Electronic Supplementary Information

Strong metal-support interactions enable highly transparent Pt-Mo_2C counter electrodes of bifacial dye-sensitized solar cells

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Experiment

Preparation of counter electrodes: An Mo_2C film was deposited on well-cleaned fluorine-doped tin oxide (FTO) by radio frequency magnetron sputtering. The Mo_2C target (99.9%) was pre-sputtered for 10 min to remove impurities. All of the samples were deposited for 3 min under an Ar atmosphere with a sputtering pressure of 0.8 Pa. The deposition power was maintained at 60 W, and the substrate temperature was 200°C. We then impregnated the sputtered Mo_2C substrates in a chloroplatinic acid/isopropyl alcohol solvent with various concentrations. Finally, the samples were placed in a rapid annealing furnace and annealed at 450°C for 15 min. For comparison, we impregnated FTO into a chloroplatinic acid solution annealed at 450°C for 15 min, which was named IM-Pt. The Mo_2C annealed at 450°C for 15 min was named HT-Mo_2C. HT-Pt was prepared by high-temperature pyrolysis.

Fabrication of DSCs: The cleaned FTO was pre-treated with a $TiCl_4$ aqueous solution (40 mM) in an oven at 70°C for 35 min. TiO_2 layers with thicknesses of approximately 11 μm were prepared by screen printing. The TiO_2 layers were sintered at 500°C for 30 min. After the samples were post-treated with a $TiCl_4$ solution for 20 min and sintered at 500°C, the electrodes were impregnated in an N719 ethanol solution (0.3 mM) for 24 h at room temperature.

Characterization: The morphologies were detected utilizing FEI Quanta 250 field-emission scanning electron microscopy (SEM) and FEI F200talos TEM. The roughness and conductivity of Mo_2C, HT-Mo_2C and HT-Pt were measured by atomic force microscopy (AFM) on a Multimode8 instrument (Busker). We use a Rigaku, D/max-2500 X-ray diffractometer (XRD) with Cu Kα radiation (λ = 1.542 Å) operated at 40 kV and 100 mA to certify the crystal structure of molybdenum carbide. The optic transmittance was obtained on a UV-vis spectrophotometer at 400nm-900nm. The electrochemical characterizations such as Tafel polarization, electrochemical impedance spectroscopy (EIS) were tested employing a ModuLab XM Photoelectrochemical Test System. The voltage range of Tafel polarization test is -1V-1V, and the forward bias of EIS is 0.4V. The photovoltaic properties of cells were measured by a Keithley 2400 source meter from front side and rear side

irradiation under AM 1.5G simulated solar light (ABET Technology, 100 mW cm^{-2}). And the simulation of indoor light is achieved by a GCI-0604 LED from Daheng Optics.

