

Supporting Information

CuS nanoparticles decorated MoS₂ sheets as an efficient nanozyme for selective detection and photocatalytic degradation of hydroquinone in water

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1 Characterization of CuS-MoS₂ nanocomposite

The crystallographic structure of the nanocomposite was investigated by X-ray diffraction (XRD) using a Rigaku X-ray diffractometer (model: ULTIMA IV, Rigaku, Japan) with a scanning rate of 3° min^{-1} at 2θ values $5\text{--}100^\circ$ with a Cu K α X-ray radiation ($\lambda = 1.54056 \text{ \AA}$) at a generator voltage of 40 kV and a current of 40 mA. The specific surface area of the synthesized CuS-MoS₂ nanocomposite was examined by nitrogen gas adsorption study at 77 K by using an Autosorb-iQ Station 1 (Quantachrome, USA) and applying Brunauer–Emmett–Teller (BET) calculations. Before performing the experiments, the samples were degassed at 200°C for 3h. The morphology and the particle size of the synthesized nanocomposite were determined by high resolution transmission electron microscopy (HRTEM) using JEOL JEM 2100 PLUS, transmission electron microscope, Japan, operated at an accelerating voltage of 200 kV.

The chemical composition of the synthesized nanocomposite CuS-MoS₂ was examined by X-ray photoelectron spectroscopy (XPS) measurements using a Thermo- Scientific ESCALAB Xi+ spectrometer with a monochromatic Al K α X-ray source (1486.6 eV) and a spherical energy analyser that operates in the CAE (constant analyser energy) mode using the electromagnetic lens mode. The CAE is 100 eV for survey spectra and that for high-resolution spectra is 50 eV. The zeta potential of CuS-MoS₂ catalyst suspensions at different pH and in presence of different inorganic salts was calculated by measuring the electrophoretic mobility using a Zetasizer analyzer (Model: Nano ZS, Malvern, UK) instrument and the Smoluchowski equation.

The colorimetric detection and photocatalytic degradation of HQ molecule were monitored using a UV–vis spectrophotometer (MS-11-UV-1800, Shimadzu, Japan).

