Electronic Supplementary Material (ESI) for Environmental Science: Nano.

In Tables S1-S5, the reference number within the parentheses corresponds to the reference number within the main text. A list of the acronyms used in the tables and their full names are provided in Table S6.

Table S1 Sensitized (metal oxide-based) devices (Section 3.1)

Classification	Precursor(s)	Approach	Purification	CND Size	Surface functionality	CND role	Device architecture	J_{SC} (mA cm^{-2})	V_{OC} (V)	FF	η (%)	Band edges (eV)	Optimized conditions	Explanation for performance	Reference
GQDs	4-bromobenzoic acid	SO	CC	13.5 nm (DLS)	Trialkyl phenyl	Sensitizer	FTO/TiO_2 NPs/**GQDs**/I_3^-:I^-/Pt	0.20	0.48	0.58	0.06[a]	3.8/5.3	No optimization	Low affinity of GQD functional groups for TiO_2	[1] (54)
GQDs	4-bromobenzoic acid	SO	CC	13.5 nm (DLS)	Trialkyl phenyl; single carboxyl group	Sensitizer	FTO/TiO_2 NPs/**GQDs**/I_3^-:I^-/Pt	~4.5	>0.5	NR	NR	Tunable	No optimization	Addition of single carboxyl group resulted in higher sensitizer packing density due to edge-on alignment which produced more efficient electron transfer	[2] (55)
CQDs	γ-butyrolactone	AD	D (1 kDa)	3–15 nm	Carbonyl, alkyl, sulfonic	Sensitizer	FTO/TiO_2 NPs/**CQDs**/I_3^-:I^-/Pt	0.53	0.38	0.64	0.13	Only bad gap (indirect: 1.1; direct: 3.1) reported	No optimization	Emissive sites acting as recombination centers, inferior charge injection properties	[3] (50)
CNDs	Melamine, glycerol	T	D (1 & 3.5 kDa)	0.8–3 nm	Hydroxyl, alkyl, aldehyde, amine, triazine	Sensitizer	FTO/TiO_2 NPs/**CNDs**/I_3^-:I^-/Pt	0.80	0.57	0.29	0.13	NR	No optimization	Two photon energy upconversion of N-doped CNDs enhanced harvesting of near-IR light. Low performance due to high recombination rates with CNDs and poor electron transfer.	[4] (52)
CQDs	Graphite rods	EC	CTFG	1–4 nm	Hydroxyl, alkyl, carboxyl, epoxy	Sensitizer	Ti Foil/TiO_2 NTs/**CQDs**/I_3^-:I^-/Pt	0.02	0.58	0.35	0.004	Only bad gap (1.9) reported	No optimization	Showed feasibility as sensitizer; due to appropriate band alignment, photoexcited electrons easily injected into TiO_2	[5] (51)
CQDs	γ-butyrolactone	AD	D (MWCO NR)	NR (1–5 nm from TEM)	Carboxyl	Sensitizer	FTO/MWCNTs/**CQDs**/I_3^-:I^- (not metal oxide based)	~1.7–3.8	~0.74–0.86	NR	Only highest reported (1.23%)	NR	5 ± 0.5 µm MWCNT:CQD film	Depends on photoanode thickness; CQDs were covalently bound to CNTs via an ester linkage which allowed for more effective injection of the excited state electrons.	[6] (45)
CNDs	Monkey grass	HT	FLTR & CTFG	2–6 nm	Carboxyl, hydroxyl, epoxy, amine; (pyridinic-N, pyrrolic-N, graphitic-N within core)	Sensitizer	FTO/TiO_2 NPs/**CNDs**/I_3^-:I^-/Pt	1.93 ± 0.07	0.49 ± 0.01	0.55 ± 0.02	0.53 ± 0.05	4.14/5.73	0.1 M I^-/0.01 M I_2 (aq.); CND uptake not optimized[b]	Aqueous I_3^-:I^- vs. organic solvent resulted in stronger quenching of the CNDs by I^- leading to enhanced utilization of the photoexcited electrons.	[7] (170)
CNDs	CA, urea	MWV	CTFG	NR (<5 nm from TEM)	NR; presumably hydroxyl, carboxyl, and amine	Sensitizer	FTO/TiO_2 NPs/**CNDs**/I_3^-:I^-/Pt	NR	NR	NR	NR	NR	Not optimized; only report IPCE	CNDs could effectively inject electrons into TiO_2 displaying an electron injection rate and efficiency of 8.8 x 10^8 s^{-1} and 91% which was attributed to strong intrinsic visible absorption and	[8] (115)

													the lack of insulating, long chain functional groups.	
CNDs	CA, urea, formic acid	MWV	CTFG	0.5–2.5 nm (calculated using AUC)	NR; elude to carboxyl	Sensitizer	FTO/TiO_2 NPs/**CNDs**/I_3^-:I^-/Pt	0.99	0.49	0.50	0.24	NR	Sensitization conducted at pH 1 for 6-8 h	Depends on pH of CND sensitizer solutions, length of CND uptake, CND optical properties (*i.e.*, precursors employed); acidic solutions improved CND coverage; increased light harvesting range of CNDs to redder wavelengths did not translate to higher photocurrents	[9] (48)
CDs	CA, ammonia (A)	T	CTFG	7–15 nm	Hydroxyl, alkyl, carboxyl, amine	Sensitizer	FTO/TiO_2 NPs/**CDs**/I_3^-:I^-/Pt	2.65	0.47	0.63	0.79	NR	Devices not directly optimized; Extent of N-doping in CDs optimized by varying precursor mass ratios (1:4 CA:A)	N-doping introduced new energy levels and trap states that increase visible absorption resulting in more electrons transferred to TiO_2 CB enhancing the photocurrent.	[10] (53)
CQDs	Strawberry powder	HT	None	1–4 nm	Hydroxyl, carboxyl, epoxy, alkyl	Sensitizer	FTO/m-TiO_2/**CQDs**/LPP/I_3^-:I^-/Pt	Dark: 0.035–0.078	Dark: 0.207–0.332	Dark: 0.327–0.460	Dark: 4.6–14.8	NR	HT reaction for 9h for cells in dark and illuminated conditions[b]	Depends on length of CQD formation (3-20h): From 3–9 h CQD conjugation increases, while >9h CQD size increases reducing quantum confinement effects. Operation under dark conditions occurs due to incorporation of a green emitting LPP and reportedly results in quite high PCE.	[11] (213)
								Light: 0.059–0.244	Light: 0.338–0.489	Light: 0.494–0.619	Light: 0.011–0.074				
GQDs	GO	AO	FLTR prior to PEG functionalization	~50 nm	PEG functionalized	Co-sensitizer	TiO_2 NPs/**GQDs**:N719/I_3^-:I^-/Pt	6.65 ± 0.02–14.07 ± 0.02	0.62 ± 0.01–0.66 ± 0.01	0.59 ± 0.01–0.71 ± 0.01	3.24 ± 0.01–6.10 ± 0.01	NR	Optimized GQD concentration and subsequent uptake by altering amount of GO (0.05 g) in synthesis	Hot electron injection from GQDs to TiO_2; depends on quantity of GO used to make GQDs, which affected dye uptake; Low GO (GQD) amounts - no discernable difference in dye uptake or performance; High GO (GQD) amounts - GQDs aggregated and dye uptake decreased hindering performance	[12] (47)
GQDs	D-(+)-Glucosamine + Tris	MWV-HT	CTFG	3.9–4.8 nm	Amine, pyrrolic, pyridinic, hydroxyl, poly(carbazole)	Co-sensitizer	FTO/TiO_2 NPs/**GQDs**:N3/I_3^-:I^-/Pt	5.58	0.58	0.66	2.15	3.16/5.68	No optimization	Enhanced charge separation & collection; GQD PL energy transfer to N3 dye; suppression of back electron transfer	[13] (49)
CQDs	CCl_4, $NaNH_2$	ST	CTFG	1–4 nm	Carboxyl, amine; (pyridinic-N, pyrrolic-N within core)	Sensitizer; photoanode dopant	FTO/TiO_2:**CQD** composite/I_3^-:I^-/Pt	0.33–0.69	0.37–0.46	0.28–0.43	0.03–0.13	NR	No optimization	N-doping of CQDs lowered the work function of the composite which resulted in better PV performance over un-doped CQD:TiO_2 composite	[14] (56)
GQDs	GO	SCF	D (MWCO NR)	3–10 nm	Hydroxyl, carbonyl/carboxyl	Photoanode dopant	ITO/PT (or PPy):**GQDs**/N719/I_3^-:I^-/graphite (not metal oxide based)	4.36–7.80	0.46–0.78	0.29–0.52	0.89–2.09	NR	0.03% (w/v) GQD in PPy composite	Depends on polymer used and GQD doping concentration; PT has poorer electron mobility (resulting in lower J_{SC}) due to high quantity of nonconducting impurities and lower band gap (resulting in higher V_{OC}); regardless GQD incorporation	[15] (84)