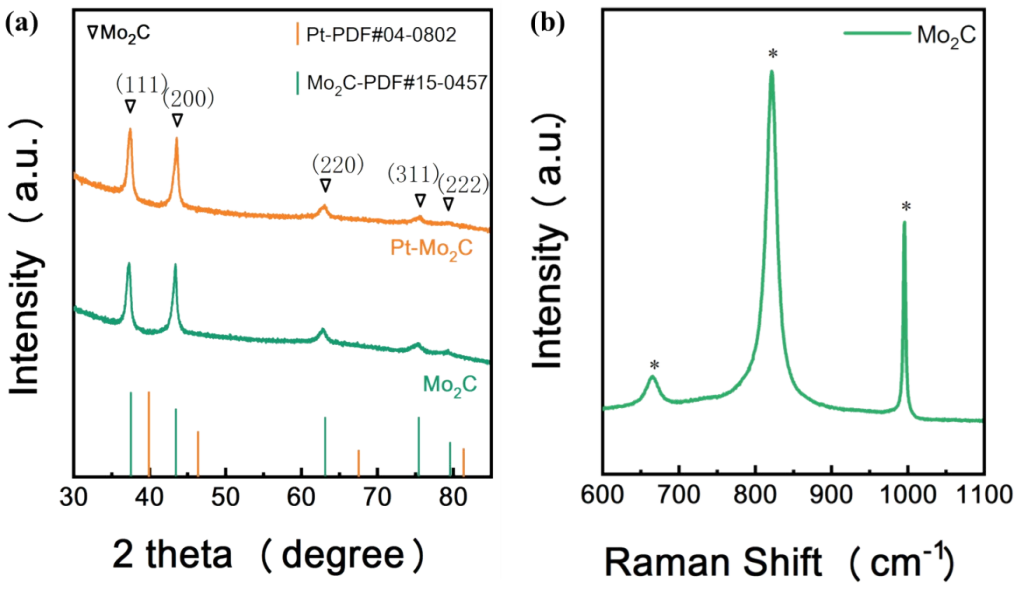

Fig. S1 (a) XRD patterns of Mo_2C and Pt-Mo_2C. (b) Raman spectroscopy of Mo_2C

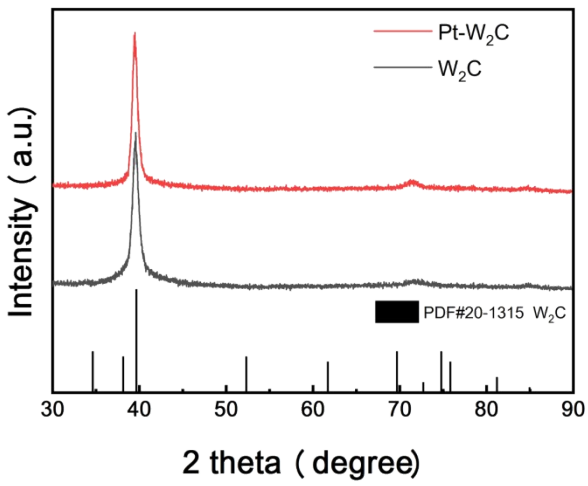

Fig. S2 XRD patterns of W_2C and Pt-Wo_2C.

The Raman results showed clear peaks at 666, 822, 996 cm^{-1}, confirming the formation of Mo_2C. The X-ray diffractionresult displayed characteristic planes of (1 1 1), (2 0 0), (2 2 0), (3 1 1), and (2 2 2) for cubic Mo_2C (PDF#15-0457). The deposition of Pt clusters showed no evident influence on the crystallization of the Mo_2C supports. We observed no diffraction peaks of Pt on the Pt–Mo2C CEs, which was likely due to the low loading and the small sizes of the Pt clusters.