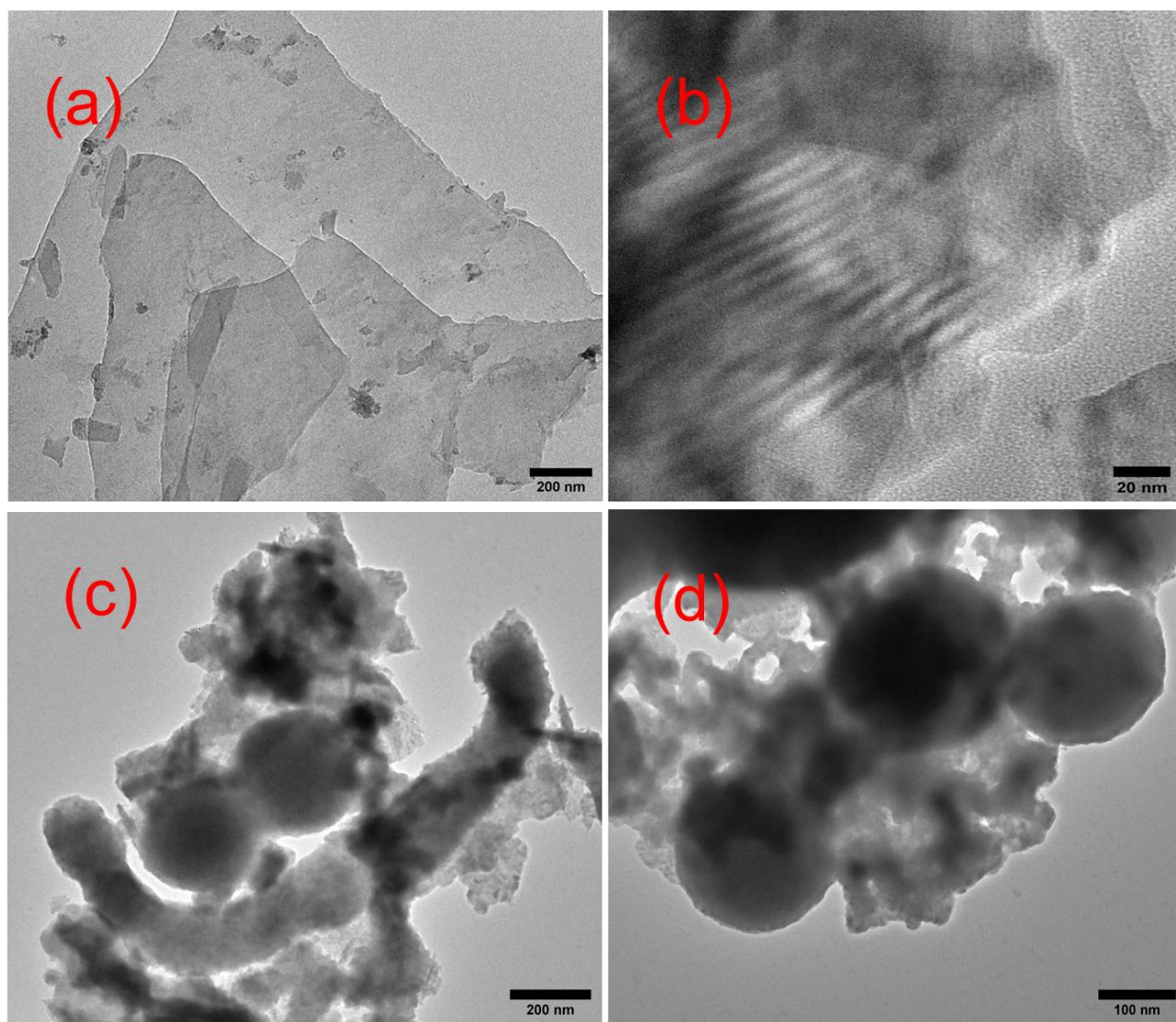


Fig. S1 (a) TEM and (b) HRTEM image of MoS₂ sheets and (c) TEM images of CuS nanoparticles

