Electronic Supplementary Material (ESI) for Inorganic Chemistry Frontiers.

Polyoxometalate modified transparent metal selenide counter electrodes for high-efficiency bifacial dye-sensitized solar cells

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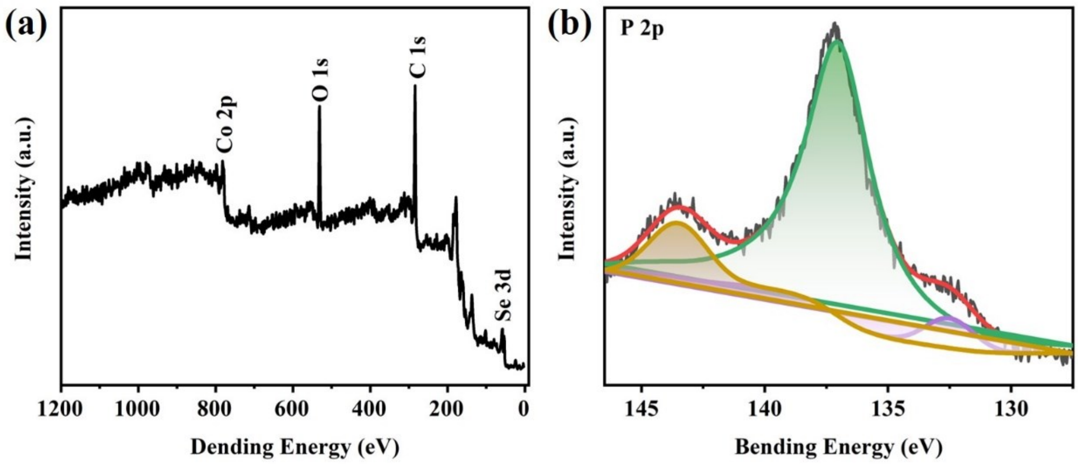

Figure S1 Full XPS spectra of (a) $Co_{0.85}Se$; High-resolution XPS spectra of (b) P 2p of $PW_{11}Co/Co_{0.85}Se$.

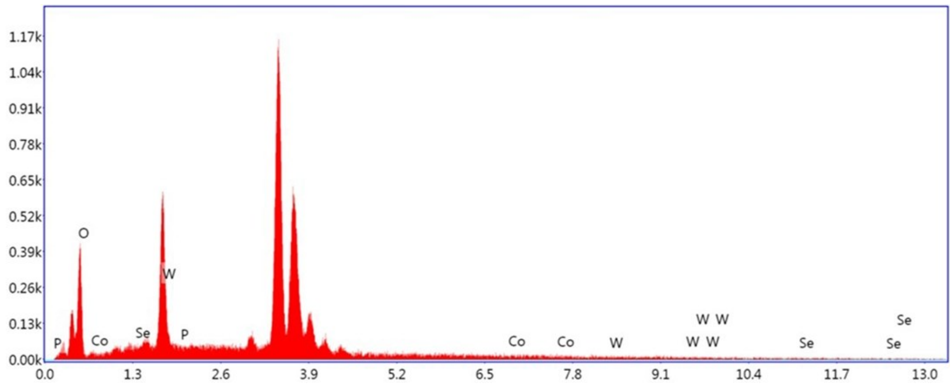

Figure. S2 EDX spectra of $PW_{11}Co/Co_{0.85}Se$.

