

Supplementary Data

N=N bond cleavage of azobenzene *via* photocatalytic hydrogenation with Dy-doped Zn(O,S) : The progress from hydrogen evolution to green chemical conversion

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Table S1 EDS analysis results of as-prepared Dy-Zn(O,S) catalysts with different Dy contents

Catalyst system	Elements in Catalyst			
	Dy	Zn	O	S
Dy-Zn(O,S)-0	0%	47.96%	27.3%	24.74%
Dy-Zn(O,S)-5	0.11%	43.99%	27.57%	28.37%
Dy-Zn(O,S)-10	0.89%	32.25%	49.10%	17.77%
Dy-Zn(O,S)-20	1.66%	37.47%	42.32%	18.54%

Table S2 XPS composition analysis for Zn(O,S) with and without Dy doping

Catalyst	Molar percentages				Oxygen percentages			Cation/anion ratio
	Zn ²⁺	Dy ³⁺	O ²⁻	S ²⁻	O _{lattice}	O _{vacancy}	O _{O-H}	
Dy-Zn(O,S)-0	47.34%	0.00%	28.45%	24.21%	17.17%	5.37%	5.91%	1.14
Dy-Zn(O,S)-10	46.91%	0.83%	24.98%	27.28%	17.46%	3.89%	3.63%	1.05

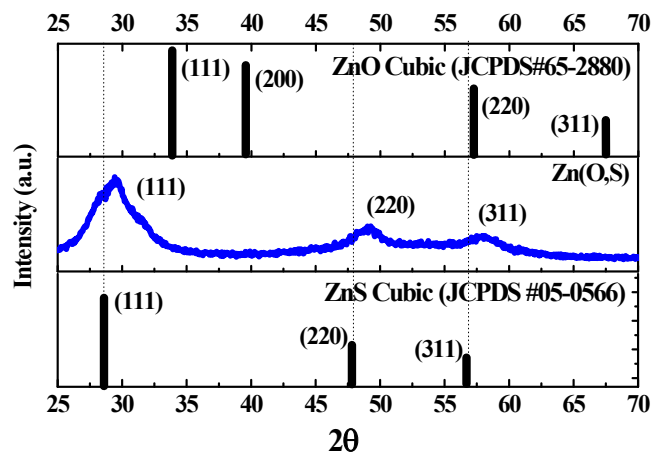


Figure S1 XRD patterns of Zn(O,S) NPs with (111), (220), and (311) planes located between those in ZnS (JCPDS #05-0566) and ZnO cubic (JCPDS #65-2880).

