

Supplementary Information (SI)

Quantum dot sensitized solar cells with efficiency over 12% based on tetraethyl orthosilicate additive in polysulfide electrolyte

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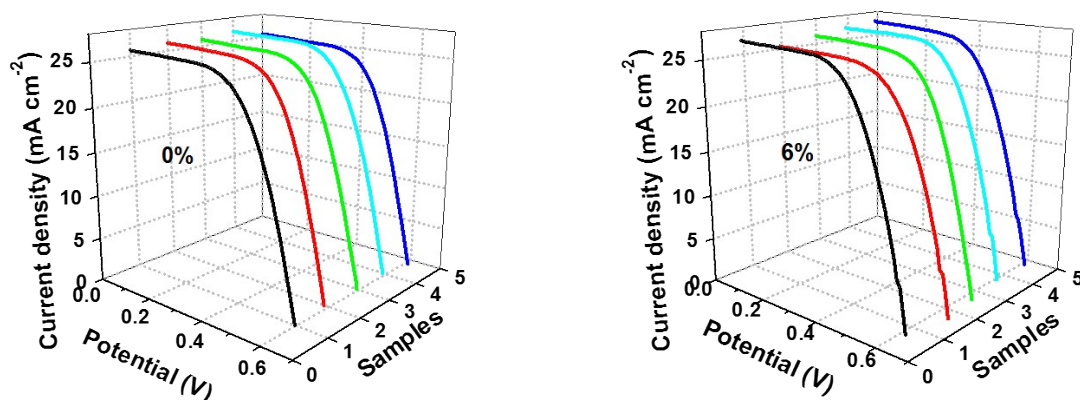


Fig. S1 J - V curves of ZCISE based QDSCs with (6 vol%) and without Na_2SiO_3 in the modified polysulfide electrolyte under the illumination of 1 full sun intensity (AM 1.5G, 100 mW/cm^2).

Table S1 Individual photovoltaic parameters of ZCISE based QDSCs with (6 vol%) and without Na_2SiO_3 in the modified polysulfide electrolyte under the illumination of 1 full sun intensity (AM 1.5G, 100 mW/cm^2).

Na_2SiO_3 Concentration (vol%)	V_{oc} (V)	J_{sc} (mA cm^{-2})	FF	PCE (%)
0	0.595	25.59	0.601	9.15
	0.583	25.93	0.608	9.19
	0.593	25.77	0.605	9.25
	0.588	26.19	0.598	9.21
	0.584	25.49	0.611	9.10
Average	0.589 ± 0.005	25.79 ± 0.28	0.605 ± 0.005	9.18 ± 0.06
6	0.615	26.22	0.596	9.61
	0.622	26.06	0.586	9.50
	0.616	26.44	0.590	9.61
	0.612	26.81	0.585	9.60
	0.610	26.43	0.598	9.64
Average	0.615 ± 0.005	26.39 ± 0.28	0.591 ± 0.006	9.59 ± 0.05

