Figure S1. High-resolution XPS spectra of C 1s for α-Fe$_2$O$_3$-CeO$_2$@Au nanocomposite
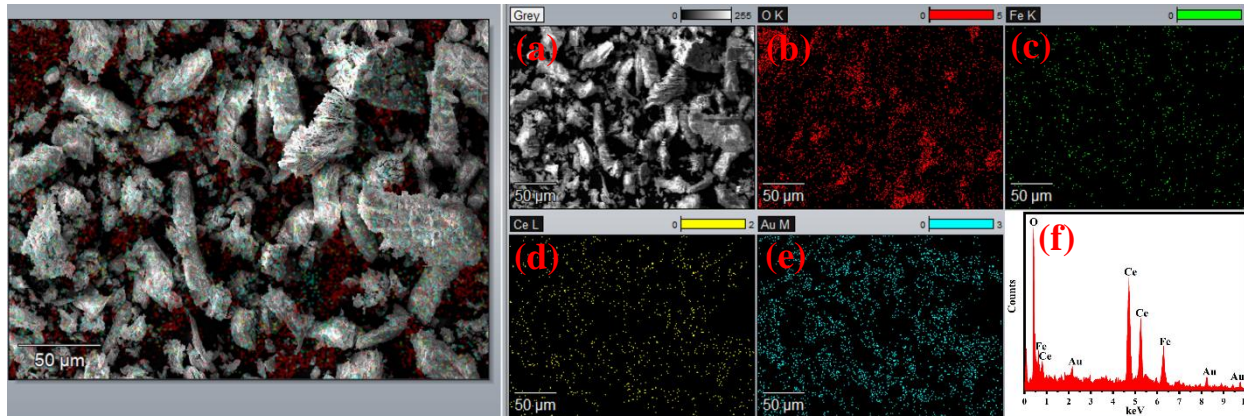

Figure S2. (a) SEM image, Elemental mapping for (b) O atoms, (c) Fe atoms, (d), Ce atoms, and (e) Au atoms; and (f) Energy-dispersive X-ray (EDX) spectra analyses of α-Fe$_2$O$_3$-CeO$_2$@Au nanocomposite.
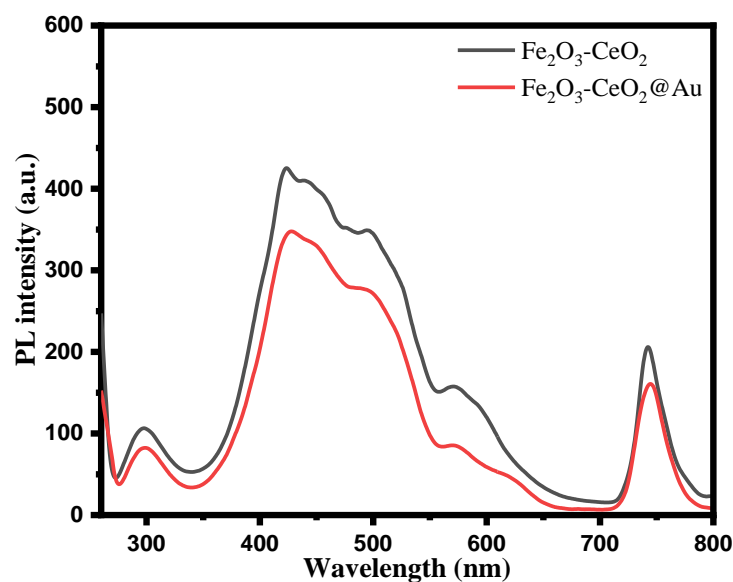
Figure S3. PL (photoluminescence) spectra of α-Fe$_2$O$_3$-CeO$_2$ and α-Fe$_2$O$_3$-CeO$_2$@Au NCs

Table S1. Literature survey of Fe$_2$O$_3$-based heterojunction in photodegradation of toxic dyes

Photocatalyst	Toxic Dye	Degradation Time	Source of light	Degradation (%)	Ref.
ZnO/Fe$_2$O$_3$	Methyl orange (MO)	90 min	UV	95%	109
CuFe$_2$O$_4$/α Fe$_2$O$_3$	Methyl Blue (MB)	120 min	solar	91 %	110
α-Fe$_2$O$_3$/g-C$_3$N$_4$/SiO$_2$	Rhodamine B (RhB)	120 min	visible	97%	111
Fe$_2$O$_3$/MoS$_2$	Acid Blue 113	45 min	visible	99 %	112
g-C$_3$N$_4$/α-Fe$_2$O$_3$	Methyl orange (MO)	300 min	visible	97%	113
g-C$_3$N$_4$/α-Fe$_2$O$_3$/V$_2$O$_5$	Methyl Blue (MB)	90 min	visible	87.5%	114
cellulose/γ–Fe$_2$O$_3$–ZrO$_2$	Congo red (CR)	30 min.	visible	98.5%	115
α-Fe$_2$O$_3$@CeO$_2$	Rose Bengal (RB)	75 min	UV	93%	34
CeO$_2$–Fe$_2$O$_3$–NiO	Methyl Blue (MB)	50 min	sunlight	73%	116
γ-Fe$_2$O$_3$@Au/MoS$_2$	Methyl Blue (MB)	4 h	green	98 %	117

α-Fe$_2$O$_3$/ BaTiO$_3$	Methyl Blue (MB)	3 h	solar	93%	118
Au@α-Fe$_2$O$_3$-CeO$_2$	Rose Bengal (RB)	120 min	visible	89%	Present work

Table S2. Pseudo-first-order reaction rate constants (k) and half-lives for the photocatalytic degradation of RB by α-Fe$_2$O$_3$-CeO$_2$@Au photocatalyst at various catalyst concentrations and initial concentrations under visible light for 120 min at pH of 7 and 30 °C

Catalyst concentration (mg/L)	k (min^{-1})	t$_{1/2}$ (min)	Dye concentration (mg/L)	k (min^{-1})	t$_{1/2}$ (min)
20	0.00895	77.43	20	0.01789	38.73
30	0.01127	61.49	30	0.01326	52.26
40	0.01395	49.67	40	0.01127	61.49
50	0.01789	38.73	50	0.00851	81.43

Table S3. Estimated band gap (E$_g$), conduction band (E$_{CB}$), and valence band (E$_{VB}$) of as-synthesized samples.

Samples	χ (eV)	E$_g$ (eV)	E$_{CB}$(eV)	E$_{VB}$ (eV)
α-Fe$_2$O$_3$	5.87	1.92	0.41	2.33
CeO$_2$	5.56	2.80	-0.34	2.46