Electronic Supplementary Information

Role of Urea on Structural, Textural, and Optical Properties of Macroemulsion-assisted Synthesized Holey ZnO Nanosheets for Photocatalytic Applications

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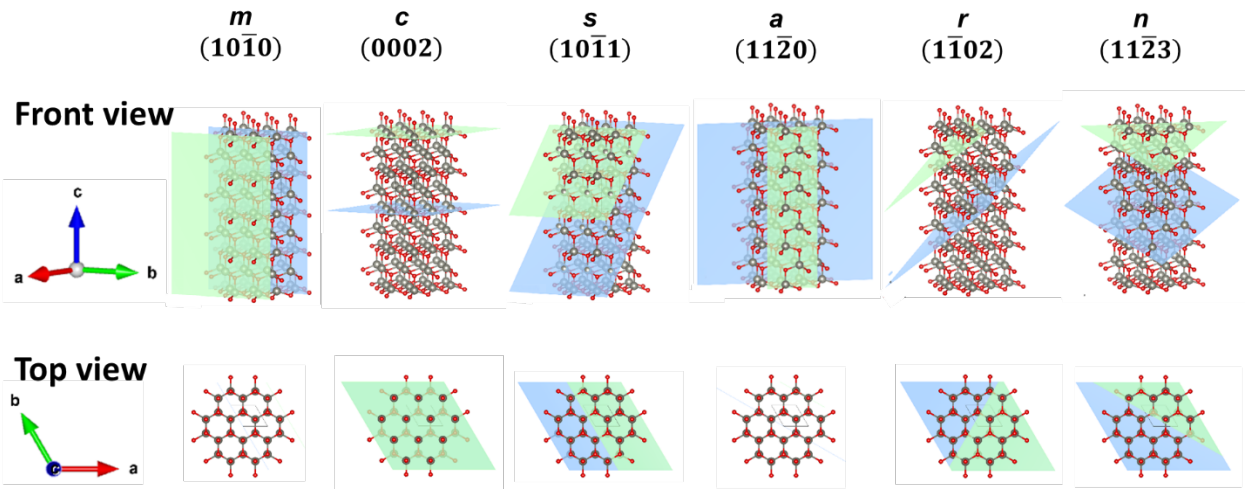

Fig. S1. Front view and top view of the six different low-index crystallographic planes in wurtzite ZnO (CIF 2300450, Crystallography Open Database), red and grey atoms represent O and Zn, respectively.

Table S1. Recent studies on the morphology-controlled syntheses of zinc oxide and their properties.

Synthesis method	Morphology	BET surface area ($m^2\ g^{-1}$)	Average pore diameter (nm)	Total pore volume ($cm^3\ g^{-1}$)	Bandgap energy	Ref.
Homogeneous precipitation	Hierarchically structured aggregates	84.0	16.0	0.253	N/A	1
Interface precipitation	Hierarchically structured aggregates	60.0	27.0	0.242		
Microwave hydrothermal and solvothermal process	Marigold-flower like	16.6	22.0	0.05	3.194	2
	Multipod-jasmine-flower like	14.7	19.5	0.07	3.157	
	Sea urchin-rod-flower like	12.6	38.7	0.11	3.153	
	Calendula-flower like	10.7	11.3	0.02	3.147	
	Rice-grain-shape like	14.9	18.4	0.16	3.114	