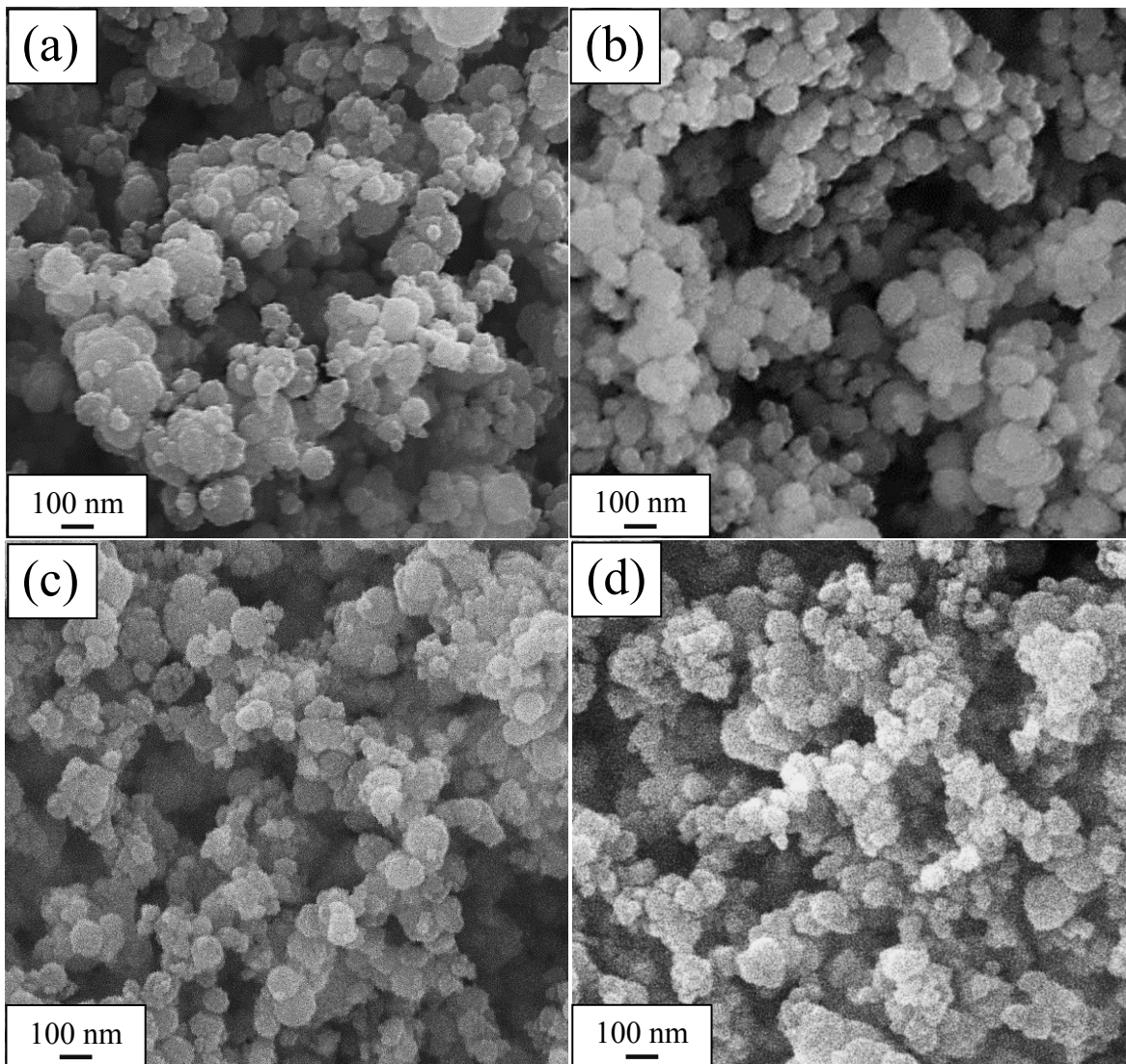


Figure S2 SEM images of Dy-Zn(O,S) nanoparticles with Dy precursor contents prepared at (a) 0%, (b) 5%, (c) 10%, and (d) 20%.