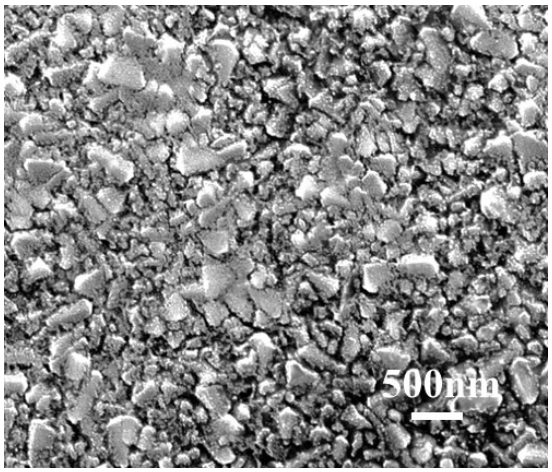

Fig. S3 Top SEM images of HT-Pt

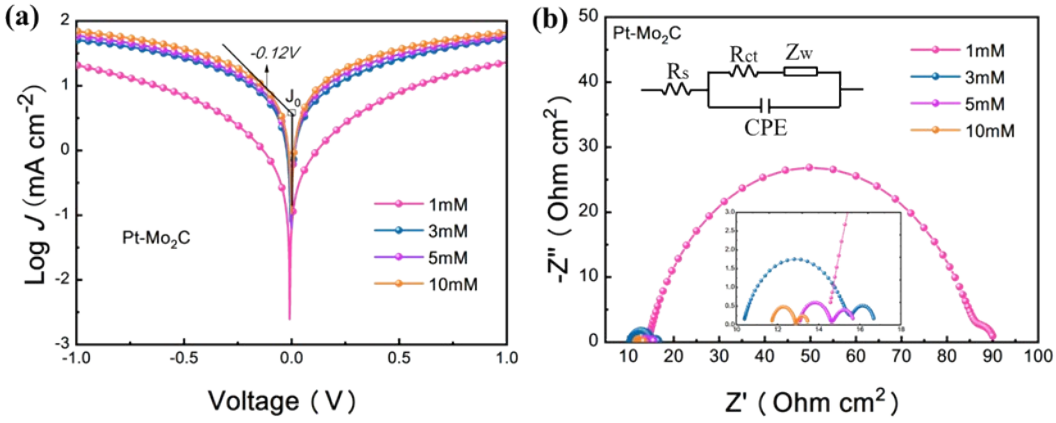

Fig. S4 (a) Tafel polarization curves and (b) Nyquist plots of different concentrations of chloroplatinic acid. Both experiments were performed with the symmetrical dummy cells with two identical electrodes (CE//iodide/triiodides electrolyte//CE). The inset (b) shows the equivalent circuit model of the symmetrical cells for fitting EIS results.

Table S1 Electrochemical properties from dummy cell with various concentrations of Chloroplatinic acid

Resistance	1mM	3mM	5mM	10mM
R_s (Ω cm^2)	12.97	12.42	12.24	11.71
R_{ct} (Ω cm^2)	39.41	22.94	7.89	1.08

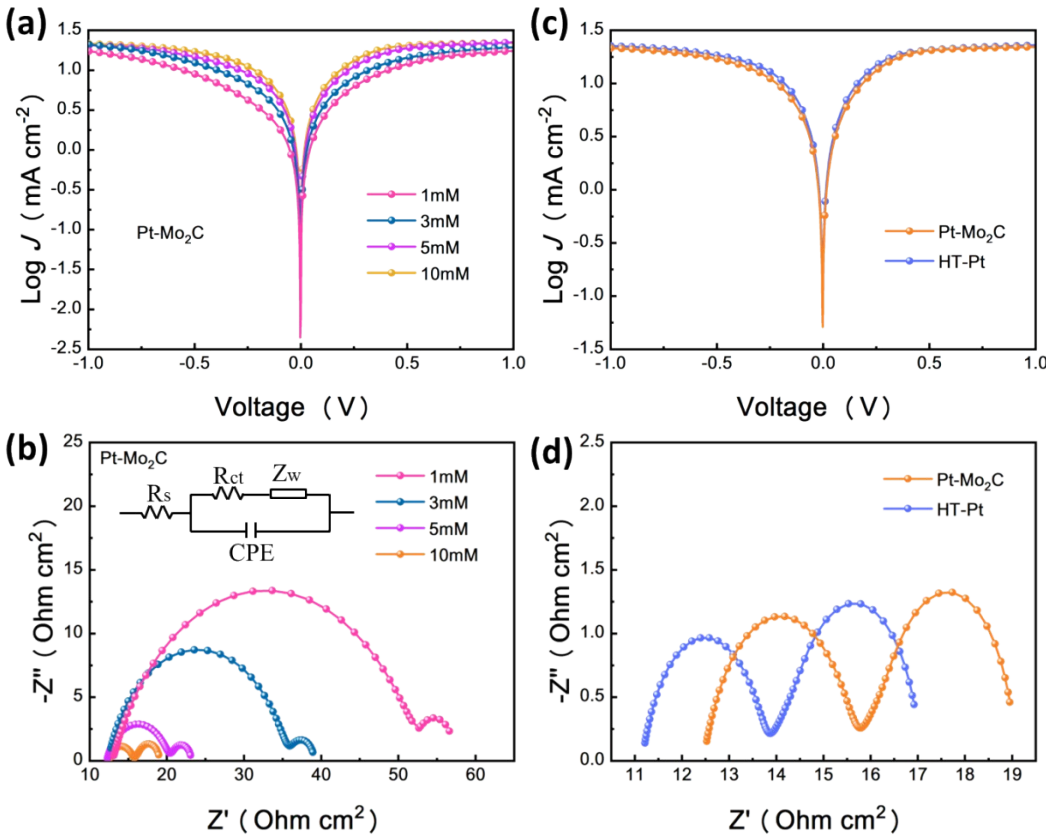

Fig. S5 (a) Tafel polarization curves and (b) Nyquist plots of different concentrations of chloroplatinic acid. (c) Tafel polarization curves and (b) Nyquist of (c-d) HT-Pt and Pt-Mo_2C. Both experiments were performed with the symmetrical dummy cells with two identical electrodes (CE//Co^{2+}/Co^{3+} electrolyte//CE). The inset (b) shows the equivalent circuit model of the symmetrical cells for fitting EIS results.

