Electronic Supplementary Material (ESI)

Dual-functional persistent luminescent nanoparticles with enhanced persistent luminescence and photocatalytic activity

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1.Experimental Section

1.1 Materials

All reagents were used as received without further purification. Ga_2O_3(99.99%),$Zn(NO_3)_2.6H_2O$(99.99%),$Bi(NO_3)_3 \cdot 5H_2O$(99.99%),$Cr(NO_3)_3 \cdot 9H_2O$ (99.95%), ethylene glycol, p-benzoquinone, isopropyl alcohol and ammonium oxalate were purchased from Aladdin (Shanghai,China), Concentrated nitric acid, aqueous ammonia (15 wt.%). was purchased from Shanghai Chemical Reagent. Ultrapure water (Hangzhou Wahaha Group Co. Ltd., Hangzhou, China) was used throughout.

1.2 Evaluation of photocatalytic performance

The 300 W mercury lamp was used as a UV light source for evaluation of the photocatalytic performance of PLNPs. The 20 mg of PLNPs sample was combined with 30 mL of a 10 mg/L aqueous RhB solution, in order to establish an adsorption-desorption equilibrium between the catalyst and the RhB, the suspension was stirred in darkness for 40 min. The suspension was then placed under UV light irradiation, and samples were taken, separated, and analyzed at regular time intervals (every 20 min) with a Shimadzu UV-2600 UV-vis spectrophotometer employed under the same conditions.

1.3 The ROS scavenging experiments

Reactive oxygen species (ROS) scavenging experiments with different scavengers, such as p-benzoquinone (BQ) as $O_2^{-}\cdot$ scavenger, isopropyl alcohol (IPA) as $OH\cdot$ scavenger, and ammonium oxalate (AO) as the hole scavenger, were carried out. [1] The detailed steps are as follows: the 20 mg of $ZnGa_{1.97}O_4:Cr_{0.01}$ / $Bi_{0.02}$ sample was combined with 30 mL of 10 mg/L RhB solution, in order to establish adsorption-desorption equilibrium between the catalyst and the dye molecules the suspension were stirred in darkness for 40 min, and then added 1 mmol of BQ、IPA and AO, respectively. Finally, the suspension was placed under UV light irradiation, and samples were taken, separated, and analyzed at regular time intervals (every 20 min) with a Shimadzu UV-2600 UV-Vis Spectrophotometer employed under the same conditions.

Table S1 The parameters of photoluminescence decay curve fitting

samples	τ_1 (s)	A_1	τ_2 (s)	A_2	τ_3 (s)	A_3	τ_{av} (s) [a]
$ZnGa_{1.99}O_4:Cr_{0.01}$	72.61	543.87	292.06	89.68	4.75	13004.07	9.35
$ZnGa_{1.98}O_4:Cr_{0.01}/Bi_{0.01}$	10.25	7482.86	10.26	6130.95	171.73	603.59	17.11
$ZnGa_{1.97}O_4:Cr_{0.01}/Bi_{0.02}$	136.77	888.32	592.18	281.92	11.53	11999.04	32.41
$ZnGa_{1.96}O_4:Cr_{0.01}/Bi_{0.03}$	111.72	331.04	648.94	41.59	6.42	13820.92	10.76

[a] $\tau_{av} = (A_1\tau_1 + A_2\tau_2 + A_3\tau_3)/(A_1 + A_2 + A_3)$

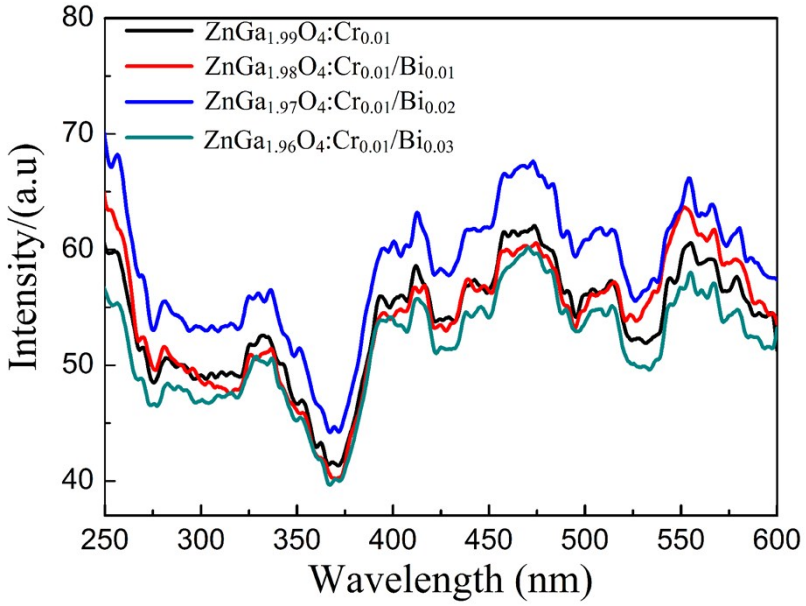

Fig. S1 Phosphorescence excitation spectra of $ZnGa_2O_4$:Cr and $ZnGa_2O_4$:Cr/Bi (obtained by monitoring 698 nm emission).

