Supplementary Information

Harnessing Chirality in Nanomaterials: Advancing Photocatalysis for Hydrogen Production and Beyond

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Table S1 Representative chiral photo(electro)catalytic systems benchmarked across diverse materials and reactions.

Type	Photocatalyst	Chirality source	Light source	Reaction	Performance gain (metric)	Ref.
Chiral plasmonic	SiO_2@Au@TiO_2 nanoribbons	Tartrate-templated silica helices	CPL	RhB degradation	Matched CPL yields reaction slope −1.97 *vs*. −0.69 under opposite CPL (~2.85× enhancement).	[1]
	Gold-gap-silver nanostructures	L-/D-cysteine	CPL/LP/ dark	4-nitrophenol reduction	Matched CPL gives ~70x and 17x higher *vs*. Au and Au@Ag core–shell NPs.	[2]
	Au NP multilayer films	L-/D-phenylalanine	CPL/LP	Photo-response	Photocurrent enhanced by 2.41 under matched CPL; achiral films show little to no change in current.	[3]
	Pd-on-cAu nanorods	L-/D-cysteine	CPL/LP/ dark	TMB oxidation	Reaction kinetics maximized under matched CPL relative to opposite CPL, LP and dark conditions.	[4]
	Branched AgAuPt nanoparticles	L-/D-cysteine	CPL/LP/ dark	Water splitting	Matched CPL shows reduced overpotentials than LP.	[5]
Chiral carbon nitride	Helical rod-like g-C_3N_4	Chiral mesoporous silica	Visible	HER	7x higher H_2 evolution rate than bulk g-C_3N_4.	[6]
	Bioinspired mesoporous chiral g-C_3N_4	Cellulose nanocrystal	Visible	HER	55x higher H_2 evolution rate than bulk g-C_3N_4; achiral samples show no CPL response.	[7]
Chiral inorganic/ hybrid semiconductor	TiO_{2-x}/ Cu_xO/Pt	Cellulose nanocrystal	Visible	HER	~1.6x higher H_2 production than non-reduced analogue and ~46x *vs*. pristine TiO_2.	[8]
	COF–Cu	L-/D-cysteine	Visible	HER	~4x higher H_2 evolution rate than achiral COF control.	[9]
	TiO_2–SiO_2	N-acylamino acid C_{14}-L-AlaA	Visible	RhB degradation, HER	~97.9% removal *vs*. negligible activity for achiral TiO_2–SiO_2. ~Substantial HER activity *vs*. negligible HER activity for achiral TiO_2–SiO_2.	[10]

	Au/TiO_2	Cellulose nanocrystal/D-glucose	UV–vis	HER	4x higher H_2 evolution rate than achiral Au/TiO_2 and 31x higher than TiO_2.	[11]
	Cd-MOFs	N-(4-pyridylmethyl)-L-leucine	AM 1.5G	HER	Highest H_2 evolution with chloride ligation than formate and acetate Cd-MOF.	[12]
	Pt-CdSe@CdS nanorods	L-/D-cysteine, histidine	LP	HER	Higher H_2 evolution than racemic and Pt-free controls.	[13]
CISS-based photo-electrode	$CdSe/TiO_2$	Organic linkers	Xe lamp	Water splitting	H_2 evolution occurs at lower overpotential only with chiral linkers; achiral linkers require higher bias.	[14]
	TiO_2	Zn-porphyrins molecules	Xe lamp	OER	Substantial OER current and H_2O_2 suppressed below detection; achiral analogues produce 43 ± 5 mmol L^{-1} peroxide.	[15]
	$BiVO_4/CoO_x$	L-/D-tartaric acid	AM 1.5G	OER	O_2 FE increased from ~60% to ~80% and H_2O_2 FE reduced from >30% to <10%.	[16]
	ZnO	L-/D-methionine	Xe lamp	OER	H_2O_2 suppressed by ~5.5x and carrier lifetime extended by up to 2.4x *vs.* DL-ZnO.	[17]
	α-Fe_2O_3	L-cysteine, glutathione	Visible	Photo-response	Photocurrent increased by up to 4x and free carrier density by ~61%.	[18]
	TiS_2	L-tartaric acid	Single sunlight	OER	Enhanced photocurrent and suppressed peroxide formation *vs.* non-chiral TiS_2.	[19]

CPL: Circularly polarized light
LP: Linearly polarized light
TMB: Tetramethylbenzidine

Table S2 Representative chiral photo(electro)catalytic systems across diverse materials for CO_2RR.

Photocatalyst	**Chirality source**	**Light source**	**Reaction**	**Performance gain (metric)**	**Ref.**
Chiral polyoxometalate–Co hybrid	L-/D-1,10-phenanthroline	Visible	CO_2RR	CO production rate ~3× higher than achiral analogue with higher AQY.	[20]
$CsPbBr_3$ perovskite nanoplates (NPLs)	R-/S-MBA:Br	AM 1.5G	CO_2RR	5x CO_2RR efficiencies compared pristine $CsPbBr_3$ perovskite NPLs.	[21]
D-BiOBr/Au	D-sorbitol	Xe lamp	CO_2RR	2.43x higher CO formation rate *vs*. achiral BiOBr.	[22]
Cu-In_2S_3	L-/D-cysteine	Xe lamp	CO_2RR	Spin polarization promotes C–C coupling, yielding ethanol with ~94% selectivity while suppressing C_1 products to ~6%, compared with ~36–38% for achiral and racemic analogues.	[23]
ZnS	L-/D-cysteine	Xe lamp	CO_2RR with NH_3	Spin polarization promotes C–C coupling while suppressing competing reaction pathways relative to non-chiral analogues, resulting in average yield enhancements of 3.5% for CO and 13.6% for C_{2+} products.	[24]

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