

Supplementary Information

Study on copper-nickel co-doped anatase titania nanosphere as highly efficient photoanode material in photocatalytic and photovoltaic applications

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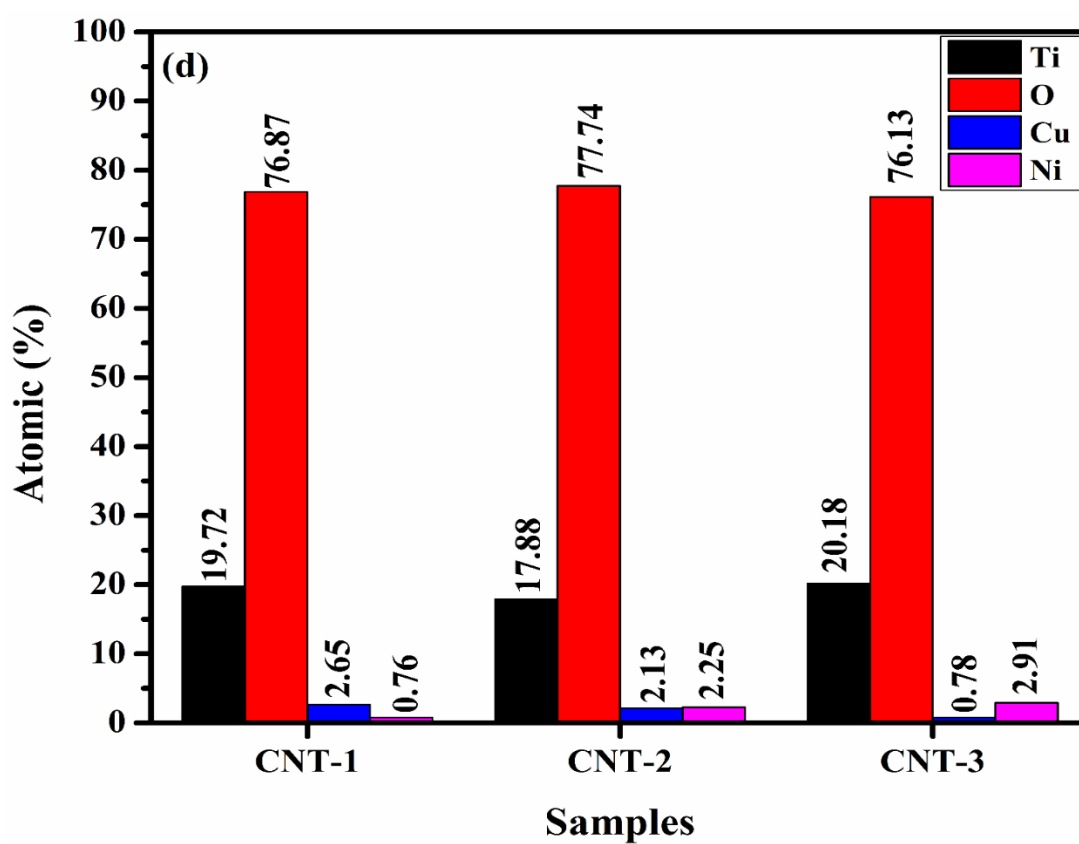