Synthesis method	Morphology	BET surface area ($m^2 g^{-1}$)	Average pore diameter (nm)	Total pore volume ($cm^3 g^{-1}$)	Bandgap energy	Ref.
Solvothermal process	Prism	15.5	N/A	N/A	N/A	3
	Polyhedron	20.1				
	Sphere	12.9				
Hydrothermal process	Hexagonal microstructure	4.30	N/A	N/A	2.99	4
		8.40			3.11	
		27.6			3.11	
		32.0			3.11	
	Doughnuts like	94.7			3.11	
Schlenk techniques	Nanocones	12.1	N/A	N/A	3.21	5
	Nanorods	15.6			3.15	
Microwave processing of a precipitate	Cone-shaped	19.1	14.2	0.0710	3.36	6
	Thin platelike aggregates	24.8	20.5	0.1147	3.35	
	Cone-shaped	15.5	25.7	0.0732	3.36	
Refluxed process	Nanosheets	83.0	7-16	N/A	3.21	7
	Nanorods	18.0	N/A	N/A	3.18	
	Nanodisks	46.0	5-8	N/A	3.15	
Thermal decomposition	Nanopyramids	N/A	N/A	N/A	3.20	8
Hydrothermal process	Nanoflakes				3.27	
	Nanocolumns				3.24	
Hydrothermal process	Hexagonal column	N/A	N/A	N/A	3.15-3.20	9
	Double hexagonal column				3.13-3.21	
Microemulsion method	Hexagonal-disk	35.0	N/A	N/A	3.35	10
	Brick-type	25.0			3.33	
	Sharp needle-like	23.0			3.31	
Microwave process	Nanospheroidal	N/A	N/A	N/A	3.20-3.24	11
Low-temperature hydrothermal processing of a precipitate	Micro-rods	N/A	N/A	N/A	3.16	12
	Partly ordered hexagonal prism rods				3.17	
	Ordered hexagonal prism rods				3.18	
	Ellipsoids				3.19	
	Spheroids				3.20	
	Nanospheres				3.22	

Synthesis method	Morphology	BET surface area ($m^2 g^{-1}$)	Average pore diameter (nm)	Total pore volume ($cm^3 g^{-1}$)	Bandgap energy	Ref.
Simple wet chemical method	Nanoflower	N/A	N/A	N/A	3.40	[13]
Sol-gel chemical process	Hexagonal rods	N/A	N/A	N/A	3.20	[14]
	A mix of thin hexagonal rods and wide slates				3.22	
	Globular shaped particle-like structure				3.33	
	Very short hexagonal rods				3.19	
Solvothermal process	Hexagonal nanoplates	14.4	N/A	N/A	N/A	[15]
	Nanorods	7.43				
Hydrothermal process	Nanoflakes	20.9	N/A	N/A	N/A	[16]
Refluxed process	Nanosheets	25.7	N/A	N/A	N/A	[17]
Thermal decomposition	Flower-like nanorods	N/A	N/A	N/A	3.37	[18]
Solvothermal process	Hexagonal tetrakaidecahedral	17.7	N/A	N/A	N/A	[19]
	Pencil stub-like	4.76				
Hydrothermal process	Flower-like aggregates	21.8	3.8	0.042	N/A	[20]

Table S2. Detailed amounts of all chemicals used to synthesize the ZnO products reported in this study.

Sample name	Composition					
	$Zn(CH_3COO)_2 \cdot 2H_2O$ (g)	Urea (g)	CTAB (g)	H_2O (mL)	Toluene (mL)	Butanol (mL)
ZnO_U0	1.4553	0	0.4957	11.87	17.17	1.21
ZnO_U0.5	1.4457	0.1966	0.4925	11.80	17.06	1.20
ZnO_U1	1.4363	0.3907	0.4893	11.72	16.95	1.19
ZnO_U2	1.4179	0.7713	0.4830	11.57	16.73	1.18