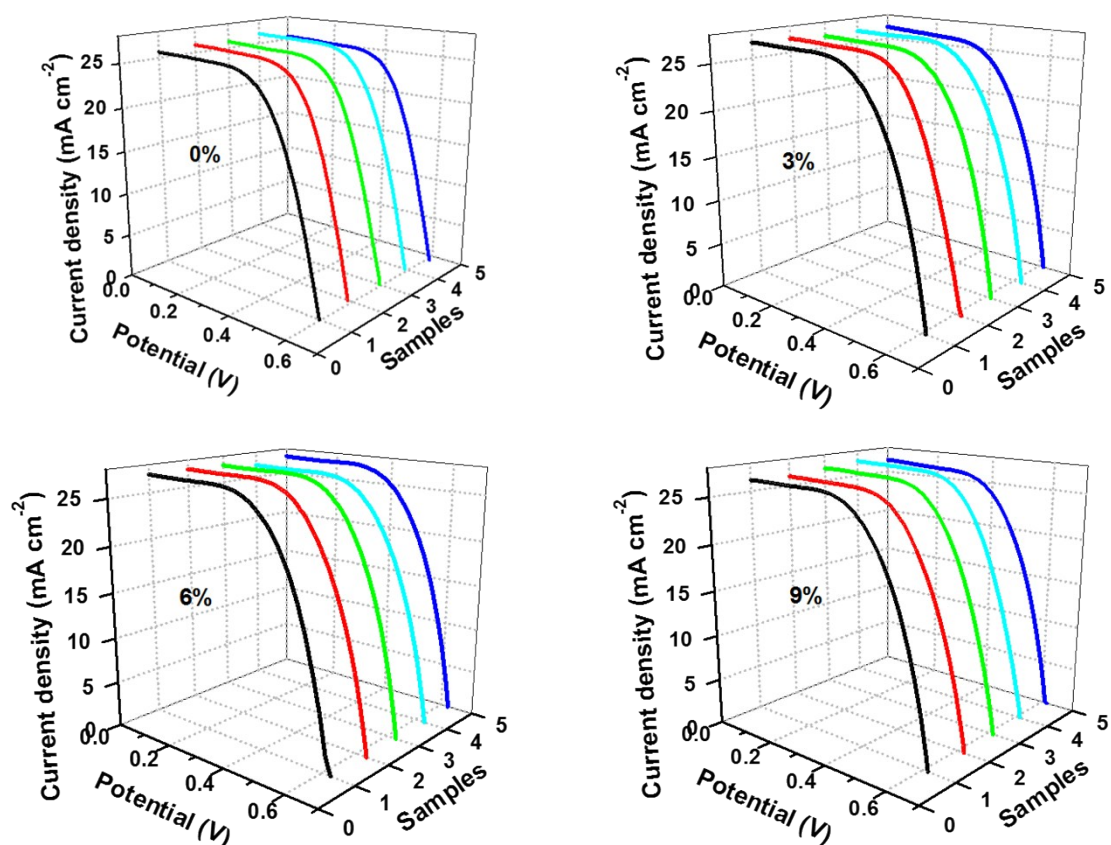


Fig. S2 J - V curves of ZCISE based QDSCs with different TEOS concentrations in the modified polysulfide electrolyte at staying time of 24 h under the illumination of 1 full sun intensity (AM 1.5G, 100 mW/cm^2).

Table S2 Individual photovoltaic parameters of ZCISe based QDSCs with different TEOS concentrations in the modified polysulfide electrolyte at staying time of 24 h under the illumination of 1 full sun intensity (AM 1.5G, 100 mW/cm²).

TEOS Concentration (vol%)	V_{oc} (V)	J_{sc} (mA cm ⁻²)	FF	PCE (%)
0	0.595	25.59	0.601	9.15
	0.583	25.93	0.608	9.19
	0.593	25.77	0.605	9.25
	0.588	26.19	0.598	9.21
	0.584	25.49	0.611	9.10
Average	0.589±0.005	25.79±0.28	0.605±0.005	9.18±0.06
3	0.611	26.68	0.597	9.74
	0.617	26.59	0.595	9.76
	0.615	26.32	0.603	9.76
	0.624	26.39	0.600	9.88
	0.613	26.49	0.598	9.71
Average	0.616±0.005	26.49±0.15	0.599±0.003	9.77±0.07
6	0.626	26.89	0.609	10.25
	0.632	27.00	0.595	10.14
	0.629	26.91	0.607	10.27
	0.630	26.41	0.598	9.95
	0.622	27.00	0.608	10.21
Average	0.628±0.004	26.84±0.25	0.603±0.006	10.16±0.13
9	0.615	26.22	0.596	9.61
	0.622	26.06	0.586	9.50
	0.616	26.44	0.590	9.61
	0.612	26.81	0.585	9.60
	0.610	26.43	0.598	9.64
Average	0.615±0.005	26.39±0.28	0.591±0.006	9.59±0.05