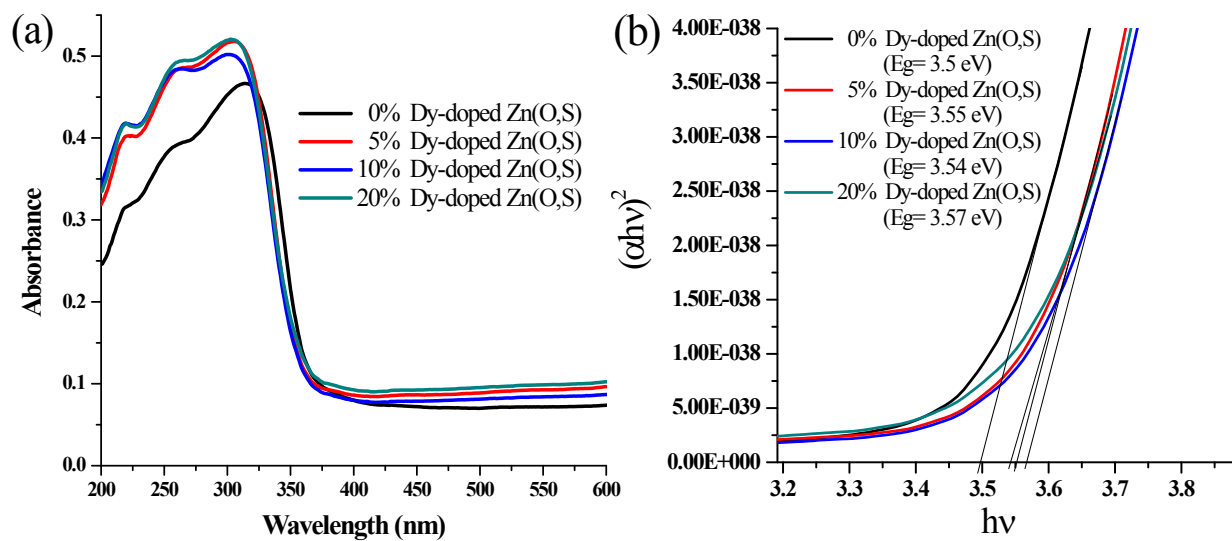


Figure S3 (a) Diffuse reflectance spectra and (b) its converted Tauc plots of Dy-Zn(O,S) prepared with different precursor amounts of 0%, 5%, 10%, and 20%.

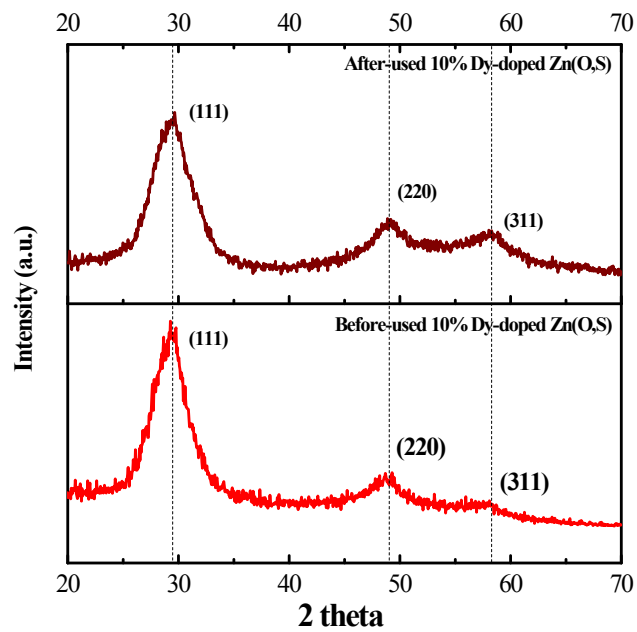


Figure S4 XRD patterns of Dy-Zn(O,S)-10 before and after used for photocatalytic hydrogenation of 4-NP to 4-AP.