														increased charge mobility of both polymer-based composites.	
GQDs	Pyrene	HT	D (3.5 kDa)	2–5 nm	MPA-capped through ligand exchange with dodecylamine; Bare GQDs: hydroxyl	Photoanode dopant/co-sensitizer	TiO_2 NPs/CdSe QDs/**GQDs**/ZnS film/SiO_2 film/Na_2S:S/Cu_2S:brass	15.11–15.88	0.605–0.662	0.614–0.659	6.02 ± 0.05–6.53 ± 0.04	NR	CdSe QDs coated first following by GQDs (0.5 g L^{-1} solution with 1 h adsorption time)	Depends on coating sequence, GQD stock concentration, and length of adsorption time. GQDs function as an energy barrier suppressing charge recombination.	[16] (216)
CDs	Carbon soot (from polystyrene foam)	AO	D (MWCO NR)	2–8 nm	Carboxyl	Photoanode dopant/co-sensitizer	FTO/TiO_2:**CD** grafted graphene/CdS:CdSe/Na_2S:S/Cu_2S	11.65–13.71	0.56–0.58	0.58–0.62	4.04–4.69	~3.8/~5.5	2.0 wt% CD grafted graphene	Larger pores afforded increased sensitizer uptake; graphene networks acted as bridge between TiO_2 NPs increasing electron transport and decreasing recombination; CDs hindered graphene agglomeration and acted as co-sensitizer transferring photoexcited electrons to graphene	[17] (88)
GQDs	GO	SCF	D (MWCO NR)	0.8–2.6 nm	Polyaniline functionalized; Bare GQDs: hydroxyl, carboxyl	Photoanode dopant/electron acceptor	ITO/PANI-**GQDs**/N719/I_3^-:I^-/Al	5.24–7.35	0.63–0.65	0.470–0.654	1.57–3.12	Cite GQD CB (3.47) from ref. [18] (83)	33.3 mg GQDs in composite	Depends on mass of GQDs (10, 20, 33.3, and 50 mg) incorporated into PANI-GQD composites. Varying GQD concentration changes compatibility between the LUMO of the donor PANI chains and CB of the GQD acceptors and changes morphology of composite from flakes (10 & 20 mg) to rods to a mixture of both. Interactions between PANI and GQDs produce BHJs on the molecular level which facilitate charge carrier separation.	[19] (215)
GQDs	CNFs	AO	D (2 kDa)	~15 nm (DLS)	NR; presumably oxygen containing moieties	Electron shuttle/electron acceptor	FTO/TiO_2 NFs/**GQDs**:N719/I_3^-:I^-/Pt	11.72	0.68	0.78	6.22	NR	No optimization	Increased roughness factor of TiO_2 NFs affording higher dye uptake; faster extraction of photogenerated electrons; reduced recombination	[20] (76)
Au@CDs	Glucose, $HAuCl_4$	HT	CTFG	130–250 nm	Hydroxyl, epoxy	Electron acceptor	FTO/ZnO Nanorods/N719/Au@**CDs**/I_3^-:I^-/MWCNTs	11.60	0.61	0.58	4.10	3.8/6.0 (Au@CD)	No optimization	Au@CDs promoted electron transfer and transport by accepting electrons from dye and shuttling them to ZnO and/or FTO; plasmonic nature of Au nanostructures and FRET from ZnO to dye both enhanced excited state electron generation of dye	[21] (73)
CDs	L-ascorbic acid	T	CC	10–30 nm	NR; presumably oxygen containing moieties	Electron donor; co-sensitizer	FTO/TiO_2 NPs/PbSe:CdS:**CDs**/Na_2S/MWCNTs	17.07 ± 0.19	0.690 ± 0.004	0.411 ± 0.004	4.84 ± 0.13	3.78/4.39	No optimization[b]	Due to co-mingling of sensitizers and appropriate band alignments, conductive CDs enhance electron propagation between QDs and TiO_2 resulting in fast electron transport and slow recombination; CDs provide minute sensitizer effect	[22] (63)
GQDs	CNFs	AO	CTFG (SSPPT)	5–40 nm	PEG functionalized	Electron donor	FTO/TiO_2 NFs/**GQDs**:D719/I_3^-:I^-/Pt	14.15–15.20	0.764–0.766	0.74-0.75	7.31–7.95	NR	80 °C acid oxidation with 2.6 mg GQD loading	Depends on oxidation temperature and mass of GQDs loaded; Upconversion properties of GQDs results in FRET to dye enhancing the photocurrent	[23] (65)
CDs	Graphite rods	EC	CTFG	5–10 nm	Not directly reported; inferred that they are IL-	Electrolyte dopant	FTO/TiO_2 NPs/N719/I_3^-:I^-:**CDs**:IL/Pt	1.94–6.64	0.57–0.66	0.47–0.67	0.59–2.71	NR	2.4 mg CDs:[bmim][PF_6], 23 mg [bmim]I, 10:1	Depends on mole ratio LiI:I_2, [bmim]I wt. content, and CD:IL blend employed; Introduction of CDs into electrolyte reduced charge transfer resistance, increasing electron mobility, and	[24] (86)