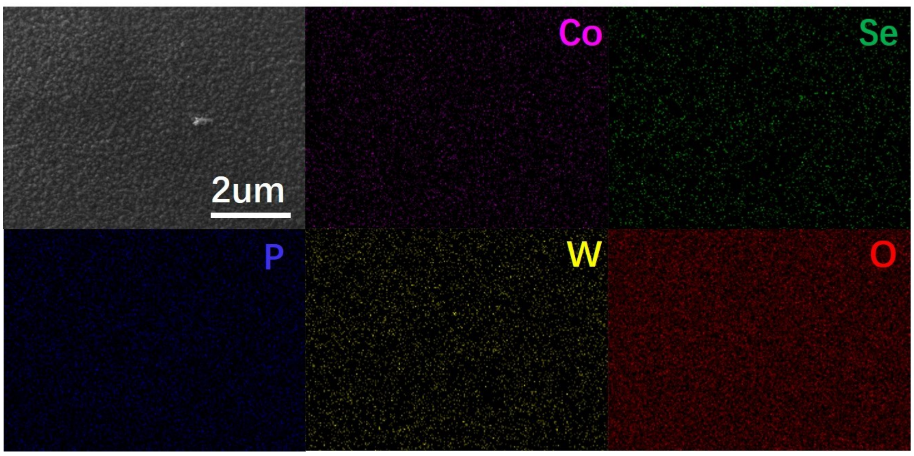

Figure S3 EDX elemental mapping of Co, Se, P, W and O in $PW_{11}Co/Co_{0.85}Se$.

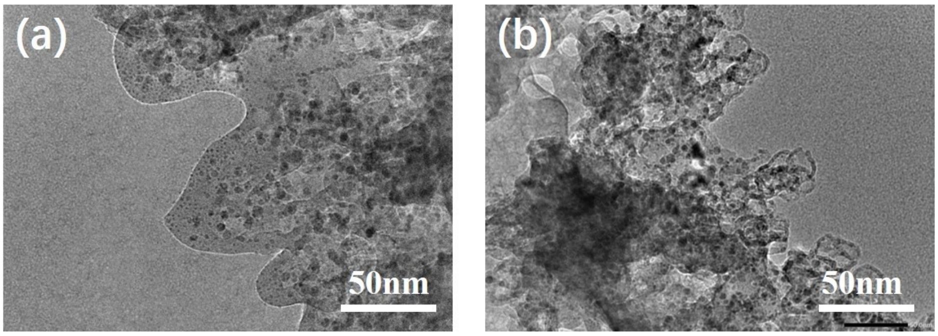

Figure S4 TEM images of $PW_{11}Co/Co_{0.85}Se$.

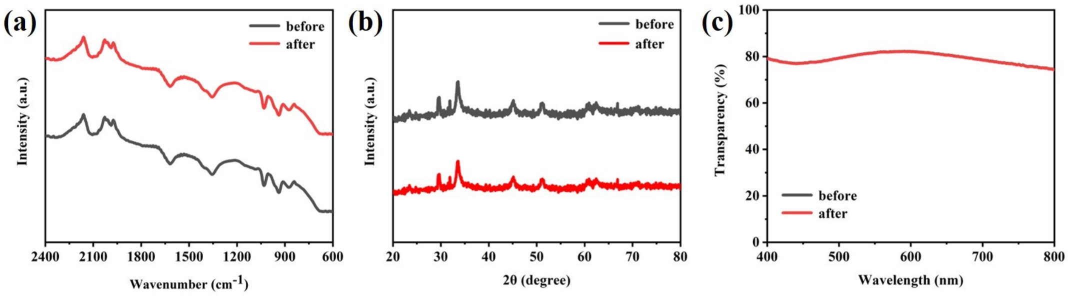

Figure S5 The IR, XRD and optical transmittance spectra of the $PW_{11}Co/Co_{0.85}Se$ CE after the durability tests.

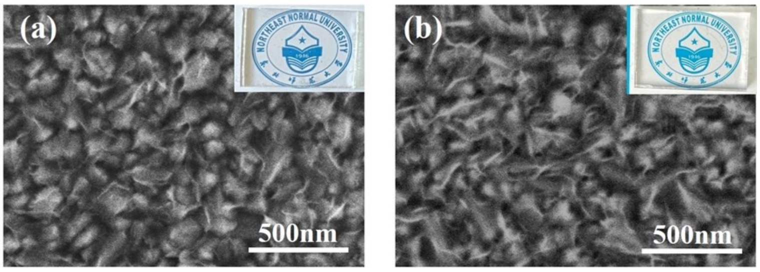

Figure S6 SEM of $PW_{11}Co/Co_{0.85}Se$ CE before and after durability test.