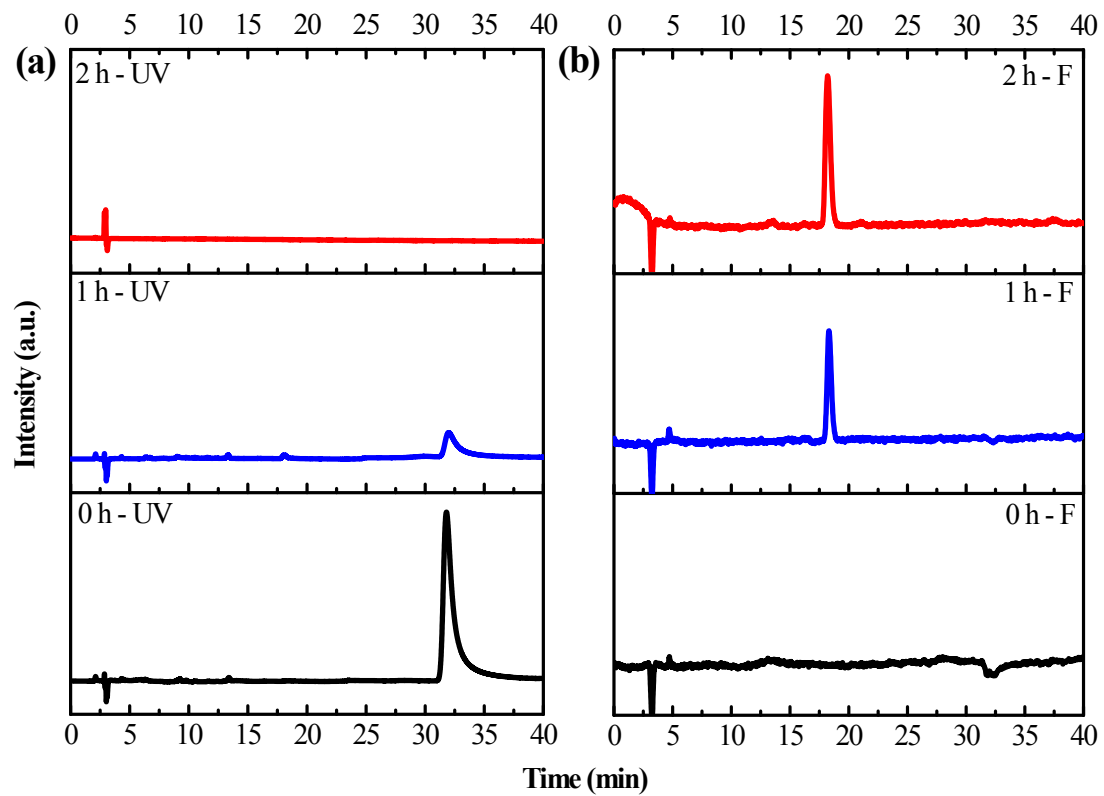


Figure S5 High performance liquid chromatograms of (a) 4-NP and (b) 4-AP solutions after photocatalytic reduction in the presence of Dy-Zn(O,S)-10 with different reaction times using UV and fluorescent detectors, respectively.

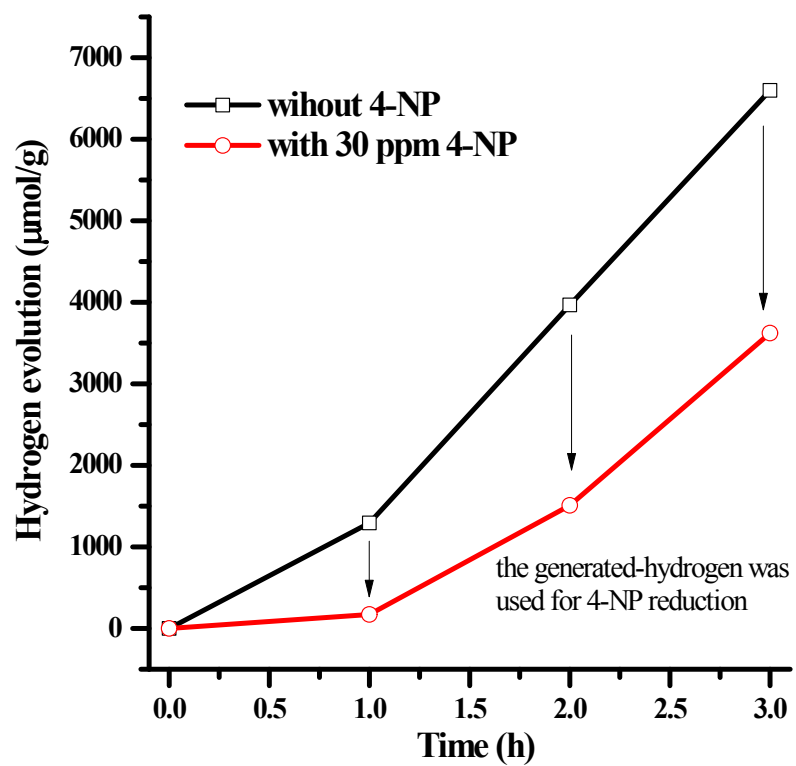


Figure S6 Hydrogen evolution obtained from photocatalytic reaction on Dy-Zn(O,S)-10 with and without 30 ppm 4-NP in sodium sulfite solution.