					stabilized since ILs were exfoliation electrolyte								μmol LiI:I_2	increased continuous illumination stability.	
GQDs	Vulcan XC-72 carbon black	AO	CTFG	~10 nm	Hydroxyl, carboxyl	CE dopant	FTO/TiO_2 NPs/N719/I_3^-:I^-/PPy:**GQDs**	11.41–14.36	0.70–0.74	0.48–0.57	4.46–5.24	NR	10% (v:v) GQDs:PPy	Depends on GQD content in CE; optimized conditions comparable to Pt CE; GQD doping increased porosity of film introducing more active sites and thereby increasing charge transfer.	[25] (81)
GDs	Glucose	MWV	D (1 kDa)	~3.5 nm	NR; presumably oxygen containing moieties	CE dopant	FTO/TiO_2 NPs/N719/Electrolyte/**GDs**:PEDOT:PSS	12.82–14.23	0.67–0.72	0.60–0.70	5.14–7.20	NR	30 v% GDs in PEDOT:PSS solution	Depends on v% of GDs; Produces rougher surface morphology of CE film resulting in enhanced electrocatalytic activity and reduced R_{CT} which translates to higher J_{SC} and η.	[26] (82)
GQDs	Carbon black	AO/MWV	NR	Depends on reaction time; 60 min gives 2–10 nm	Carboxyl, carbonyl, hydroxyl, epoxy	CE dopant	FTO/TiO_2 NPs/N719/I_3^-:I^-/**GQDs**:Carbon aerogel	11.36	0.79	0.67	5.97	NR	Devices not optimized; GQD:carbon aerogel thickness optimized (1.2 μm) with CV	Inclusion of GQDs into carbon aerogel increased catalytic efficiency at the CE compared to neat carbon aerogel due to nanoscale nature of GQDs that possess higher percentage of more energetic, catalytically active edge carbons	[27] (85)
CNDs	CA	HT	CTFG	4.1 ± 0.6 nm	Oxygen-rich functional groups, specifically carboxyl	CE dopant	FTO/TiO_2 NPs/N719/I_3^-:I^-/PANI:**CNDs**	10.3–13.8	0.76–0.78	0.67–0.72	5.71–7.45	NR	5 wt% CNDs in PANI	CNDs acted as nuclei for PANI polymerization leading to a more homogeneous nucleation to produce films with higher porosity, surface roughness, conductivity, and electrocatalytic activity. Depends on CND wt%; 1 wt% not enough to produce highly porous film giving only slight improvement, while 10 wt% led to supersaturation and subsequent aggregation of nuclei which hindered homogenous polymerization, resulting in poorer performance. Optimized (5 wt%) CE comparable to Pt CE.	[28] (223)
GQDs	CA, thiourea	HT	CTFG	1.0–5.0 nm	Hydroxyl, carboxyl, amine/amide, sulfur moieties	CE dopant	FTO/TiO_2 NPs/N719/I_3^-:I^-/PANI:**GQDs**	5.39–9.30	0.38–0.44	0.329–0.497	0.754–1.603	NR	PANI-GQD CE electropolymerized at a scan rate of 10 mV s^{-1}	Inclusion of GQDs led to mace-like morphology compared to spherical NPs when electropolymerizing neat PANI, which enhanced surface area and conductivity. Performance depends on scan rate used for electropolymerization; scan rates of 30, 50, 80, and 100 mV s^{-1} led to lower J_{SC} and FF producing a lower PCE.	[29] (224)

[a] Value calculated by authors; [b] Multiple devices characterized per each condition and/or for all device architectures (including controls)

Table S2 Bulk Heterojunction Organic Photovoltaics (Section 3.2)

Classification	Precursor(s)	Approach	Purification	CND Size	Surface functionality	CND role	Device architecture	J_{SC} (mA cm^{-2})	V_{OC} (V)	FF	η (%)	Band edges (eV)	Optimized conditions	Explanation for performance	Reference
GQDs	GSs	HT	D (3.5 kDa)	5–15 nm	Carboxyl; subsequent functionalization with aniline	Electron acceptor	ITO/PEDOT:PSS/P3HT:**GQDs**/LiF/Al	0.36–3.51	0.58–0.62	0.47–0.53	0.12–1.14	3.55/5.38	1 wt% GQDs	Depends on GQD wt%; Appropriate band alignment, improved optical properties and morphology (*i.e.*, nanoscale phase separation) of composite film,	[30] (61)
GQDs	Graphene film	EC	D (8–14 kDa)	3–5 nm	Hydroxyl, carbonyl	Electron acceptor	ITO/PEDOT:PSS/P3HT:**GQDs**/Al	0.92–6.33	0.67–0.77	0.27–0.3	0.19–1.28	4.2/4.4	Annealed device (140 °C for 10 min)	Appropriate band alignments, nanoscale size, and electron mobility within GQDs led to more interfaces for sufficient carrier separation and transportation	[31] (68)
GQDs	GO	AO	D (3.5 kDa)	NR (~5 nm from TEM)	Carbonyl, hydroxyl, epoxy	Electron acceptor	ITO/PEDOT:PSS/PTB7:PC$_{71}$BM:**GQDs**/Al	15.2–16.1	0.733–0.740	0.604–0.676	7.11–7.60	NR	0.5 wt% GQDs reduced for 5 h	Depends on wt% of GQDs and whether the as-synthesized GQDs or dots that were reduced for 5 or 10 h are employed; non-reduced GQDs (*i.e.*, highly oxygenated) show higher absorptivity while fully reduced (10 h) GQDs show higher conductivity; partially reduced (5 h) GQDs provides an optimum balance of optical absorptivity and electrical conductivity.	[32] (62)
CNDs	CA, oleylamine	SFTP/T	CTFG	1–4.5 nm	Aldehyde, carboxyl, oleylamine	Electron acceptor	ITO/PEDOT:PSS/P3HT:**CNDs**/Al	0.29	1.59	48.5	0.23	2.80–3.80/6.30	No optimization	CNDs functioned as electron acceptors but insulating oleylamine ligand layer hindered charge transport (lowered J_{SC})	[33] (64)
CQDs	D-glucose, ODA	T	CC	1–4 nm	Alkyl	Electron acceptor	ITO/PEDOT:PSS/PFO-DBT:**CQDs** (or ZnO@**CQDs**)/Al	6.0–14.8	0.80–0.88	0.26–0.32	1.5–3.9	4.1/NR (ZnO@CQDs)	40 mg mL^{-1} active layer, 1:1 wt ratio PFO-DBT:ZnO@CQDs (or CQDs)	Increased roughness of film, which led to formation of charge transport channels; large surface area of CQDs resulted in increased heterojunction interfaces reducing recombination; ZnO improved charge carrier mobility and conductivity	[34] (77)
GQDs	Double-walled CNTs	AO	UFCT (3 kDa)	3–5 nm	NR; presumably oxygen containing moieties	Co-electron acceptor	ITO/PEDOT:PSS/P3HT:PCBM:**GQDs**/LiF/Al	11.80–26.46	0.56–0.60	0.28–0.33	2.05–5.24	3.44/5.75	P3HT:PCBM weight ratio 1:0.6 with GQDs at 0.05 mg mL^{-1}	Depends on P3HT:PCBM ratio; GQD concentration not optimized, held constant; Improvement from enhanced absorption of blended film and appropriate band alignment	[35] (66)
GQDs	GO	HT	D (3.5 kDa)	27–38 nm	Carboxyl, hydroxyl, epoxy	Co-electron acceptor	ITO/MoO$_3$/PCDTBT:PC$_{71}$BM:**GQDs**/LiF/Al	10.81 ± 0.02–12.79 ± 0.04	0.85 ± 0.01–0.88 ± 0.01	0.601 ± 0.001–0.636 ± 0.002	5.55 ± 0.07–7.04 ± 0.02	4.7 (work function)	0.08 wt% GQDs[a]	Depends on GQD wt%; GQDs provide large surface areas for the formation of exciton separation (donor/acceptor) interfaces and charge transport pathways; too high of a GQD wt% causes dots to agglomerate forming parasitic pathways; GQDs increase incident light absorbed due to scattering and reflective effects	[36] (58)
GQDs	GO	AO	D (3.5 kDa)	~5 nm	Hydroxyl, carboxyl	Co-electron acceptor/active layer dopant	ITO/PEDOT:PSS/p-DTS(FBTTh$_2$)$_2$:PC$_{71}$BM:**GQDs**/Ca/Al	13.35–13.58	0.748–0.754	0.60–0.63	5.94–6.40	NR	1 wt% GQDs	Strong light scattering by GQDs increased optical path length; nanoscale GQDs led to favorable morphology and phase separation of film enhancing current density and reducing charge transfer resistance	[37] (78)
CQDs	Polystyrene-	T	OE	NR	NR	Active layer	ITO/TiO$_2$/PCDTBT:PC$_{71}$BM:**CQDs**/M	12.28–13.61	0.86–0.87	0.56–	5.98–7.05	NR	0.062 wt% CQDs[a]	Depends on CQD wt% in active layer; introduction of CQDs led to	[38] (235)

