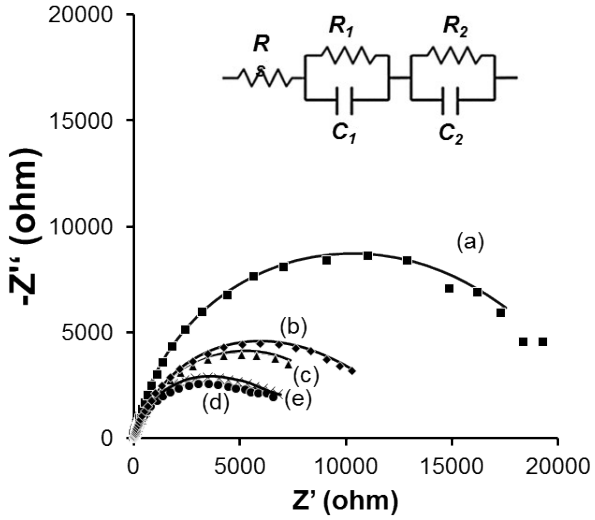

Figure S3 Nyquist plots of EIS measurements under 100 mW cm^{-2} illumination patterns of (a) pTiO$_2$(0), (b) pTiO$_2$(20), (c) pTiO$_2$(50), (d) pTiO$_2$(80) and (e) pTiO$_2$(100). Inset shows the equivalent circuit model employed for fitting the Nyquist plot. Rs (ohmic series resistance), R_1 (charge transfer resistance of counter/electrolyte interface), C_1 (capacitance of counter/electrolyte interface), R_2 (charge transfer resistance of pTiO$_2$/electrolyte interface) and C_2 (capacitance of of pTiO$_2$/electrolyte interface). For the analyses, constant phase elements were used instead of ideal capacitance in order to improve the quality of fittings.

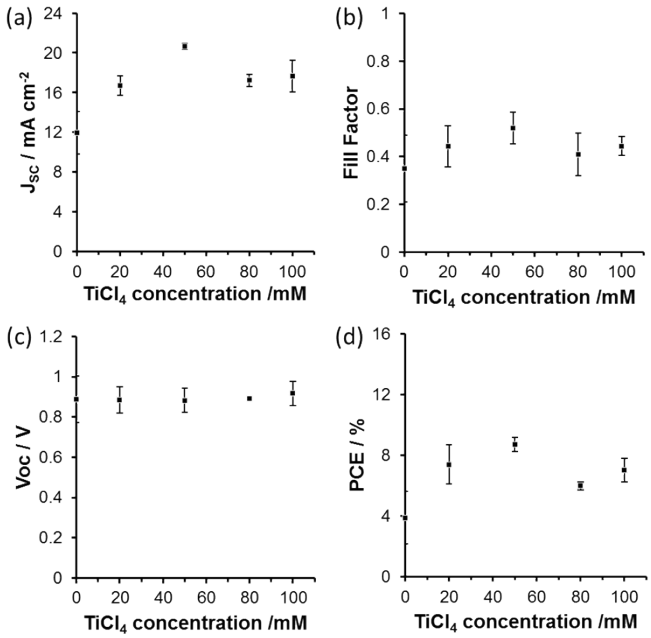

Figure S4 Photovoltaic performances of the $CH_3NH_3PbI_3$ perovskite solar cells deposited on *p*TiO_2 layer treated at different concentrations of $TiCl_4$ solution treatment for forward scan conditions; (a) short circuit current density (J_{SC}), (b) fill factor, (c) open circuit voltage (V_{oc}) and (d) power conversion efficiency (PCE). Each point represents the average value with standard deviation (error bars).

Table S1 Summary of electrochemical impedance parameters of various pTiO$_2$ samples

	R_s /Ω	R_1 /Ω	R_2 /Ω
pTiO$_2$(0)	27	$61x10^2$	$19x10^3$
pTiO$_2$(20)	27	$61x10^2$	$78x10^2$
pTiO$_2$(50)	43	$54x10^2$	$54x10^2$
pTiO$_2$(80)	31	$62x10^2$	$33x10^2$
pTiO$_2$(100)	29	$55x10^2$	$41x10^2$

Table S2 Summary of electrochemical impedance parameters of $CH_3NH_3PbI_3$ perovskite solar cells based on various pTiO$_2$ samples

	R_s /Ω	R_{sc} /Ω	R_{rec} /Ω
pTiO$_2$(0)	30	$45x10^2$	$11x10^3$
pTiO$_2$(20)	14	$42x10^1$	$50x10^2$
pTiO$_2$(50)	22	$14x10^2$	$56x10^3$
pTiO$_2$(80)	20	$27x10^2$	$40x10^3$
pTiO$_2$(100)	30	$63x10^1$	$12x10^3$