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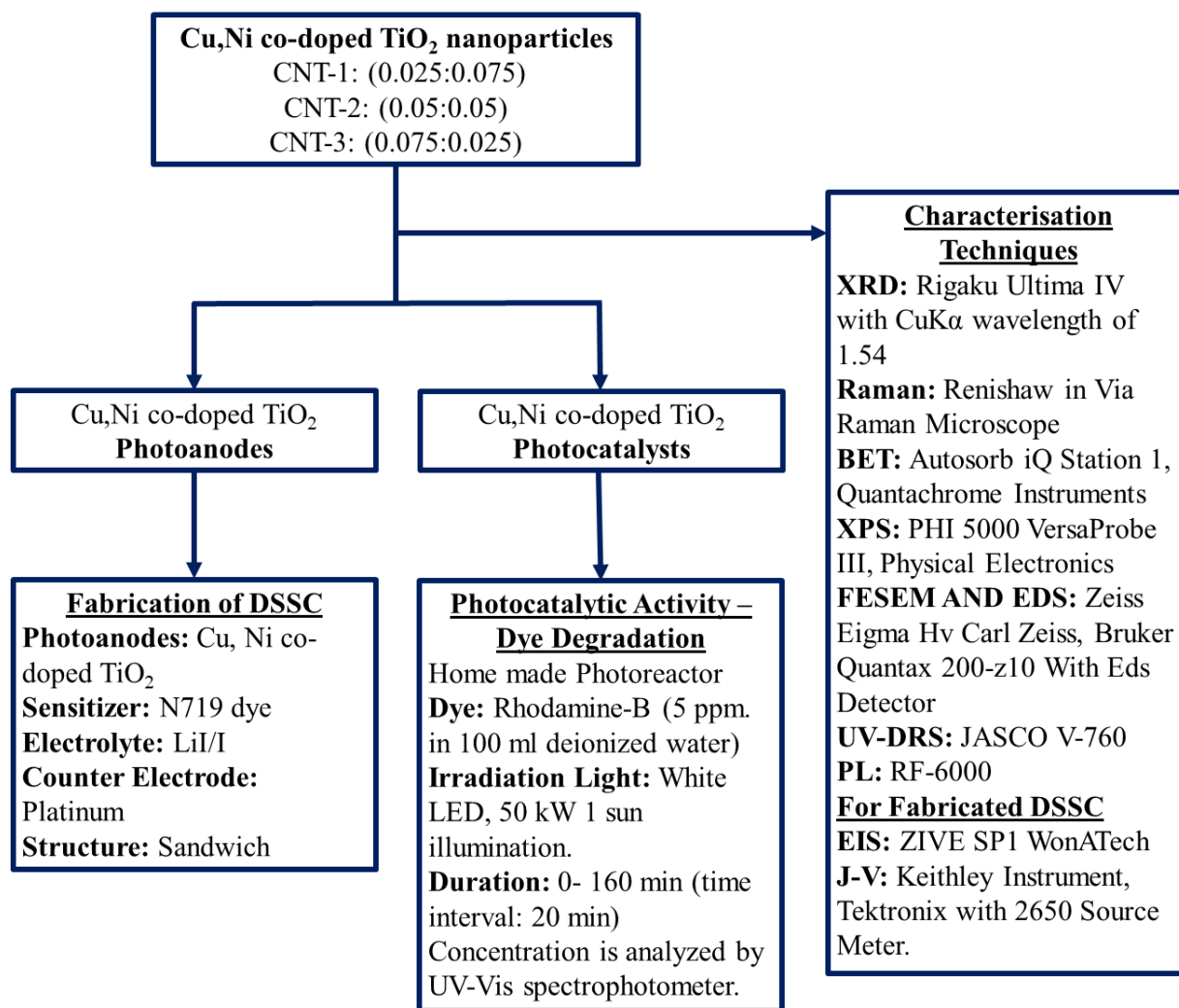


Fig. S2 Flow chart of Cu, Ni-co-doped TiO₂ nanospheres used as photoanodes and photocatalyst in DSSC and Photocatalytic activity and analyzing the characterization techniques

Table S1 Microstructural parameters of Cu, Ni co-doped TiO₂ nanospheres by sol-gel technique

Samples	Avg. Crystallite Size (nm)	Lattice Constants (Å) a = 3.782, c = 9.502	Microstrain (10⁻⁶)	Volume (Å)³
CNT-1	7.82	a = 3.791, c = 9.974	0.0047	143.3431
CNT-2	7.57	a = 3.791, c = 9.923	0.0048	142.6102
CNT-3	7.80	a = 3.793, c = 9.953	0.0047	143.1923