	co-maleic anhydride, EDA					dopant	oO_3/Ag			0.60				more homogenous phase separation of the active layer resulting in continuous interpenetrating networks that improved charge transfer; CQDs increased electron and hole mobility resulting in improved charge carrier transport; CQDs had minor electron donor contribution via fluorescence property	
CNPs	CA, urea	MWV	CTFG	1–5 nm	Hydroxyl, carboxyl, amine, alkyl	Active layer dopant	ITO/PEI/P3HT:ICBA:**CNPs**/MoO_3/Ag	7.74 ± 0.02–11.31 ± 0.01	0.84 ± 0.01–0.85 ± 0.01	0.5234 ± 0.0004–0.6109 ± 0.0002	3.40 ± 0.02–5.90 ± 0.02	NR	3 wt% CNPs[a]	Depends on CNP wt%; CNPs acted as scattering centers to increase light path length; inclusion of CNPs created interpenetrating network of donor/acceptor forming efficient charge separation interfaces that enhanced transport and reduced recombination; excess doping led to deterioration of network	[39] (89)
GQDs	Graphite powder	T w/ GIC	FLTR/D	NR (3–10 nm from TEM)	PEG (0.2, 1, or 3 kDa MW) functionalized	Active layer dopant	ITO/PEDOT:PSS/P3HT:PCBM:**GQDs**/Al	8.2 ± 0.9–13.8 ± 0.5	0.30 ± 0.02–0.55 ± 0.01	0.276 ± 0.04–0.542 ± 0.09	0.81 ± 0.11–4.10 ± 0.04	LUMO ~3.3	GQDs functionalized with 0.2 kDa PEG[a]	Depends on the MW of PEG; higher MWs result in poor performance possibly due to PEG wrapping around GQD or interfering with donor/acceptor domains; films showed larger more clump-like domains. Optimized MW shows higher performance than GQD free device due to faster P3HT exciton dissociation which results in absorption improvements arising from fewer bound charges. Pristine GQDs showed poor performance due to minimal oxidation from synthetic approach which leads to very few edge sites to facilitate exciton dissociation.	[40] (236)
GQDs	GO?	ST	Article not in English			Active layer dopant	ITO/PEDOT:PSS/P3HT:$PC_{61}BM$:**GQDs**/Al	1.61–2.50	0.48–0.54	0.335–0.556	0.31–0.75	NR	0.15% mass fraction GQDs with an annealing step	Article not in English however performance depends on GQD mass fraction (0.03, 0.06, 0.15, and 0.30%), subsequent reduction time of GQDs (2, 5, 10, 30, and 45 min), and whether the device is annealed or not.	[41] (237)
g-C_3N_4 QDs	Bulk g-C_3N_4 made from urea	ST	FLTR	10–20 nm	CN heterocycles, triazine, carboxyl	Active layer dopant	ITO/ZnO/**C_3N_4 QDs**:P3HT:$PC_{61}BM$ (or PBDTTT-C:$PC_{71}BM$ or PTB7-Th:$PC_{71}BM$)/PEDOT:PSS/MoO_3/Ag	11.44–16.74	0.61–0.78	0.571–0.699	4.23 ± 0.25–9.18 ± 0.19	NR	No optimization[a]	PV parameters depend on active layer employed. In all cases, the inclusion of g-C_3N_4 QDs produced higher performing devices over undoped and bulk g-C_3N_4 due to an increase in J_{SC} and, therefore, the PCE, while V_{OC} and FF remain relatively constant. Improvements attributed to (1) increased film surface roughness providing better interfacial contact, (2) increased optical absorption (and possibly scattering), (3) increased PL quenching of P3HT indicating QDs facilitate electron transfer due to their conductivity, (4) decreased impedance, and (5) increased carrier mobility.	[42] (238)
GCDs	Fumaronitrile	T	NR	3–6 nm	Hydroxy, amine, alkyl, nitrile; (pyridinic-N, pyrrolic-N within core)	Electron donor/subphotosensitizer	ITO/PEIE/PTB7:$PC_{71}BM$:**GCDs**/MoO_3/Ag	16.6 ± 0.14	0.74 ± 0.003	0.71 ± 0.03	8.4 ± 0.2	NR	No optimization[a]	Inclusion of GCDs resulted in enhanced light absorption and improved electron transport; photoexcited electrons transferred from GCDs to $PC_{71}BM$ via FRET and π-π stacking interactions between GCDs and $PC_{71}BM$ induced efficient charge transport.	[43] (71)
GQDs	GQDs:	GQDs: T-	D (2 kDa)	GQDs: ~5 nm	GQDs: hydroxyl,	GQDs: HEL	ITO/PEDOT:PSS:**GQDs**/PTB7:$PC_{71}B$	15.5 ± 0.05–	0.719 ±	0.618 ±	7.22 ±	NR	0.4 wt% GQDs in HEL and	Depends on GQD wt% in HEL and whether rGQDs are included in	[44] (240)