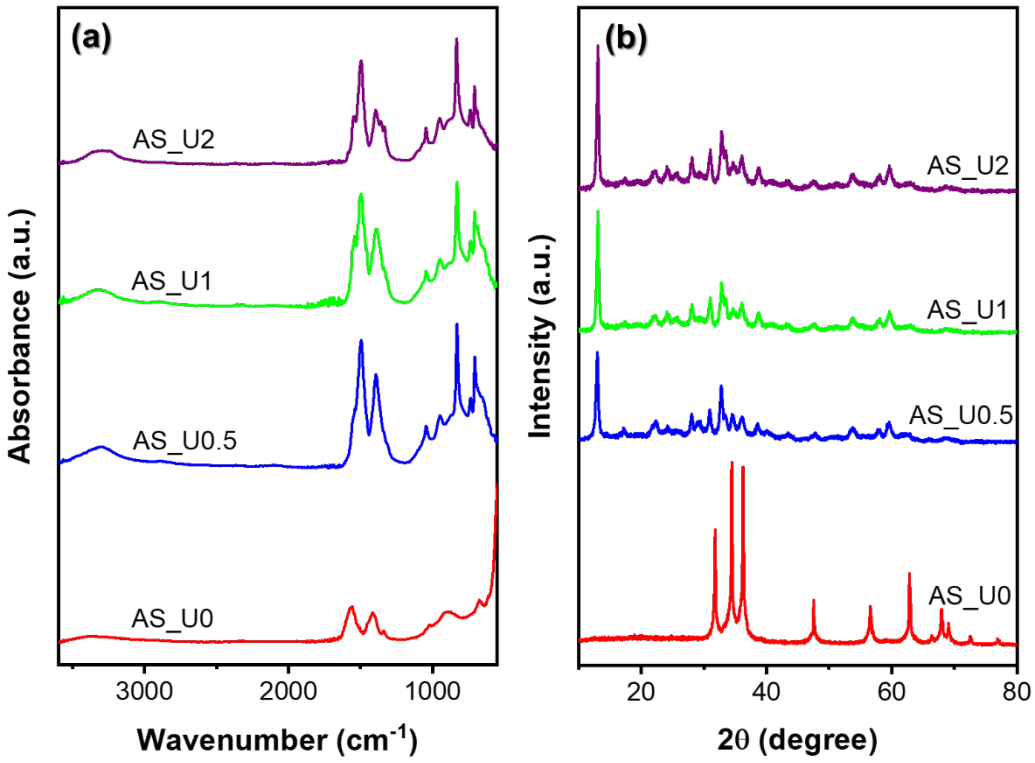

Fig. S2. Structural analyses of as-synthesized products before calcination: (a) FTIR spectra and (b) XRD patterns.

Table S3. Rietveld refinement parameters of synthesized ZnO samples

Sample name	R_p (%)	R_{wp} (%)	R_{exp} (%)	χ^2
ZnO_U0	12.2	15.0	12.4	1.466
ZnO_U0.5	13.1	16.1	15.9	1.030
ZnO_U1	13.2	16.0	15.7	1.039
ZnO_U2	10.0	13.2	12.6	1.860