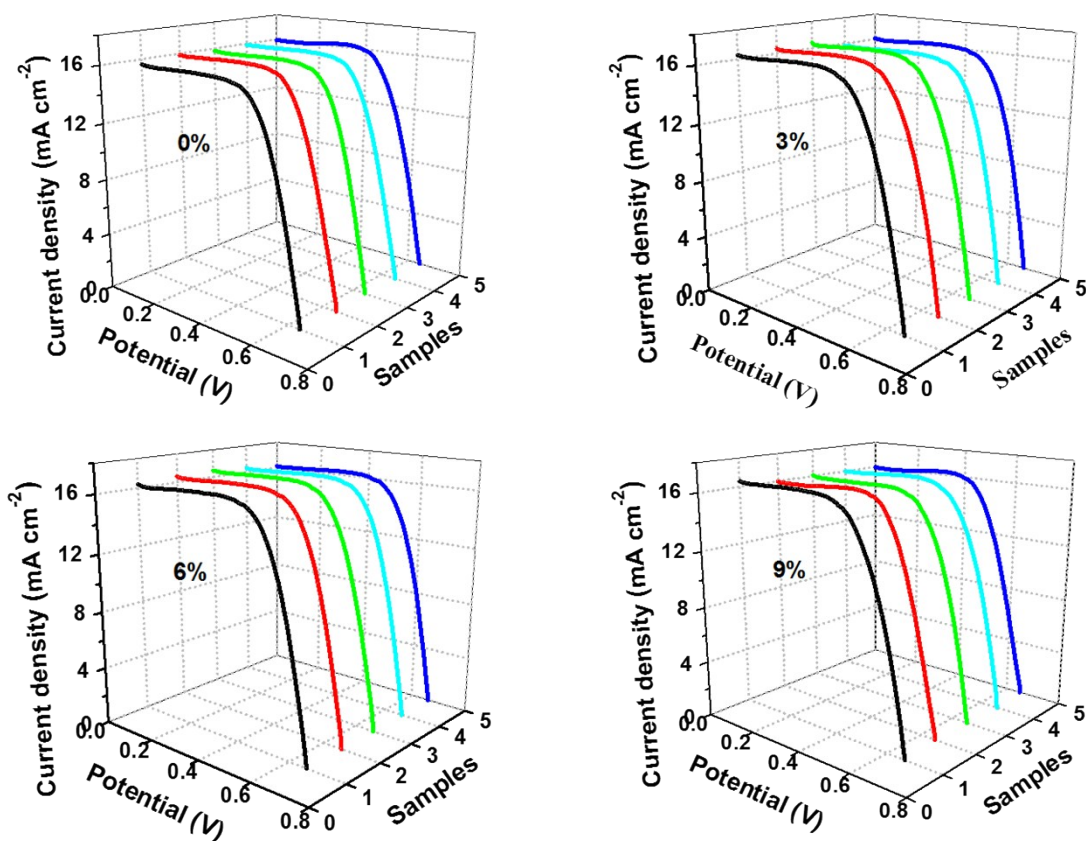


Fig. S3 J - V curves of CdSe based QDSCs with different TEOS concentrations in the modified polysulfide electrolyte at staying time of 24 h under the illumination of 1 full sun intensity (AM 1.5G, 100 mW/cm^2).

Table S3 Individual photovoltaic parameters of CdSe based QDSCs with different TEOS concentrations in the modified polysulfide electrolyte at staying time of 24 h under the illumination of 1 full sun intensity (AM 1.5G, 100 mW/cm²).

TEOS Concentration (vol%)	V_{oc} (V)	J_{sc} (mA cm ⁻²)	FF	PCE (%)
0	0.643	15.60	0.668	6.70
	0.653	15.91	0.659	6.82
	0.644	15.80	0.668	6.80
	0.652	15.93	0.653	6.78
	0.647	15.96	0.658	6.80
Average	0.648±0.005	15.84±0.15	0.661±0.007	6.78±0.05
3	0.664	16.26	0.658	7.11
	0.663	16.34	0.651	7.06
	0.664	16.41	0.649	7.07
	0.663	15.81	0.686	7.19
	0.662	16.01	0.682	7.23
Average	0.663±0.001	16.17±0.25	0.665±0.018	7.13±0.18
6	0.663	16.20	0.681	7.31
	0.664	16.41	0.673	7.34
	0.665	16.49	0.660	7.24
	0.663	16.31	0.679	7.34
	0.663	16.12	0.682	7.28
Average	0.664±0.001	16.31±0.15	0.675±0.009	7.30±0.04
9	0.666	16.40	0.639	6.98
	0.652	15.98	0.657	6.84
	0.657	16.05	0.648	6.83
	0.664	16.01	0.651	6.92
	0.652	15.96	0.655	6.83
Average	0.658±0.007	16.07±0.19	0.650±0.007	6.88±0.07