Table S2 BET surface area, pore volume and pore diameter of Cu, Ni co-doped TiO₂ nanospheres by sol-gel technique

Samples	BET surface area (m² g⁻¹)	Pore Volume (cc/g)	Pore Diameter (Å)
CNT-1	241.662	0.200	34.1600
CNT-2	314.984	0.466	29.5560
CNT-3	195.939	0.290	30.5760

Table S3 Pseudo first order kinetic parameters of CNT's photocatalysts against Rhodamine-B dye and degradation efficiencies

Samples	Pseudo first order Rate constant k (min⁻¹)	Regression Coefficient (R²)	Half-life degradation time (t_{1/2}) (min)	Degradation efficiencies (%)
CNT-1	0.0289	0.8747	23.9792	82.8021
CNT-2	0.0471	0.9912	14.7133	99.0833
CNT-3	0.0308	0.9812	22.5000	83.5864

Table S4 J-V parameters of fabricated DSSC using Cu, Ni co-doped TiO₂ photoanodes

Samples	V_{oc} (V)	J_{sc} (mA/cm²)	FF	Efficiency η (%)
CNT-1	1.1426	6.5638	0.6652	4.9888
CNT-2	1.2313	7.0086	0.6565	5.6653
CNT-3	0.9876	6.3457	0.6219	3.8974

Table S5 EIS parameters of fabricated DSSC using Cu, Ni co-doped TiO₂ photoanodes

Samples	R_s (Ω)	R_{ct1} (Ω)	R_{ct2} (Ω)	C_{μ} (F)	τ_e (ms)	τ_t (ms)	ϕ_c (%)
CNT-1	5.2031	4.0271	168.4000	10.3630	0.2744	0.4173	0.9963
CNT-2	5.1810	4.8300	043.0500	19.3706	0.2802	0.9356	0.9966
CNT-3	5.0820	4.6289	182.9000	07.4631	0.1071	0.9255	0.9961

Table S6 Dye degradation efficiency comparison of different doped TiO₂ nanospheres

Samples	Dye	Light sources	Time	Dye Degradation (%)	Reference
Ti ³⁺ /N co-doped TiO ₂	Rhodamine-B	300 W Xenon lamp	60 min	97.8	[60]
Porphyrin functionalized UiO-66 and kegging unit co-doped TiO ₂	Rhodamine-B	300 W Xe lamp	120 min	98.6	[61]
Fe-Co-S co-doped TiO ₂	Congo red	Sunlight	70 min	99.3	[62]
Zr-Ag co-doped TiO ₂ nanofibers	Congo red	300-W Xe lamp	120 min	99.3	[63]
Cu/Ni co-doped TiO ₂ nanospheres (CNT-2)	Rhodamine-B	White LED, 50 kW	120 min	99.08	Present work

Table S7 Comparison of DSSC efficiency with different doped TiO₂ photoanodes

Samples	V_{oc} (V)	J_{sc} (mA/cm²)	FF	Efficiency η (%)	Reference
Ca-doped TiO ₂ nanorods	0.63	7.3	0.69	2.32	[54]
Carbonate-doped mesoporous TiO ₂ nanospheres	0.73	12.16	0.61	5.4	[55]
Nickel-Zinc co-doped TiO ₂	0.694	1.436	0.459	0.76	[56]
Cobalt-rGO co-doped TiO ₂	0.618	12.83	0.593	5.24	[57]
Ho ³⁺ -Yb ³⁺ -F-Tri doped TiO ₂ nanospheres	0.76	9.45	0.69	4.96	[58]
TiO ₂ @Ag nanospheres	0.69	11.90	0.64	5.27	[59]
Cu/Ni co-doped TiO ₂ nanospheres (CNT-2)	1.23	7.00	0.65	5.66	Present work