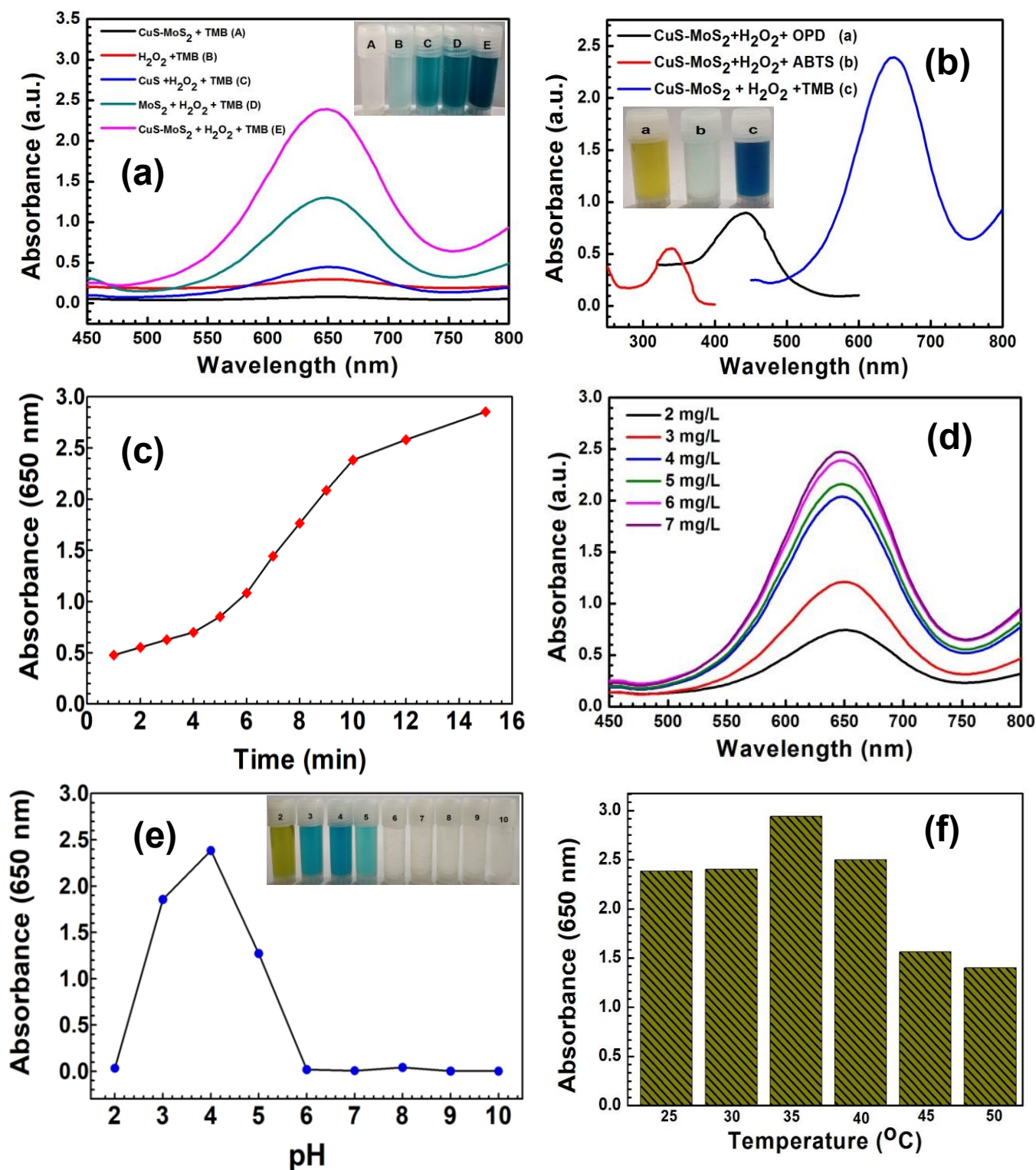


Fig. S2 (a) UV-vis spectral analysis of oxTMB solution under different experimental conditions; (Catalyst dosage = 6 mg/L, pH = 4, temperature = 25 °C, TMB = 0.5 mM, Incubation time = 10 min) (b) Peroxidase like catalytic activity of CuS-MoS₂ nanocomposite towards different

peroxidase substrate; effect of (c) incubation time, (d) catalyst concentration (e) pH and (f) temperature on the oxidation reaction of TMB to oxTMB in presence of CuS-MoS₂ nanocomposite.