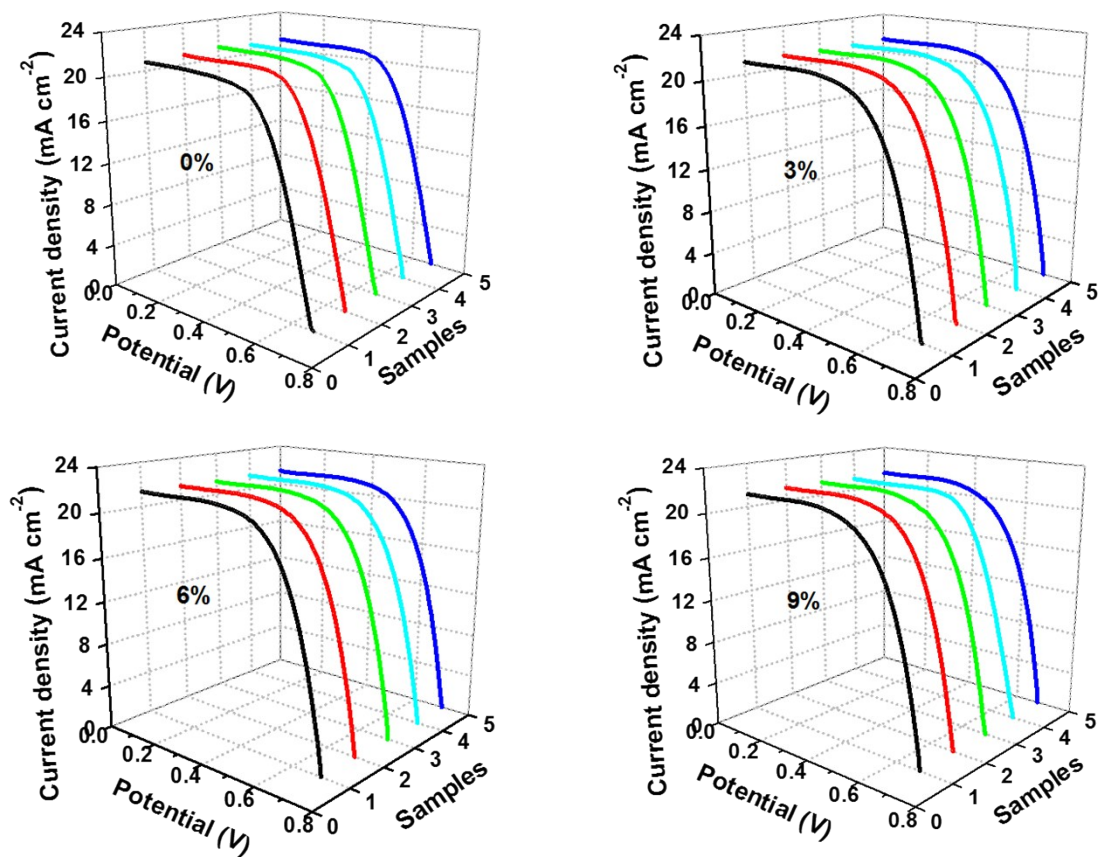


Fig. S4 J - V curves of CdSeTe based QDSCs with different TEOS concentrations in the modified polysulfide electrolyte at staying time of 24 h under the illumination of 1 full sun intensity (AM 1.5G, 100 mW/cm²).

