Electronic Supplementary Material (ESI) for Physical Chemistry Chemical Physics.

Supporting Information

Improving Photocatalytic Performance of ZnO via Synergistic Effects of Ag Nanoparticles and Graphene Quantum Dots

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Table S1 Process for producing the precursor aqueous solutions for the six samples.

Sample number	Process for producing the precursor aqueous solutions
(1)	233μl $Zn(NO_3)_2$+2ml H_2O+3h UV light irradiation
(2)	233μl $Zn(NO_3)_2$+2ml GQDs+3h UV light irradiation
(3)	233μl $Zn(NO_3)_2$+2ml H_2O+100μl$AgNO_3$ +3h UV light irradiation
(4)	233μl $Zn(NO_3)_2$+2ml GQDs+100μl$AgNO_3$+3h UV light irradiation
(5)	100μl $AgNO_3$+2ml GQDs+3h UV light irradiation+233μl $Zn(NO_3)_2$
(6)	233μl $Zn(NO_3)_2$+2ml GQDs+100μl$AgNO_3$

Sample (1) was designed to obtain a pure ZnO film, while sample (2) and (3) was used to obtain ZnO-GQDs and Ag-ZnO binary films. The three samples all prepared with UV irradiation for 3 h before annealing treatment. In the case of sample (4), Zn $(NO_3)_2$ and $AgNO_3$ were added to the GQDs solution simultaneously, stirred for 30 min, and then irradiated under UV light for 3 h to obtain the precursor solution. This sample was used to investigate the effects of Zn^{2+} ions on the formation of Ag NPs in the precursor solution. Sample (5) was an experimental sample, prepared as the experimental details. Sample (6) was deigned to study the effects of UV irradiation on the formation of Ag NPs in the GQDs solution, which Zn $(NO_3)_2$ and $AgNO_3$ were added to the GQDs solution simultaneously and stirred for 30 min without UV irradiation. After those six precursor solution prepared, annealing treatment was performed in the same rapid heat treatment furnace.

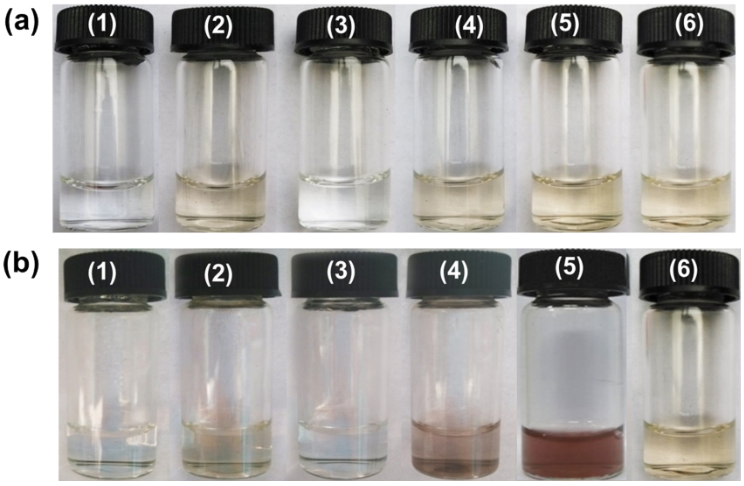

Figure S1 The color change of the precursor solution for six samples (a) before and (b) after UV light irradiation (except for sample 6).

It can be seen that precursor solution for sample (4) and sample (5) exhibited obviously color change before and after UV-light irradiation which confirmed the formation of Ag NPs in GQDs solution, while, the precursor solution for sample (4) displayed lighter color than sample (5) probably due to the competitive electrostatic absorption of Zn cations and Ag cations with GQDs which suppressed the formation of Ag NPs.

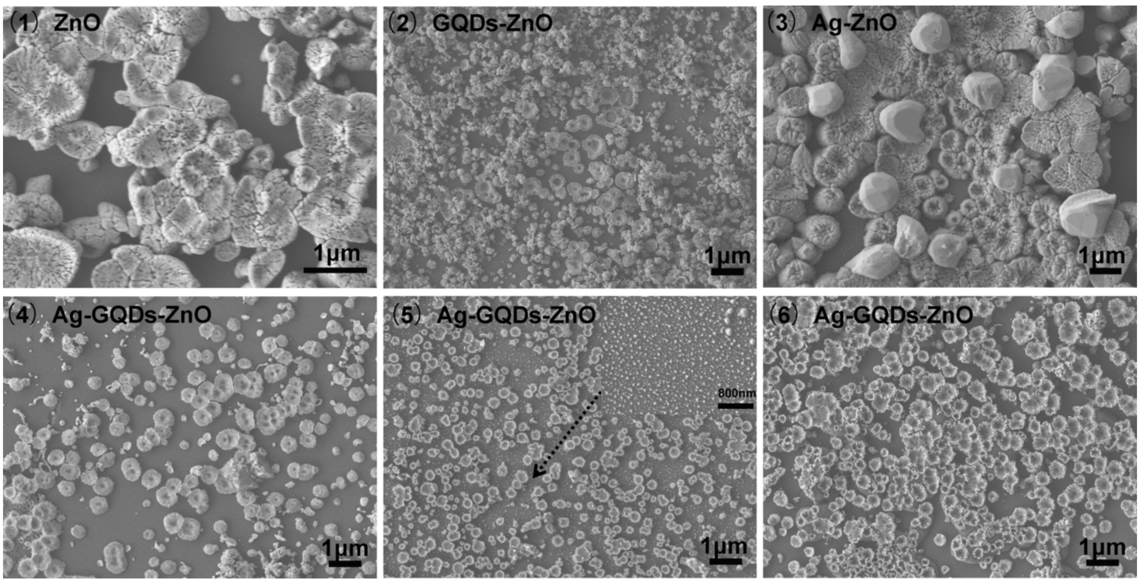

Figure S2 Typical SEM images of six films (inset: part amplified of sample (5)). ((1) Pure ZnO film, (2) GQDs-ZnO binary film, (3) Ag-ZnO binary film,(4) Ag-GQDs-ZnO ternary films with Zn $(NO_3)_2$ and $AgNO_3$ were added to the GQDs solution simultaneously (5) Ag-GQDs-ZnO ternary films with advanced formation of Ag-GQDs (6) Ag-GQDs-ZnO ternary films without UV irradiation.

The distinct morphologies of six films were clear that the use of GQDs-solution as solvent can efficiently decrease the size of ZnO flowers and form the uniform island distribution. The reason was that GQDs could act as an obstacle during annealing process that prevents the ZnO gain growth and recombination.