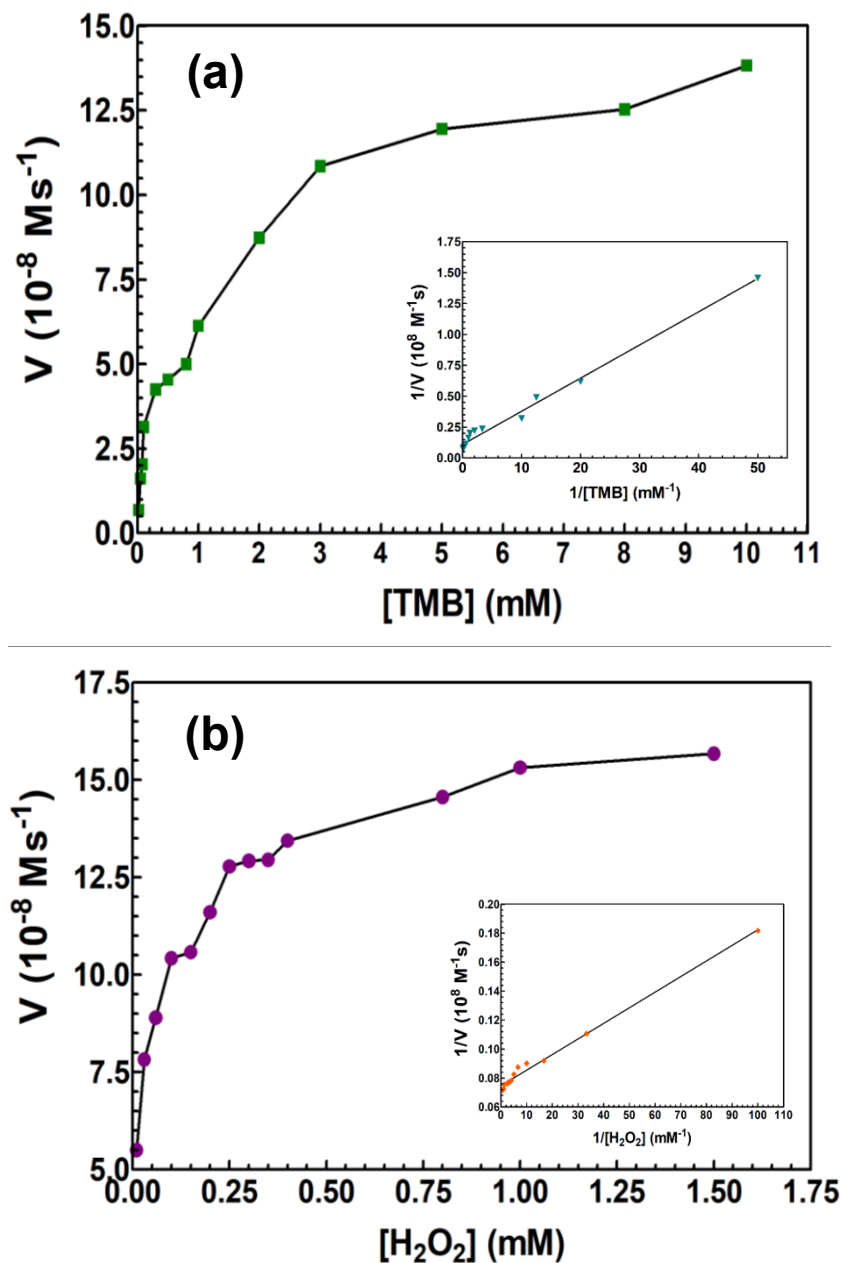


Fig. S3 Steady-state kinetic assay with (a) Variation of TMB concentration (0.02–10.0 mM) at constant H₂O₂ concentration (5 mM) and (b) for variation of H₂O₂ concentration (0.01–1.5 mM)

at constant TMB concentration (0.5 mM) for CuS-MoS₂. The corresponding Lineweaver–Burk plots of the double reciprocal of Michaelis-Menten equation are shown in the insets.