Table S4 Individual photovoltaic parameters of CdSeTe based QDSCs with different TEOS concentrations in the modified polysulfide electrolyte at staying time of 24 h under the illumination of 1 full sun intensity (AM 1.5G, 100 mW/cm²).

TEOS Concentration (vol%)	V_{oc} (V)	J_{sc} (mA cm ⁻²)	FF	PCE (%)
0	0.678	20.83	0.626	8.84
	0.668	20.88	0.633	8.83
	0.670	21.17	0.627	8.89
	0.665	20.91	0.625	9.12
	0.674	21.01	0.632	8.95
Average	0.671±0.005	20.96±0.14	0.629±0.004	8.93±0.12
3	0.695	21.16	0.642	9.44
	0.696	21.18	0.644	9.49
	0.690	21.15	0.640	9.34
	0.696	21.21	0.636	9.39
	0.698	21.35	0.639	9.52
Average	0.695±0.003	21.21±0.08	0.640±0.003	9.44±0.07
6	0.702	21.36	0.650	9.75
	0.699	21.32	0.646	9.63
	0.705	21.31	0.645	9.69
	0.708	21.38	0.638	9.66
	0.703	21.43	0.651	9.81
Average	0.703±0.003	21.36±0.05	0.646±0.005	9.71±0.07
9	0.686	21.20	0.628	9.13
	0.682	21.27	0.636	9.23
	0.688	21.23	0.632	9.23
	0.684	21.17	0.633	9.17
	0.680	21.28	0.630	9.12
Average	0.684±0.003	21.23±0.05	0.632±0.003	9.18±0.05