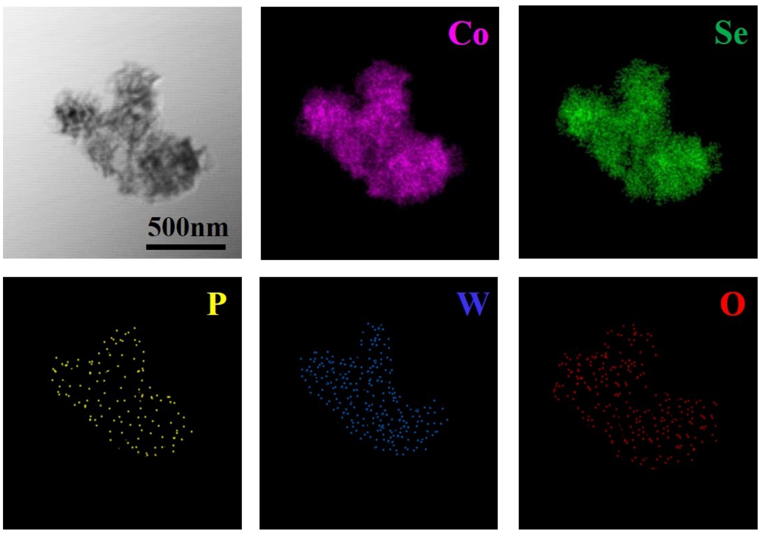

Figure S7 Elemental mapping of Co, Se, P, W and O in $PW_{11}Co/Co_{0.85}Se$ after durability test.

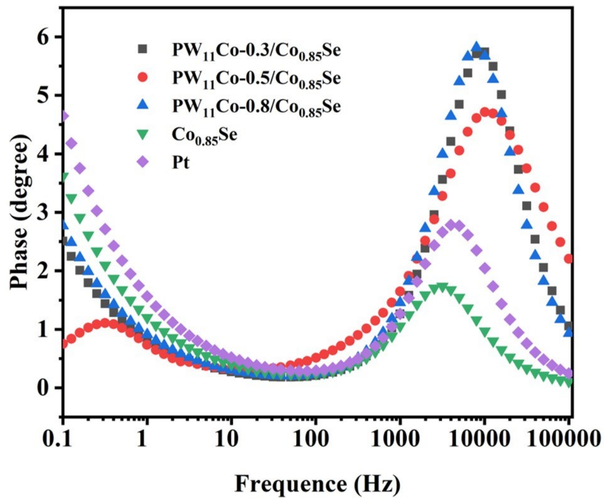

Figure S8 Bode curves of Pt, $Co_{0.85}Se$, $PW_{11}Co$-0.3/$Co_{0.85}Se$, $PW_{11}Co$-0.5/$Co_{0.85}Se$, and $PW_{11}Co$-0.8/$Co_{0.85}Se$ CEs.

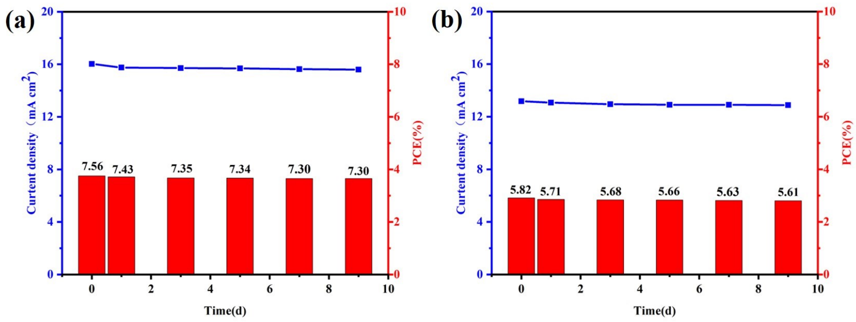

Figure. S9 Long-term stability of DSSCs based on $PW_{11}Co/Co_{0.85}Se$.