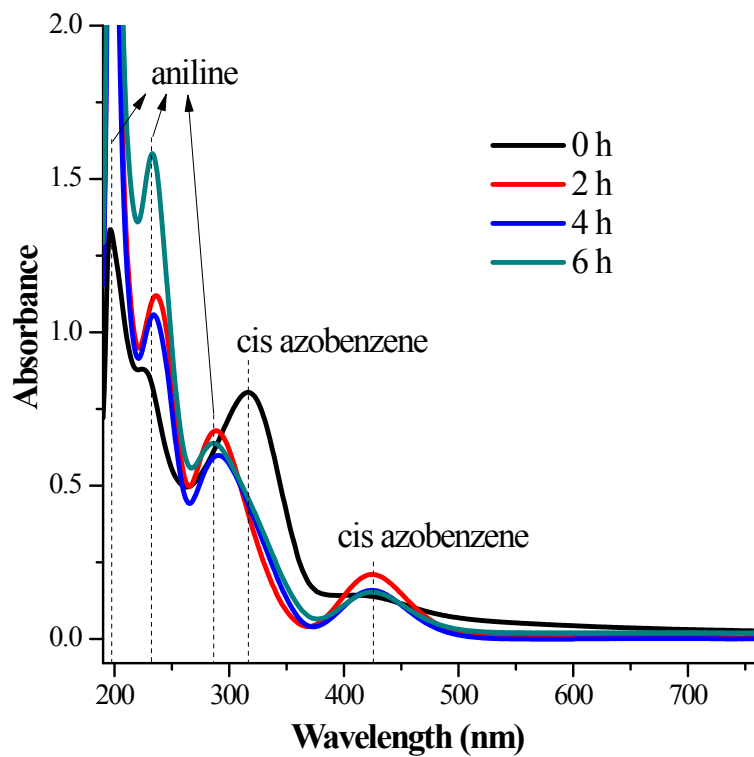


Figure S7 UV-vis absorbance spectra of azobenzene solution with different photo reaction times in the presence of Dy-Zn(O,S)-0

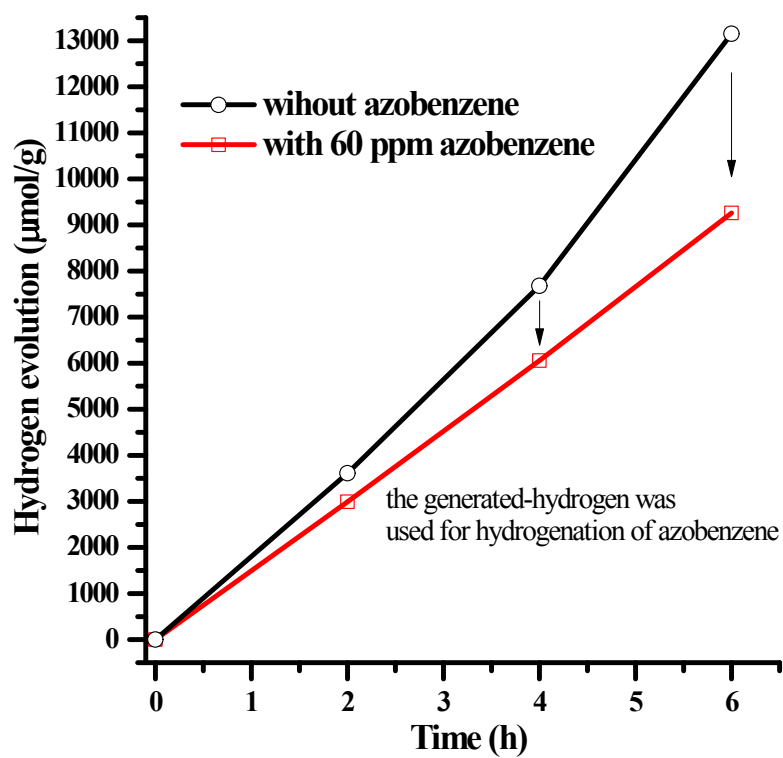


Figure S8 Hydrogen evolution obtained from photocatalytic reaction on Dy-Zn(O,S)-10 nanoparticles with and without 60 ppm azobenzene in 10% ethanol solution.