	Carbon fibers; rGQDs: GO	AO; rGQDs: HT			carboxyl, epoxy; rGQDs: same but much smaller amount	dopant; rGQDs: active layer dopant	M:(**rGQDs**)/TiO_x/Al	17.3 ± 0.03	0.012–0.748 ± 0.002	0.0019–0.718 ± 0.0020	0.08–8.67 ± 0.10		0.02 wt% rGQDs in active layer[a]	active layer. Inclusion of GQDs improved film morphology; negatively charged GQDs increase size of PEDOT-rich cores (grain size) and spread out grain boundaries more evenly which improves current pathways and charge conductance. GQDs also extended light scattering and light confinement; however higher wt% likely decrease light penetration negatively affecting devices. Inclusion of rGQDs in active layer decreased resistance owing to conductivity of rGQDs. Taking advantage of both improvements leads to synergistic effect, resulting in highest performance.	
GQDs	CFs	AO	D (2 kDa)	20–30 nm	NR; presumably oxygen containing moieties	Hole extraction layer	ITO/**GQDs**/P3HT:$PC_{61}BM$ or DR_3TBDT:$PC_{71}BM$/LiF/Al	9.77–11.36	0.50–0.92	0.502–0.652	2.57–6.82	4.9 (work function)	1.5–2 nm layer of GQDs[a]	Depends on donor:acceptor pair and layer thickness of GQD HEL; high conductivity and homogeneous morphology of GQD films afforded efficient HEL	[45] (67)
GQDs	Vulcan VXC-72 carbon black	AO	FLTR	~4 nm	Mainly carboxyl; some hydroxyl, epoxy	Hole extraction layer	ITO/**GQDs**/PTB7:$PC_{71}BM$ or PCDTBT:$PC_{71}BM$/LiF/Al	10.65–15.20	0.75–0.89	0.67–0.69	6.30–7.91	5.26 (work function)	No optimization	Depends on donor:acceptor pair; large quantity of carboxyl functionality increased GQD work function affording good ohmic contact with the donor polymers which improved hole extraction and suppressed recombination; high transmittance of homogeneous GQD film allowed for increased light collection.	[46] (59)
GQDs	CNFs	AO	CTFG (SSPPT); D	8–10 nm	NR; presumably oxygen containing moieties	co-hole extraction layer	ITO/PEDOT:PSS:**GQDs**/P3HT:$PC_{61}BM$/LiF/Al	14.59–16.08	0.58–0.59	0.48–0.50	4.08–4.74	5.0 (work function)	20 vol% GQDs in hole extraction organogel	Depends on vol% of GQDs added; GQDs electrostatically interacted with PEDOT chains forming core-shell like nanostructure; reorientation of the PEDOT domains improved charge hopping pathways (*i.e.*, enhanced conductivity)	[47] (69)
CNDs	CA, urea	MWV	NR	2–5 nm	NR; presumably oxygen and amine containing moieties	Buffer layer/hole extraction layer	ITO/TiO_2/PCDTBT:$PC_{71}BM$/**CNDs**/MoO_3/Ag	13.70 ± 0.07–14.71 ± 0.07	0.86 ± 0.01–0.87 ± 0.05	0.5465 ± 0.0002–0.5693 ± 0.03	6.51 ± 0.11–7.22 ± 0.13	NR	0.15 mg mL^{-1} CND solution spin-casted at 2300 rpm and annealed for 5 min. [a]	Depends on CND concentration (0.10, 0.15, 0.20 mg mL^{-1}), spin casting speed (1500, 2300, 3200 rpm), and annealing time (5 or 10 min). Incorporation of CND film lowers work function of active layer, decreasing energy barrier and promoting hole extraction, generates a rougher surface for increased reflected and scattered light, decreased current leakage, and improved hole mobility producing more balanced charge transport. At optimized concentration CNDs uniformly disperse in interfacial layer to give better phase separation and interfacial contact increasing conductivity. Low spinning speeds lead to a thick, poor quality film that increase charge recombination while high speeds produce thin poorly conducting films.	[48] (239)
CDs	CA, EDA	HT	D (1 kDa)	1–2 nm	Hydroxyl, carboxyl, amine	Buffer layer	ITO/PEDOT:PSS/DR_3TBDTT:$PC_{71}BM$ (or P3HT:$PC_{61}BM$)/**CDs**/Al	9.86–13.32	0.608–0.905	0.52–0.64	3.15–7.67	NR	0.1–0.5 mg mL^{-1} CD solution for film deposition depending upon device architecture[a]	PV parameters depend on BHJ architecture employed; in all cases incorporation of CDs as buffer layer showed enhanced parameters over no or conventional buffer layer due to improved ohmic contact, reduced current leakage, more balanced charge transport, reduced charge recombination, higher exciton dissociation, and increased	[49] (242)

														charge collection efficiency; CDs also lowered work function of Al electrode and led to more (air) stable devices.	
CQDs	Acetylene	CVD	FLTR	2–7 nm	Mostly alkyl; some hydroxyl/carboxyl	Buffer layer	ITO/PEDOT:PSS/P3HT:$PC_{61}BM$(or PTB7:$PC_{61}BM$, PTB7-Th:$PC_{71}BM$)/**CQDs**/Al	9.44–16.26	0.630–0.792	0.50–0.67	2.97 ± 0.10–8.18 ± 0.03	3.84/7.00	0.05–0.1 mg mL^{-1} CQD solution for film deposition regardless of BHJ architecture[a]	PV parameters depend on BHJ architecture employed; in all cases incorporation of CQDs as buffer layer showed enhanced parameters over no or conventional buffer layer due to improved electron-extracting, hole-blocking ability, and reduced interfacial resistance. CQD devices showed improved thermal stability due to reduced molecular diffusion. More hydrophilic CQDs showed poorer performance due to increased surface defects that hindered charge transport.	[50] (241)
GQDs	Vulcan VXC-72 carbon black	AO	FLTR	~4 nm	TMA functionalized	Buffer layer; labelled as cathode interlayer (CIL)	ITO/PEDOT:PSS/PCDTBT:$PC_{71}BM$(or PTB7-Th:$PC_{71}BM$)/**GQDs**(or Ca, LiF, ZnO)/Al (or Au, Ag)	9.42–17.39	0.76–0.91	0.6452–0.7111	5.41–8.80	NR	3–7 nm GQD layer (don't show results) with Al cathode[a]	Depends on device architecture and cathode selection: PCDTBT gives higher V_{OC} while PTB7-Th gives higher J_{SC} (and PCE); Cathode performance - Al>Ag>Au. All GQD included devices show improvement over controls and conventional buffer layers (CILs) in part from conductivity of GQDs which reduced series resistance. GQDs form interfacial dipole at metal cathode interface lowering the work function creating an ohmic contact and increasing the built-in potential across the active layer which improves charge carrier selection/extraction and suppresses charge recombination. Increasing the alkyl chain length on the functional groups from methyl to ethyl to n-butyl gradually decreases performance possibly due to decreased conductivity from more insulating functionality.	[51] (244)
GQDs	CA, ammonia	HT	D (3 kDa)	2–8 nm	NR; likely oxygen and nitrogen containing moieties	Buffer layer; labelled as conductive intermediate layer (IML)	ITO/PEI/P3HT:PCBM/PEDOT:PSS/**GQDs**[PEI/P3HT:PCBM/PEDOT:PSS]/Ag	6.61–8.95	0.58–1.15	0.49–0.61	3.15–3.72	4.9 eV (work function?; not discussed)	No optimization	Not much discussion in lieu of GQDs; mainly focused on AgNPs as the IML but showed feasibility of GQDs as IML. Compared single and tandem (architecture includes bracketed components in 'Device Architecture') cells. Both types of devices show improvement in J_{SC}, FF, and PCE over devices without GQDs. Single cells have higher J_{SC} values while tandem devices have higher V_{OC} values. Thicker layer of GQDs decreased efficiency due to lower conductivity (no results shown).	[52] (245)
GQDs	CA, L-cysteine	HT	NR	0.5–3.5 nm	NR; likely oxygen and sulfur containing moieties	Buffer layer dopant	ITO/**GQDs**-Cs_2CO_3/P3HT:PCBM/V_2O_5/Au	9.04	0.585	0.6	3.17	Only bad gap (3.3) reported	No optimization	Inclusion of GQDs into Cs_2CO_3 buffer layer promoted exciton dissociation at the P3HT/buffer interface enhancing electron transfer and hole blocking; due to wide bandgap and appropriate energy alignments	[53] (90)
GQDs	CA, L-cysteine	HT	NR	~5 nm	Carboxyl, hydroxyl, epoxy/ether, thioether	Buffer layer dopant	ITO/**GQDs**-Cs_2CO_3/P3HT:PCBM/V_2O_5/Au	~5.0–9.2	0.510–0.585	0.35–0.60	~0.90–3.23	4.04/7.34 (GQDs-Cs_2CO_3)	50% GQDs in a buffer layer annealed at 120 °C[a]	Depends on GQD concentration and slightly on annealing temperature; at higher concentrations insulating nature of oxidized GQDs plagues device performance; Optimized conditions results in excellent electron-selective buffer (*i.e.*, hole-blocking ability) that	[54] (87)