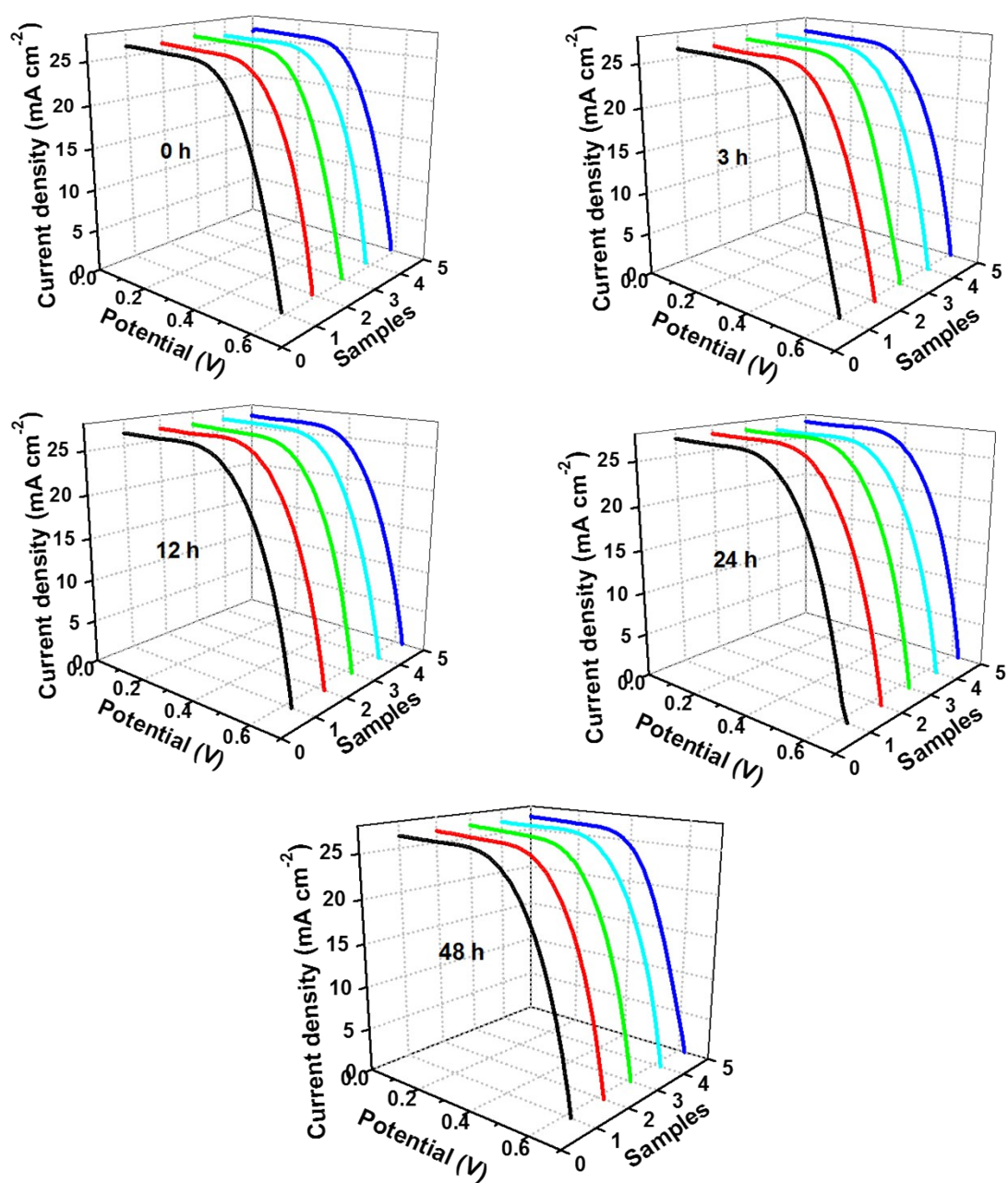


Fig. S5 $J-V$ curves of ZCISe based QDSCs with 6 vol% TEOS in the modified polysulfide electrolyte at staying time of 0, 3, 12, 24 and 48 h under the illumination of 1 full sun intensity (AM 1.5G, 100 mW/cm^2).

Table S5 Individual photovoltaic parameters of ZCISe based QDSCs with 6 vol% TEOS in the modified polysulfide electrolyte at staying time of 0, 3, 12, 24 and 48 h under the illumination of 1 full sun intensity (AM 1.5G, 100 mW/cm²).

Time (h)	V_{oc} (V)	J_{sc} (mA cm ⁻²)	FF	PCE (%)
0	0.586	26.15	0.599	9.18
	0.583	25.93	0.606	9.16
	0.587	26.25	0.597	9.20
	0.579	25.89	0.609	9.13
	0.582	25.94	0.608	9.18
Average	0.583±0.003	26.03±0.16	0.604±0.005	9.17±0.03
3	0.603	26.09	0.602	9.47
	0.615	25.79	0.592	9.39
	0.603	26.13	0.601	9.47
	0.610	26.11	0.592	9.43
	0.605	26.20	0.598	9.48
Average	0.607±0.005	26.06±0.16	0.597±0.005	9.45±0.04
12	0.623	26.43	0.600	9.88
	0.628	26.37	0.599	9.92
	0.623	26.35	0.605	9.93
	0.627	26.53	0.594	9.88
	0.625	26.47	0.593	9.81
Average	0.625±0.002	26.43±0.07	0.598±0.005	9.88±0.05
24	0.626	26.89	0.609	10.25
	0.632	27.00	0.595	10.14
	0.629	26.91	0.607	10.27
	0.630	26.41	0.598	9.95
	0.622	27.00	0.608	10.21
Average	0.628±0.004	26.84±0.25	0.603±0.006	10.16±0.13
48	0.620	26.39	0.596	9.75
	0.621	26.34	0.604	9.88
	0.612	26.51	0.599	9.72
	0.622	26.41	0.599	9.84
	0.620	26.61	0.594	9.80
Average	0.619±0.004	26.45±0.11	0.598±0.004	9.80±0.07