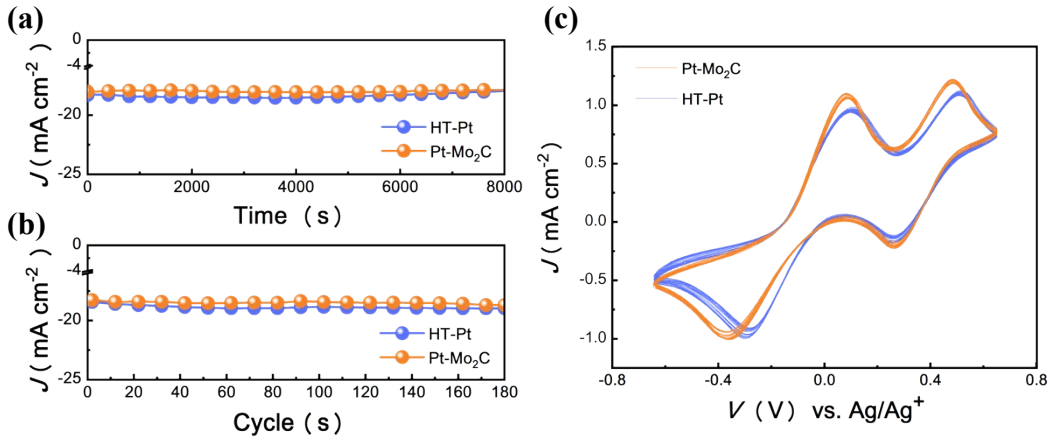

Fig. S6 (a) Current density vs time plots under bias voltages of -0.25 V, (b) extracted current density at -0.25 V from multi-cycle Tafel tests (180 cycles), and (c) successive CV (30 cycles) results of of Pt-Mo_2C and HT-Pt.

Table S2 Summary of *J* of I-t and successive CV

	I-t			CV		
	Initial *J* (mA cm^{-2})	End *J* (mA cm^{-2})	E *J* / I *J*	Initial *J* (mA cm^{-2})	End *J* (mA cm^{-2})	E *J* / I *J*
HT-Pt	18.30	17.95	98%	-1.00	-0.91	91%
Pt-Mo_2C	18.00	17.85	99%	-1.01	-0.94	93%

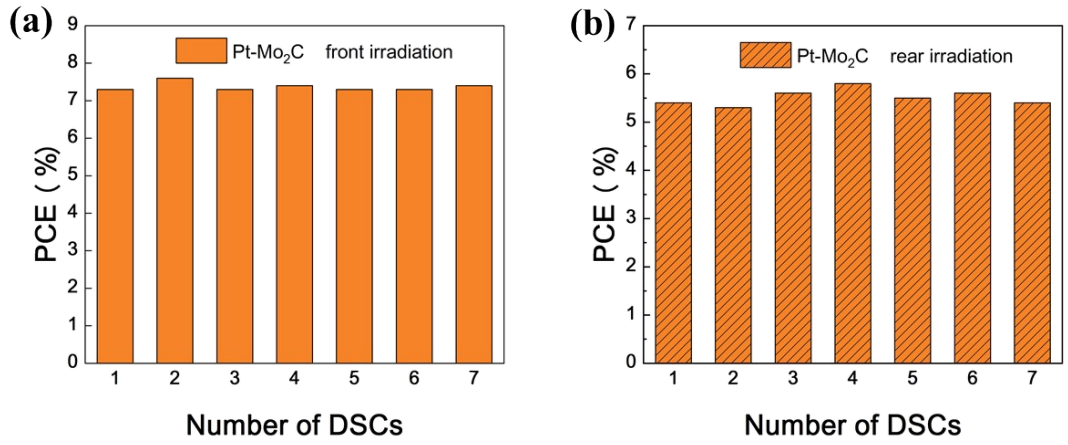

Fig. S7 Histogram of PCE for Pt-Mo_2C as CE in DSSCs (a) front irradiation (b) rear irradiation.