														has the appropriate work function and band alignments for effective charge dissociation	
GQDs	GNSs	LA/HT	CTFG (nothing after HT treatment)	3.5–6.0 nm	NR; presumably oxygen containing moieties	Buffer layer dopant	FTO/TiO_2 NPs/**GQDs**/P3HT/PEDOT:PSS/Pt	7.98 ± 0.18	0.757 ± 0.009	0.52 ± 0.02	3.16 ± 0.05	3.47/5.94	No optimization[a]	GQDs provide better conduits for photoexcited charge transfer and suppressed recombination; GQDs reduced energy offset between donor (P3HT) and acceptor (TiO_2) which promoted charge carrier propagation	[18] (83)
CNDs	CA, urea	MWV	CTFG	1–5 nm	Hydroxyl, carboxyl, amine	Buffer layer dopant	ITO/PEI:**CNDs**/PCDTBT:$PC_{71}BM$/MoO_3/Ag	12.34 ± 0.11–14.84 ± 0.19	0.86 ± 0.01–0.87 ± 0.01	0.4717 ± 0.01–0.5854 ± 0.03	5.01 ± 0.13–7.56 ± 0.20	4.4 (work function)	1.0 wt% CNDs in PEI buffer layer[a]	Incorporation of CNDs led to higher surface roughness and better morphology of the film which resulted in improved interfacial contact; CNDs improved built-in potential and charge mobility/transport properties and decreased recombination; slightly enhanced light absorption due to improved scattering of composite film.	[55] (243)

[a] Multiple devices characterized per each condition and/or for all device architectures (including controls)

Table S3 Solid-state Solar Cells (Section 3.3)

Classification	Precursor(s)	Approach	Purification	CND Size	Surface functionality	CND role	Device architecture	J_{SC} (mA cm^{-2})	V_{OC} (V)	FF	η (%)	Band edges (eV)	Optimized conditions	Explanation for performance	Reference
GQDs	GO	HR	NR	4–15 nm	Hydroxy, carboxyl, epoxy	Sensitizer	AZO/ZnO NWs/**GQDs**/TPD/Au	0.45	0.8	0.5	0.2	1.8–2.8/5.1–5.4	No optimization	Insufficient hole collection due to small interfacial contact between GQDs & TPD	[56] (46)
CQDs	Glucose, chitin, chitosan	ST	CTFG/FLTR	2.6-14.1 nm (depends on precursor)	Hydroxyl, carboxyl, epoxy, amine, amide	Sensitizer	FTO/ZnO Nanorods/**CQDs**/CuSCN/Au	0.054–0.674	0.175–0.300	0.35–0.44	0.006–0.077	NR	Mixture of chitin- and chitosan-derived CQDs	Depends on precursor employed to make CQDs (*i.e.*, the surface functionality of the resultant dots) evidenced by variability in internal resistance; glucose-derived dots led to higher recombination; all devices poor performance due to low internal efficiency.	[57] (44)
CDs	Glucose	HT	CTFG	~16 nm	NR; likely oxygen moieties	Electron donor/acceptor	FTO/ZnS/CdS QDs/ZnS/**CDs**/CuPc/Na_2S/MWCNT	1.70–1.88	0.564–0.605	0.31–0.36	0.34–0.35	NR/4.5	No optimization	CDs functioned as excellent electron conduits channeling charge to current collector due to high conductivity, nanoscale proximity to surrounding components, and favorable energy alignments; CdS QDs transfer electrons to CuPc via FRET which then cascade into the CDs that shuttle them to FTO; liquid electrolyte gave higher performance	[58] (72)
GQDs	Oxidized GSs	HT	D (3.5 kDa)	2–16 nm	Hydroxy, carboxyl, epoxy	HEL/EBL	In:Ga/Si/**GQDs**/Au	18.0–25.9	0.47–0.50	0.47–0.63	4.6–6.2	2.15/5.95	Methylated Si; 80 nm layer of 2–6 nm GQDs[a]	Depends on GQD size & layer thickness; due to appropriate band alignment GQDs efficiently transported holes and reduced carrier recombination at anode	[59] (60)
CQDs	Graphite Rods	EC	CTFG	2–8+ nm	NR; Likely hydroxy, carboxyl, epoxy	HEL/EBL	In:Ga/n-Si/Si NWs/**CQDs**/Au	17.6–30.1	0.34–0.51	0.31–0.59	2.6–9.1	2.26/5.56	Methylated Si; 23 nm layer of 2–6 nm CQDs	Depends on CQD size & layer thickness; due to appropriate band alignment GQDs efficiently transported holes and reduced carrier recombination at anode	[60] (79)
GQDs	rGO	AO	D (2 kDa)	NR	Hydroxyl, carboxyl, carbonyl	Down-shifting layer	**GQDs**/Ag/SiNx:H Emitter/Si wafer/BSF/Al	30.04–31.14	0.622–0.621	0.79–0.81	14.93–15.55	NR	30 mm s^{-1} coating speed (corresponds to 2.25 nm GQDs)	Depends on coating speed (*i.e.*, film thickness); thinner GQD coatings showed 'improvements' that were within variability of device preparation; thicker coatings decreased transmittance; optimized coating absorbed UV light and via fluorescence converted energy to region better utilized by Si devices	[61] (246)
CNDs	CA, EDA	HT	D (0.5 kDa)	2–8 nm	Carboxyl, hydroxyl, epoxy, amine/amide (pyridinic-N, pyrrolic-N within core)	Down-shifting layer	**CNDs**(in PVA)/SiNx NWs/Si wafer/electrode	29.55	0.53	0.7	10.96	NR	2.0% volume ratio CNDs spin-coated 8 times (optimized by EQE)	Optimized coating absorbed UV light and via fluorescence converted energy to region better utilized by Si devices, increasing the EQE between 300-400 nm	[62] (247)
CQDs	Graphite Rods	EC	CRMT	NR (<10 nm from TEM)	NR; Likely hydroxy, carboxyl, epoxy	Down-shifting layer	**CQDs**(in PMMA)/commercial Si SC	36.49–37.32	0.617–0.625	0.577–0.606	13.03 ± 0.58–14.06 ± 0.26	NR	CQDs synthesized with: 50 mA current gave highest overall PCE; 20 mA current gave largest % increase in PCE[a]	CQDs can function as modest down-shifting layers (2-5% improvements in PCE over devices without layer); performance depends on size of CQD which was influenced by applied current (10-60 mA); no correlation between CQD size and applied current was provided.	[63] (250)
GQDs	Oxidized	HT	D (3.5 kDa)	3–12 nm	NR; Likely	HEL/EBL	In:Ga/n-Si	26.07–33.93	0.51–0.58	0.50–0.65	7.99–	3–6 nm:	20 nm layer of 3–6 nm	Depends on GQD size (determined by length of sonication during	[64] (248)