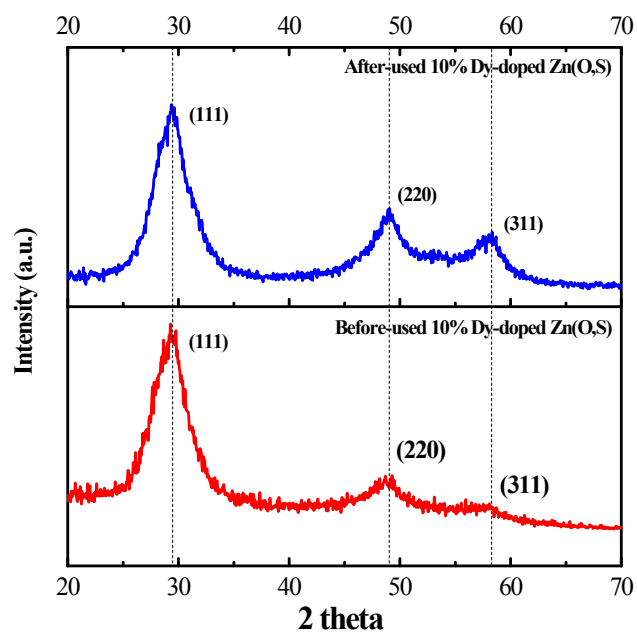
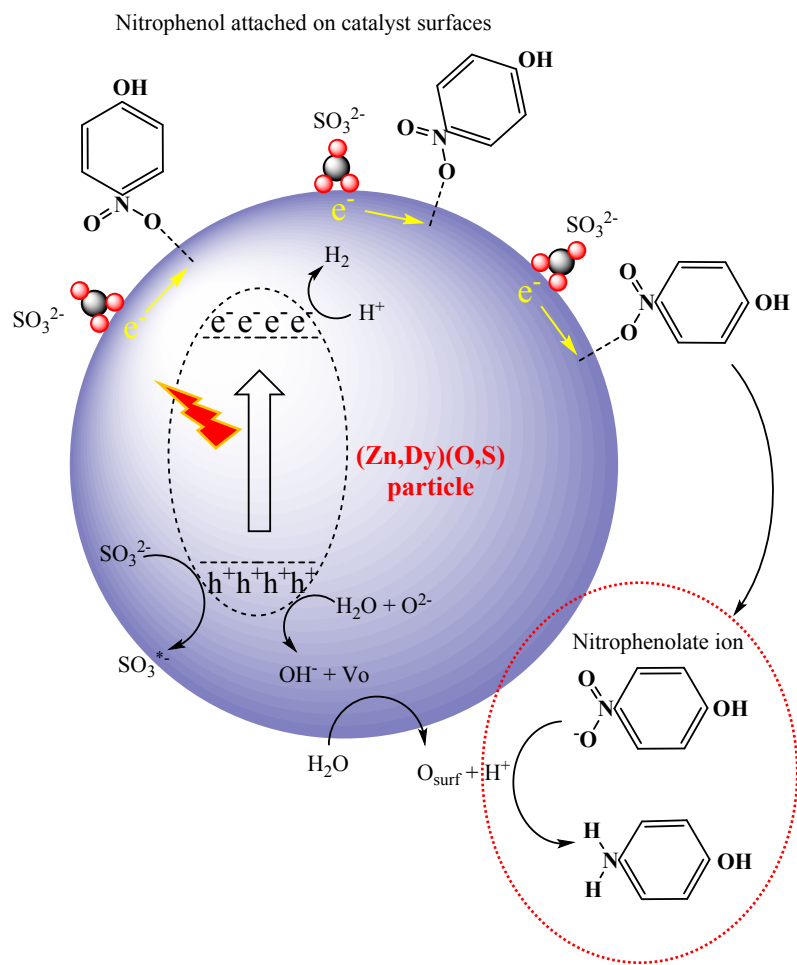


Figure S9 XRD patterns of Dy-Zn(O,S)-10 before and after the photocatalytic hydrogenation of azobenzene to aniline.