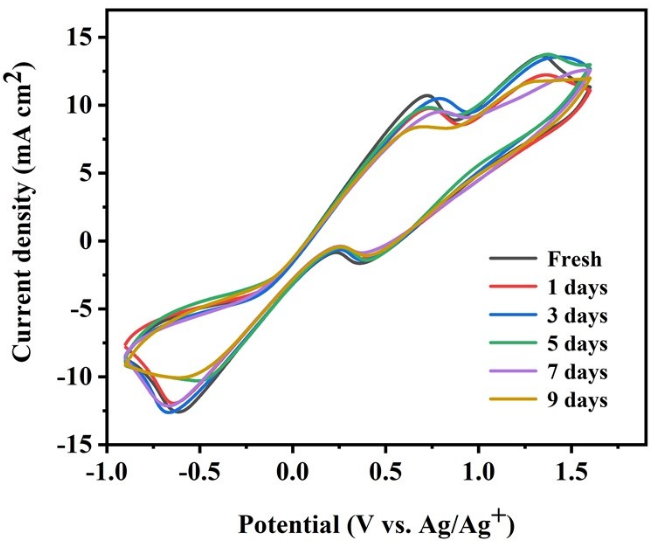

Figure. S10 CV curves of $PW_{11}Co/Co_{0.85}Se$ electrode subjected to aging for some days at room temperature.

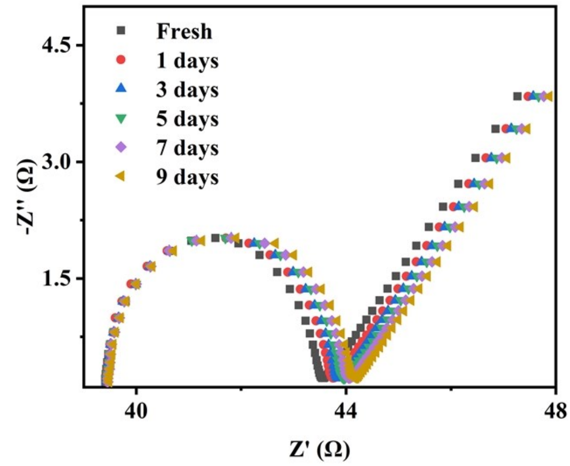

Figure. S11 Nyquist plot of $PW_{11}Co/Co_{0.85}Se$ electrode subjected to aging for some days at room temperature.

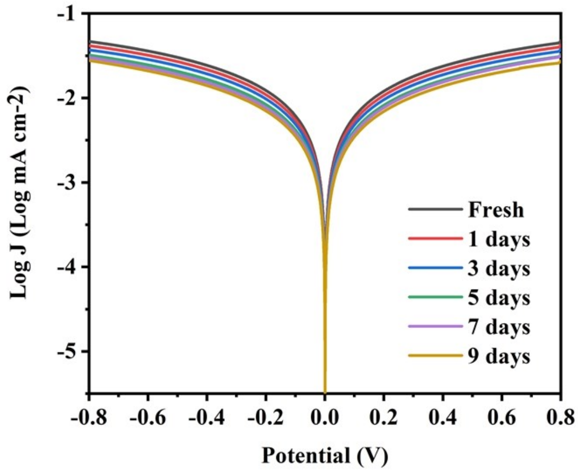

Figure. S12 Tafel of $PW_{11}Co/Co_{0.85}Se$ electrode subjected to aging for some days at room temperature.