	GSs				hydroxy, carboxyl, epoxy based on previous paper ref [59] (60)		(methylated)/**GQDs**/window of SiO_2:Au/graphene				12.35	2.96/6.56; 5–8 nm: 3.14/6.07; 6–12 nm: 3.74/6.01	GQDs	oxidation of GSs) and layer thickness (8, 20, 50 nm; determined by volume of GQDs deposited). Due to appropriate band alignment, (1) photogenerated charge carriers diffuse to interface and are separated by built-in electric field of the heterojunction and (2) electrons prevented from transferring from Si to graphene, minimizing recombination (evidenced by increased minority carrier lifetimes). Hole transport possibly occurs via tunneling or the existence of intermediate energy levels in GQDs. Change in GQD size affects band alignment while films thinner or thicker than 20 nm result in a nonuniform GQD layer or light-blocking effects and poor conductivity, respectively. Devices showed good stability for over 6 months (in air). Doping of graphene film using HNO3 vapor improved performance of all devices.	
GQDs	Glucose	MWV	NR	2–4 nm	NR; hydroxyl, carboxyl, epoxy based on previous report	HEL dopant	Al/n-Si (top side pyramidal array)/PEDOT:PSS:**GQDs**/Ag	31.56–36.26	0.51–0.57	0.6223–0.6387	10.02–13.22	NR	0.5 wt% GQDs in PEDOT:PSS with back surface field treatment	Depends on GQD wt% (0.1, 0.3, 0.5, 0.7, or 1). Inclusion of GQDs improves optical and electrical properties due to downconversion effect and conductivity of GQDs. GQD wt% higher than 0.5 decreases minority carrier lifetime and increases recombination likely due to GQD aggregation that forms trap sites. Higher amounts can also inhibit Si light absorption. Back surface field treatment by heavily doping the Si via a thermal diffusion of $POCl_3$ enhanced all device parameters for all GQD wt% (0-1%).	[65] (249)
GQDs	Glucose	MWV	NR	~3.4 nm	NR; hydroxyl, carboxyl, epoxy based on previous report	Down-shifting layer	Ag/ITO/n-type a-Si:H/a-Si:H/n-type Si (micropyramidal)/a-Si:H/p-type a-Si:H/ITO/**GQDs**/Ag	36.05–37.47	0.61	0.7049–0.7251	15.60–16.55	NR	0.3 wt% GQDs	GQDs downconvert UV photons to visible photons, which have longer extinction distances, increasing the probability of an absorption event and reducing power losses to defect induced recombination. All GQD concentrations (0.05, 0.1, 0.3, 0.7, 1.0, 2.0 wt%) improve performance over bare device although 0.7 wt% and higher begin to show decreased J_{SC}, FF, and PCE. Authors attribute this to poorer conductivity typically associated with thicker GQD layers; however, based on the understood device architecture this should not play a role here and would more likely result from decreased transmittance due to a thicker GQD film.	[66] (251)

[a]Multiple devices characterized per each condition and/or for all device architectures (including controls)

Table S4 Bio-inspired Devices (Section 3.4)

Classification	Precursor(s)	Approach	Purification	CND Size	Surface functionality	CND role	Device architecture	J_{SC} (mA cm^{-2})	V_{OC} (V)	FF	η (%)	Band edges (eV)	Optimized conditions	Explanation for performance	Reference
CQDs	Graphite rods	EC	FLTR/CTFG	4–30 nm	Hydroxyl, carboxyl, epoxy	Electron acceptor/donor	FTO/TiO_2 NPs/RhB/**CQDs**/I_3^-:I^-/Pt	~6.4	~0.5	NR	0.147	NR	No optimization	CQDs act as electron/energy transfer bridge between RhB and TiO2 mimicking processes involved in photosynthesis; CQDs enhanced absorbance of RhB and acted as one-way bridge, effectively separating the charge carriers and suppressing recombination.	[67] (70)
CQDs	Graphite rods	EC	CC	126 ± 8 by 77 ± 7 nm	NR; presumably oxygen containing moieties	Electron donor	Carbon paper/Thylakoid membranes/**CQDs**/Si thin film	3.1 ± 0.9 (μA/cm^2)	0.62 ± 0.02	NR	NR	NR	No optimization	Nanoscale dimension of CQDs (*i.e.*, increased surface area) creates more intimate contacts with the thylakoid membranes affording increased direct electron transfer; due to well-aligned absorbance and fluorescence properties, CQDs absorb unused photons and convert them to photosynthetic relevant wavelengths	[68] (75)
CQDs	Ascorbic acid, EDBE	MWV	OE	1–2 nm	Hydroxyl, carboxyl, amine	Electron donor	No device made	NR	NR	NR	NR	NR	No optimization	CQDs promoted photosynthesis by enhancing the electron transfer process; chloroplasts absorbance profile overlaps with CQDs emission profile (390 nm excitation) resulting in electron transfer from CQDs to chloroplasts	[69] (57)

[a] Multiple devices characterized per each condition and/or for all device architectures (including controls)

Table S5 Perovskite-based Devices (Section 3.5)