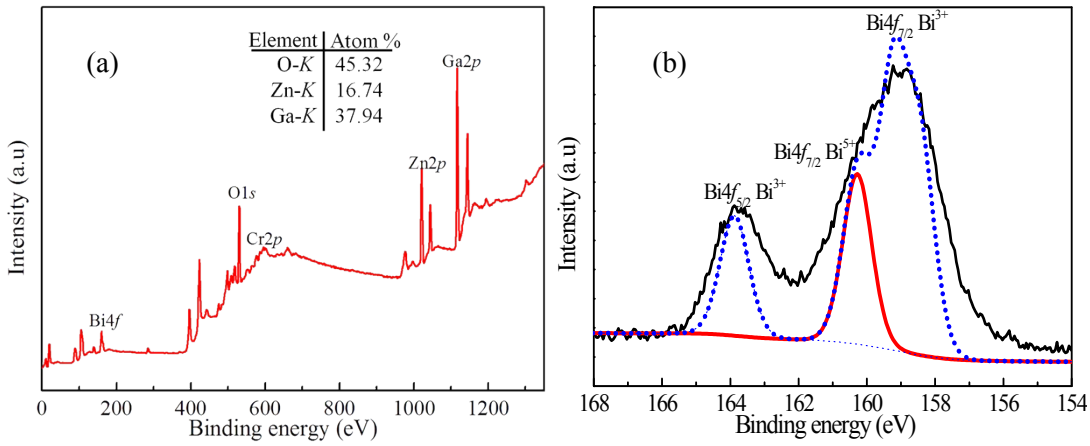

Fig. S2 Survey XPS spectrum (a) and Bi 4f XPS spectrum (b) of the $ZnGa_{1.97}O_4:Cr_{0.01}$ / $Bi_{0.02}$

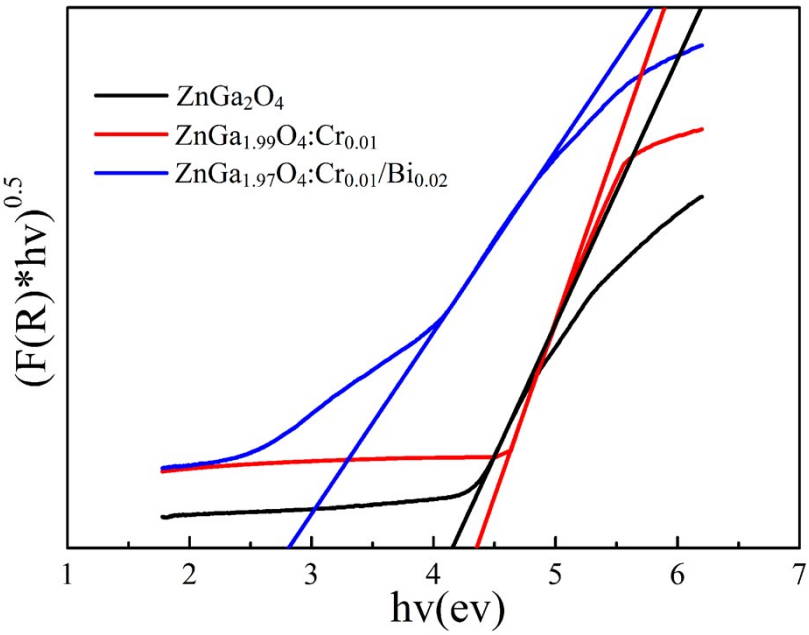

Fig. S3 Band gap of $ZnGa_2O_4$、$ZnGa_2O_4$:Cr and $ZnGa_{1.97}O_4$:$Cr_{0.01}$/$Bi_{0.02}$

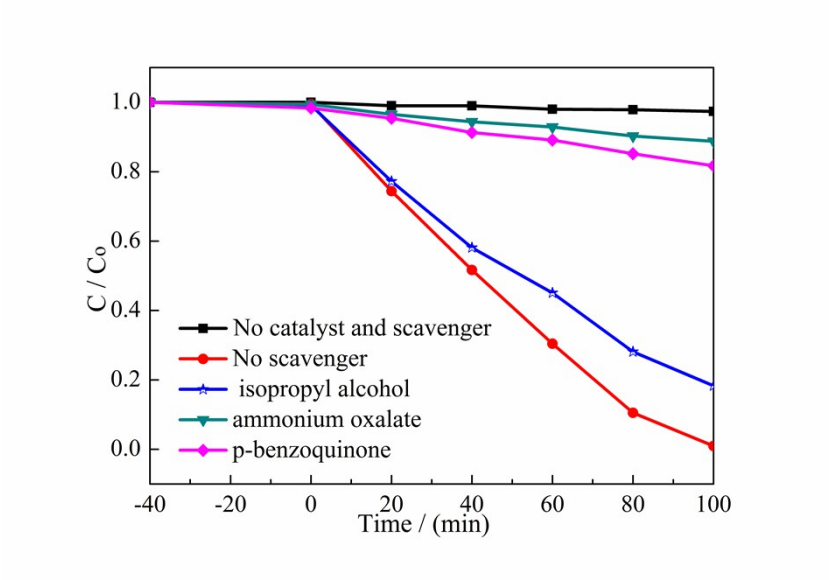

Fig. S4 The photo-degradation efficiency of $ZnGa_{1.97}O_4:Cr_{0.01}/Bi_{0.02}$ for RhB in the presence of various ROS scavengers.

4. References

[1] B. M. Pirzada, Pushpendra, R. K. Kunchala, B. S. Naidu, *ACS Omega,* 2019, **4**, 2618-2629.