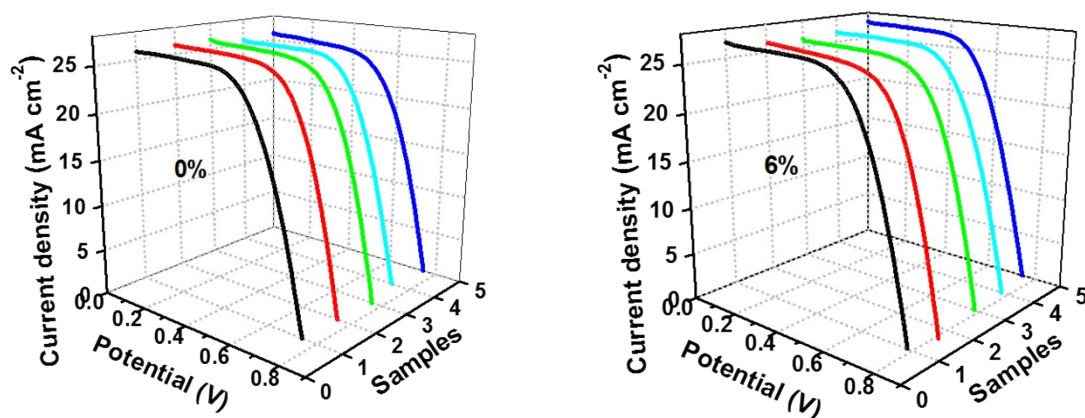


Fig. S6 J - V curves of ZCISE based QDSCs with 0 and 6 vol% TEOS concentrations in the modified polysulfide electrolyte at staying time of 24 h, applying Ti mesh supported mesoporous carbon (MC/Ti) counter electrodes under the illumination of 1 full sun intensity (AM 1.5G, 100 mW/cm²).

Table S6 Impedance Individual photovoltaic parameters of ZCISE based QDSCs with 0 and 6 vol% TEOS concentrations in the modified polysulfide electrolyte at staying time of 24 h, applying Ti mesh supported mesoporous carbon (MC/Ti) counter electrodes under the illumination of 1 full sun intensity (AM 1.5G, 100 mW/cm²).

TEOS Concentration (v%)	V_{oc} (V)	J_{sc} (mA cm ⁻²)	FF	PCE (%)
0	0.742	25.87	0.607	11.65
	0.746	25.89	0.626	12.09
	0.759	26.09	0.614	12.16
	0.723	25.53	0.609	11.24
	0.745	25.84	0.602	11.59
Average	0.743±0.013	25.84±0.20	0.612±0.009	11.75±0.38
6	0.781	26.61	0.601	12.49
	0.758	26.13	0.618	12.24
	0.781	25.92	0.624	12.63
	0.773	26.15	0.605	12.23
	0.747	26.97	0.602	12.13
Average	0.768±0.015	26.36±0.43	0.610±0.010	12.34±0.21

Table S7 Impedance parameters under the forward bias of -0.6 V. series resistance R_s , recombination resistance R_{rec} , chemical capacitance C_μ , and electron lifetime $\tau_n = R_{rec} \cdot C_\mu$.

TEOS (vol%)	R_s $\text{W} \cdot \text{cm}^2$	R_{rec} $\text{W} \cdot \text{cm}^2$	C_μ $\text{mF} \cdot \text{cm}^{-2}$	τ_n ms
0	24.17	178.8	3.64	651
3	32.85	199.2	3.61	720
6	30.38	234.8	3.70	869
9	37.09	255.6	3.70	947

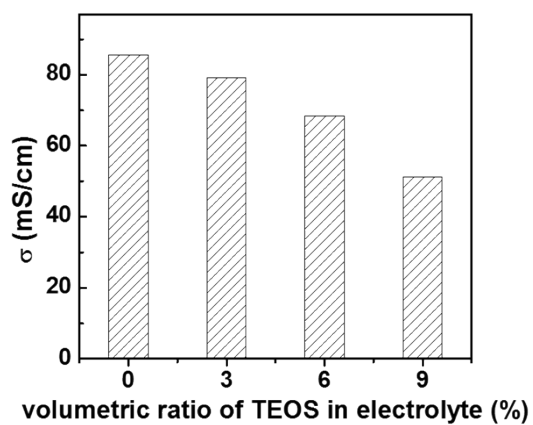


Fig. S7 Conductivity of electrolytes containing different TEOS volumetric fractions at 25 °C.