Classification	Precursor(s)	Approach	Purification	CND Size	Surface functionality	CND role	Device architecture	J_{SC} (mA cm^{-2})	V_{OC} (V)	FF	η (%)	Band edges (eV)	Optimized conditions	Explanation for performance	Reference
GQDs	Graphite rod	EC	D (3.5 kDa)	5–10 nm	Carboxyl, hydrazide (GQDs were treated with hydrazine)	Electron acceptor/donor	FTO/TiO_2/**GQDs**/$CH_3NH_3PbI_3$/Spiro-OMeTAD/Au	15.20 ± 0.78–16.81 ± 0.83	0.909 ± 0.032–0.917 ± 0.038	0.589 ± 0.029–0.618 ± 0.031	8.58 ± 0.54–9.76 ± 0.58	4.2/6.8	TiO_2 loaded with 0.5 mg mL^{-1} GQDs[a]	Depends on GQD loading; GQDs act as superfast electron funnel, enhancing the electron extraction from the perovskite sensitizer to TiO_2	[70] (80)
CQDs	CA, p-phenylenediamine	HT	CTFG	2–4 nm	NR; likely amines, carboxyl	HEL	FTO/TiO_2/$CH_3NH_3PbI_3$/**CQDs**/Au	7.83	0.515	0.74	3	2.07/5.12	No optimization	Band alignments appropriate to ensure GQDs will efficiently transfer holes while simultaneously block electrons; Low performance attributed to non-homogenous CQD film (island-like domains of CQDs), which led to poor Ohmic contact.	[71] (74)

[a] Multiple devices characterized per each condition and/or for all device architectures (including controls)

Table S6 Acronym Definitions

Acronym	Full Name	Acronym	Full Name
AD	Acid dehydration	LUMO	Lowest unoccupied molecular orbital
AO	Acid oxidation	MW	Molecular weight
AUC	Analytical ultracentrifugation	MWCNTs	Multi-walled carbon nanotubes
AZO	Aluminum-doped zinc oxide	MWCO	Molecular weight cut-off
Bmim	1-Butyl-3-methylimidazolium	MWV	Microwave
BSF	Back surface field	MWV-HT	Microwave-assisted Hydrothermal
CA	Citric acid	N3	cis-Bis(isothiocyanato) bis(2,2’-bipyridyl-4,4’-dicarboxylato)ruthenium(II)
CB	Conduction band	N719	Di-tetrabutylammonium cis-bis(isothiocyanato)bis(2,2’-bipyridyl-4,4’-dicarboxylato)ruthenium(II)
CC	Column chromatography	NP	Nanoparticles
CD	Carbon dot	NR	Not reported
CE	Counter electrode	NT	Nanotubes
CF	Carbon fiber	ODA	Octadecylamine
CND	Carbon nanodot	OE	Organic extraction
CNF	Carbon nanofiber	P3HT	Poly(3-hexylthiophene)
CNP	Carbon nanoparticles	PANI	Polyaniline
CNT	Carbon nanotube	PBDTTT-C	Poly(4,8-bis-alkyloxybenzo(l,2-b:4,5-b’)dithiophene-2,6-diylalt-(alkylthieno(3,4-b)thiophene-2-carboxylate)-2,6-diyl)
CQD	Carbon quantum dot	PC71BM	(6,6)-phenyl-C71 butyric acid methyl ester
CRMT	Chromatography	PCBM	(6,6)-phenyl-C61 butyric acid methyl ester
CTFG	Centrifugation	PCDTBT	Poly(N-9''-hepta-decanyl-2,7-carbazole-alt-5,5-(4',7-di-2-thienyl-2',1',3'-benzothiadiazole))
CV	Cyclic voltammetry	PCE	Power conversion efficiency
CVD	Chemical vapor deposition	p-DTS(FBTTh$_2$)$_2$	7,7’-(4,4-bis(2-ethylhexyl)-4H-silolo[3,2-b:4,5-b’]dithiophene-2,6-diyl)bis(6-fluoro-4-(5’-hexyl-[2,2’-bithiophen]-5-yl)benzo[c][1,2,5]thiadiazole)
D	Dialysis	PEDOT	poly(3,4-ethylendioxythiophene)
D719	Di-tetrabutylammonium cis-bis(isothiocyanato)bis(2,2’-bipyridyl-4,4’-dicarboxylato)ruthenium(II)	PEG	Poly(ethylene glycol)
DLS	Dynamic light scattering	PEI	Poly(ethylenimine)
EBL	Electron blocking layer	PEIE	Poly(ethylenimine) ethoxylated
EC	Electrochemical	PFO-DBT	Poly[2,7-(9,9-dioctylfluorene)-alt-4,7-bis(thiophen-2-yl)benzo-2,1,3-thiadiazole]
EDA	Ethylenediamine	PL	Photoluminescence
EDBE	2,2-(ethylenedioxy)bis(ethylamine)	PMMA	Poly(methylmethacrylate)
EQE	External quantum efficiency	PPy	Polypyrrole
FLTR	Filtration	PSS	poly(styrenesulfonate)
FRET	Förster resonance energy transfer	PT	Polythiophene
FTO	Fluorine doped tin oxide	PTB7	Poly({4,8-bis[(2-ethylhexyl)oxy]benzo[1,2-b:4,5-b’]dithiophene-2,6-diyl}{3-fluoro-2-[(2-ethylhexyl)carbonyl]thieno[3,4-b]thiophenediyl})
g-C_3N_4	Graphitic carbon nitride	PTB7-Th	Poly[4,8-bis(5-(2-ethylhexyl)thiophen-2-yl)benzo[1,2-b:4,5-b’]dithiophene-co-3-fluorothieno [3,4-b]thiophene-2-carboxylate]

GCD	Graphitic carbon dot	PVA	Polyvinyl alcohol
GD	Graphene dot	QD	Quantum dot
GIC	Graphite intercalation compound	rGO	Reduced graphene oxide
GNS	Graphene nanosheet	RhB	Rhodamine B
GO	Graphene oxide	SCF	Sonochemical fenton
GQD	Graphene quantum dot	SFTP	Soft template
GS	Graphene sheet	SO	Step-wise organic
HEL	Hole extraction layer	Spiro-OMeTAD	N2,N2,N2′,N2′,N7,N7,N7′,N7′-octakis(4-methoxyphenyl)-9,9′-spirobi[9H-fluorene]-2,2′,7,7′-tetramine
HR	Hydrazine reduction	SSPPT	Size-selective precipitation
HT	Hydrothermal	ST	Solvothermal
ICBA	Indene–C_{60} bisadduct	T	Thermal
IL	Ionic liquid	TEM	Transmission electron microscopy
IPCE	Incident photon to conversion efficiency	TPD	N-N'-diphenyl-N-N'-bix(3-methylphenyl)-1,1'-biphenyl)-4,4'-diamine
ITO	Indium doped tin oxide	Tris	2-Amino-2-(hydroxymethyl)propane-1,3-diol
LA	Laser ablation	UF	Ultrafiltration
LPP	Long persistence phosphor	UFCT	Ultrafiltration centrifugal tube

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