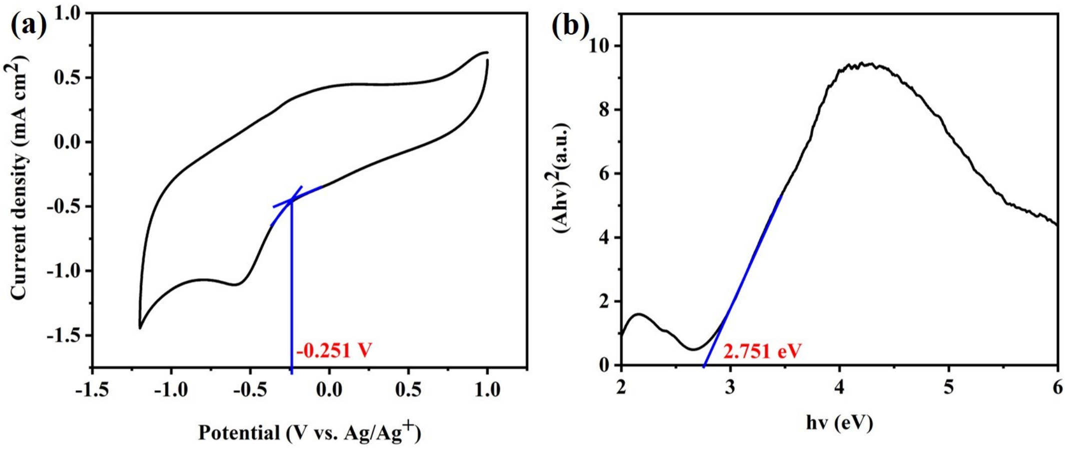

Figure. S13 (a) Cyclic voltammetry curve of $PW_{11}Co$ (1 mol L^{-1} KCl solution at pH=7). (b)A plot of Kubelka–Munk function F against energy E of $PW_{11}Co$.

Cyclic Voltammetry (CV) is widely used to study the electrochemical characteristics of materials. The first reduction peak of the CV curve is used to estimate the LUMO energy level of $PW_{11}Co$.[16] The value of the abscissa relative to the Ag/AgCl standard electrode is -0.251 V, which is converted to a standard hydrogen electrode of -0.054 V, and converted to a vacuum energy level, that is, the LUMO energy level is -4.45 eV. Solid diffuse reflection is used to estimate the bandwidth of $PW_{11}Co$. We use the Kubelka–Munk function F to plot the energy E of $PW_{11}Co$.[16] The energy axis and the extrapolation line of the linear region of the absorption edge intersect at a certain point whose quantitative value is the E_g of $PW_{11}Co$, so the E_g of $PW_{11}Co$ is estimated to be 2.751 eV.

Table S1. EIS parameters using the different materials as CEs.

Sample	R_s(Ω/cm^2)	R_{ct}(Ω/cm^2)	Z_w(Ω/cm^2)
0.3-$PW_{11}Co/Co_{0.85}Se$	35.08	7.83	0.45
0.5-$PW_{11}Co/Co_{0.85}Se$	39.40	4.02	0.23
0.8-$PW_{11}Co/Co_{0.85}Se$	35.93	8.09	0.39
$Co_{0.85}Se$	34.94	7.65	0.47
Pt	41.23	2.56	0.31

Table S2. Photovoltaic parameters of the DSSCs assembled with other CEs.

CEs	**irradiation**	V_{oc} **/ mV**	J_{sc} **/ mA cm^{-2}**	***FF***	***PCE* / %**	**Ref.**
$Co_{0.85}Se$ nanotubes	front	706	14.51	0.52	5.34	(1)
$Co_{0.85}Se$ nanoparticles	front	660	13.44	0.68	6.03	(2)
Co–$Co_{0.85}Se$	front	650	14.73	0.68	6.55	(3)
$Co_{0.85}Se$/RGO	front	706	16.01	0.69	7.81	(4)
CuCoSe	front	680	10.61	0.74	5.38	(5)
Polycrystalline $Co_{0.85}Se$	front	716	15.85	0.69	7.87	(6)
CoSe	front	690	15.60	0.66	6.79	(7)
$Ni_{0.85}Se$ nanospheres	front	760	13.2	0.68	6.82	(8)
PVP	front	570	20.32	0.46	5.45	(9)

(4w%)/PANI	rear	550	19.08	0.43	4.66	
RuSe	front	729	12.17	0.73	6.51	(10)
	rear	681	3.64	0.74	1.84	
PtNP-EMTE	front	700	11.63	0.68	5.67	(11)
	rear	700	9.98	0.67	4.87	
Pt–Mo_2C	front	710	15.61	0.67	7.4	(12)
	rear	700	12.00	0.66	5.5	
PVP(4wt%)/PANI	front	570	20.32	0.46	5.45	(13)
	rear	550	19.05	0.43	4.66	
16nm-MoS_2	front	714	13.96	0.69	6.88	(14)
	rear	689	6.67	0.72	3.31	
Zn-TCPP-Pt	front	690	12.95	0.61	5.48	(15)
	rear	690	10.93	0.63	4.88	
$PW_{11}Co/Co_{0.85}Se$	front	830	15.94	0.60	7.51	This work
	rear	730	13.33	0.60	5.79	

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