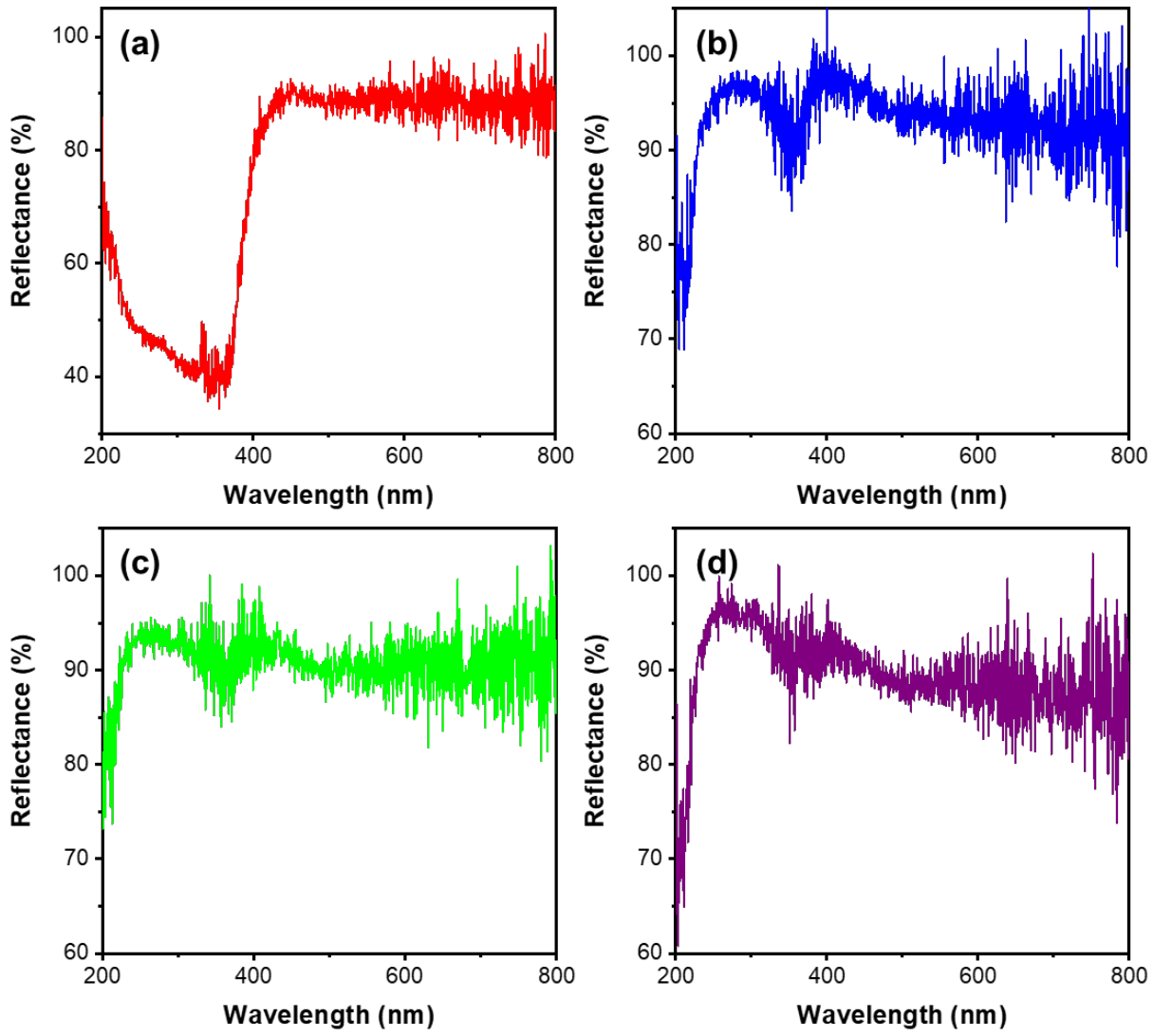

Fig. S3. UV-vis diffuse reflectance spectra of as-synthesized samples before calcination: (a) AS_U0, (b) AS_U0.5, (c) AS_U1, and (d) AS_U2.

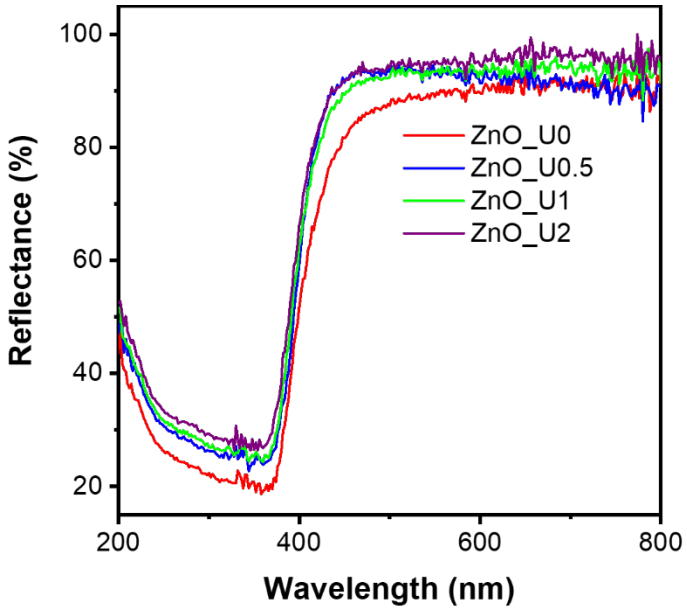

Fig. S4. UV-vis diffuse reflectance spectra of the synthesized ZnO samples.