Steps of 4-nitrophenol reduction:

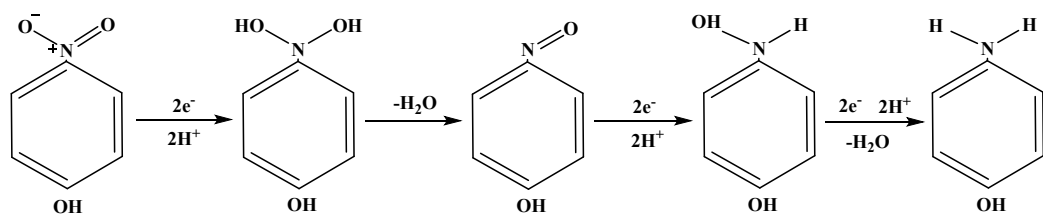


Figure S10 Schematic mechanism of 4-nitrophenol reduction in the presence of Dy-Zn(O,S)-10 nanoparticle under low intensity of UV light illumination.

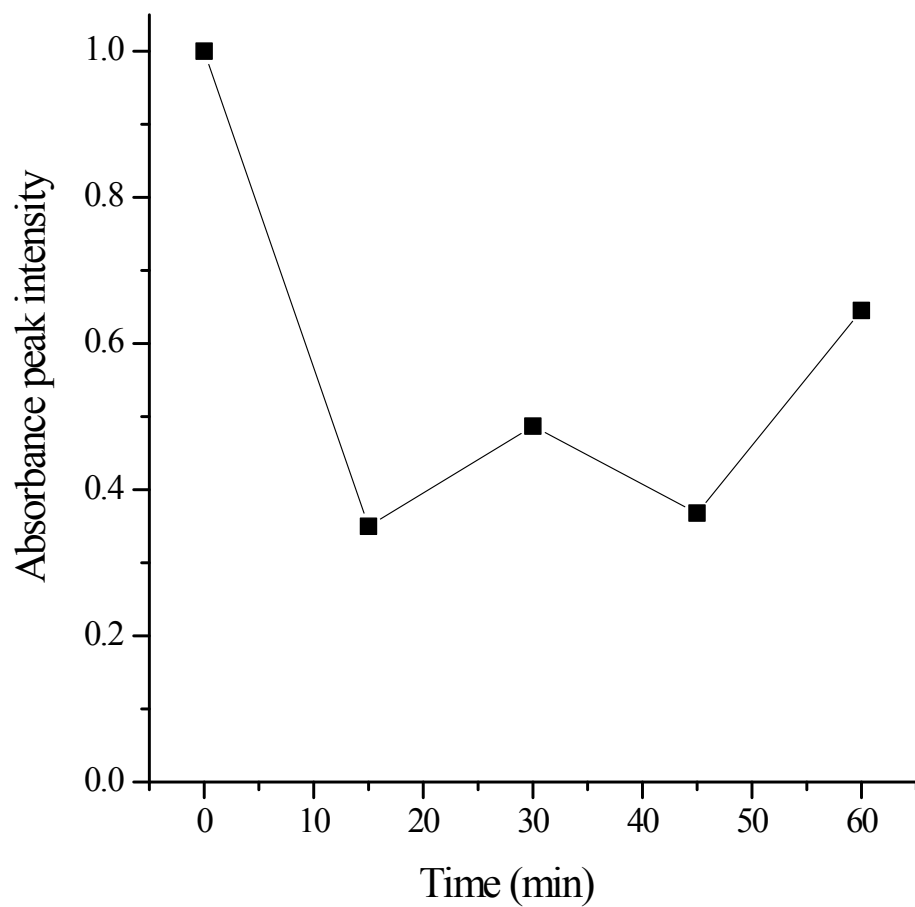


Figure S11 Adsorption and desorption of 15 ppm azobenzene on Dy-Zn(O,S)-10 catalyst without light illumination based on the absorbance peak of cis-azobenzene at 318 nm in UV-vis absorbance spectra.