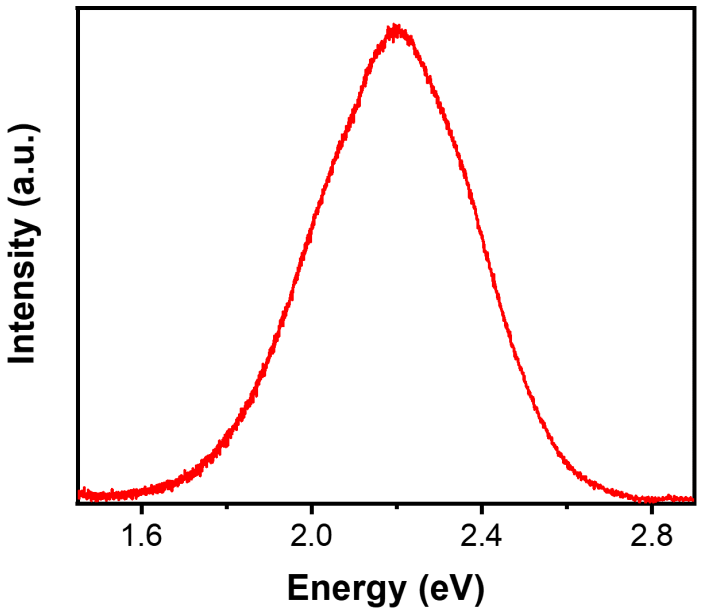

Fig. S5. Photoluminescence spectrum of commercial ZnO (Merck, CAS No:1314-13-2).

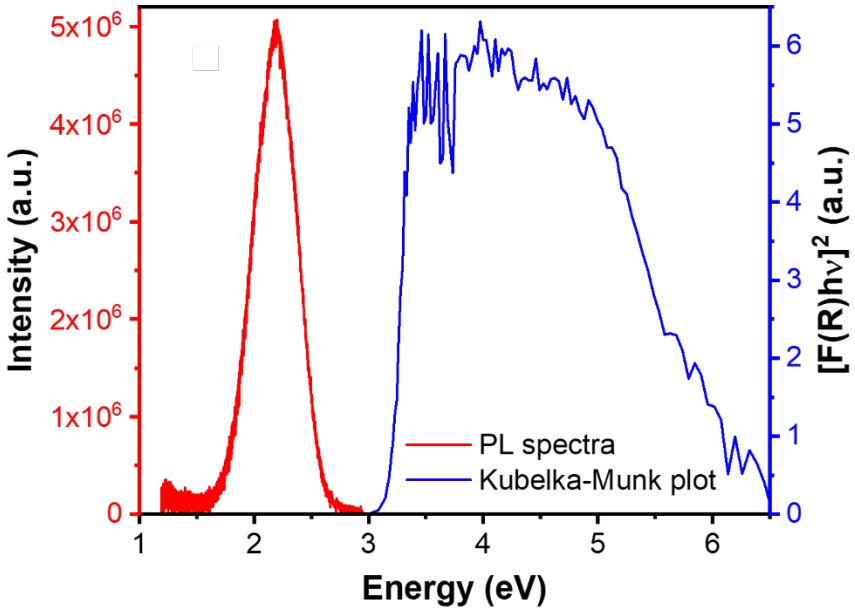

Fig. S6. Photoluminescence spectra and the Tauc plot of ZnO_U2 sample, revealing the presence of electronic state inside the bandgap caused by crystal defects.

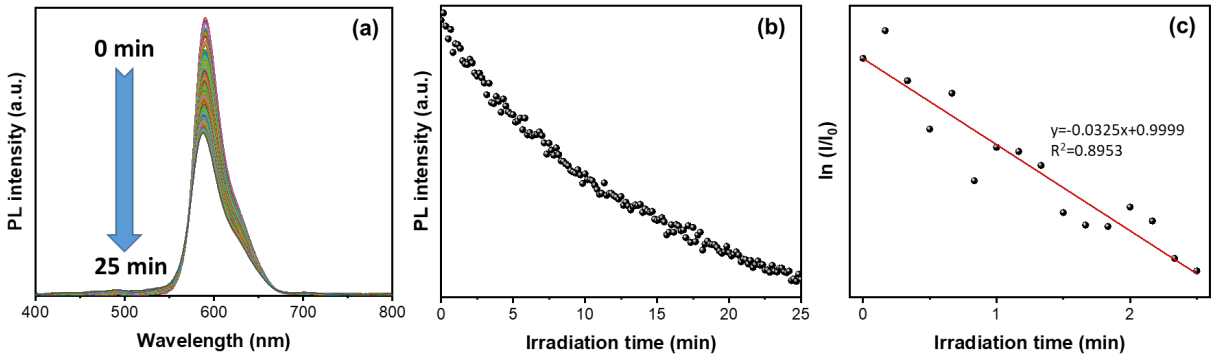

Fig. S7. Photodegradation of rhodamine B without the ZnO photocatalyst. (a) PL spectra with respect to irradiation time, (b) evolution of PL intensity, and (c) first-order kinetic plot.

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