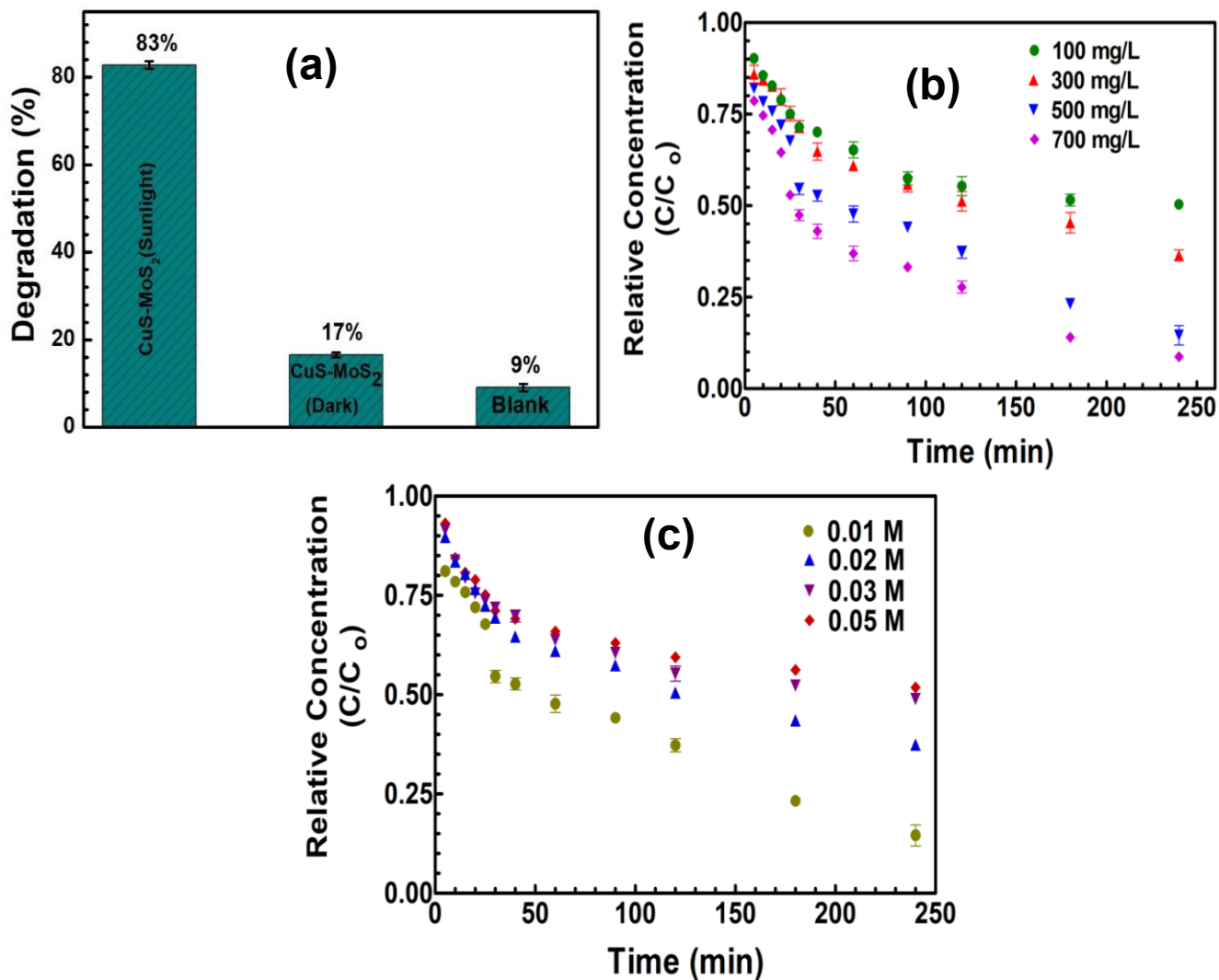


Fig. S4 (a) Comparative degradation of HQ under different experimental conditions (HQ concentration: 0.01M; Time: 240 min; pH: 5), (b) Effect of catalyst dosages on the degradation process (HQ concentration: 0.01M; pH: 5), (c) Effect of HQ concentration on the degradation process (Catalyst dosage: 500 mg/L; pH 5)

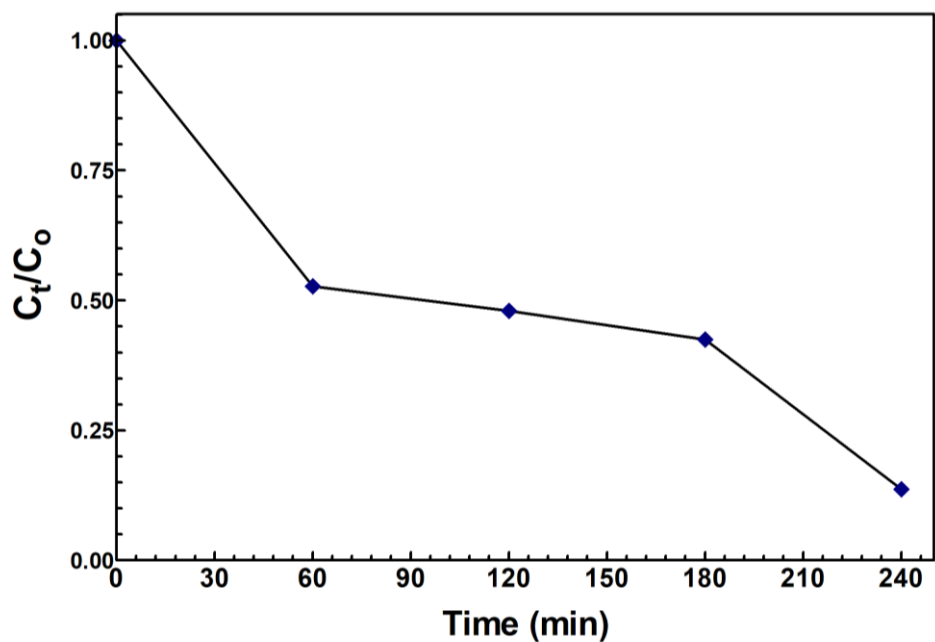
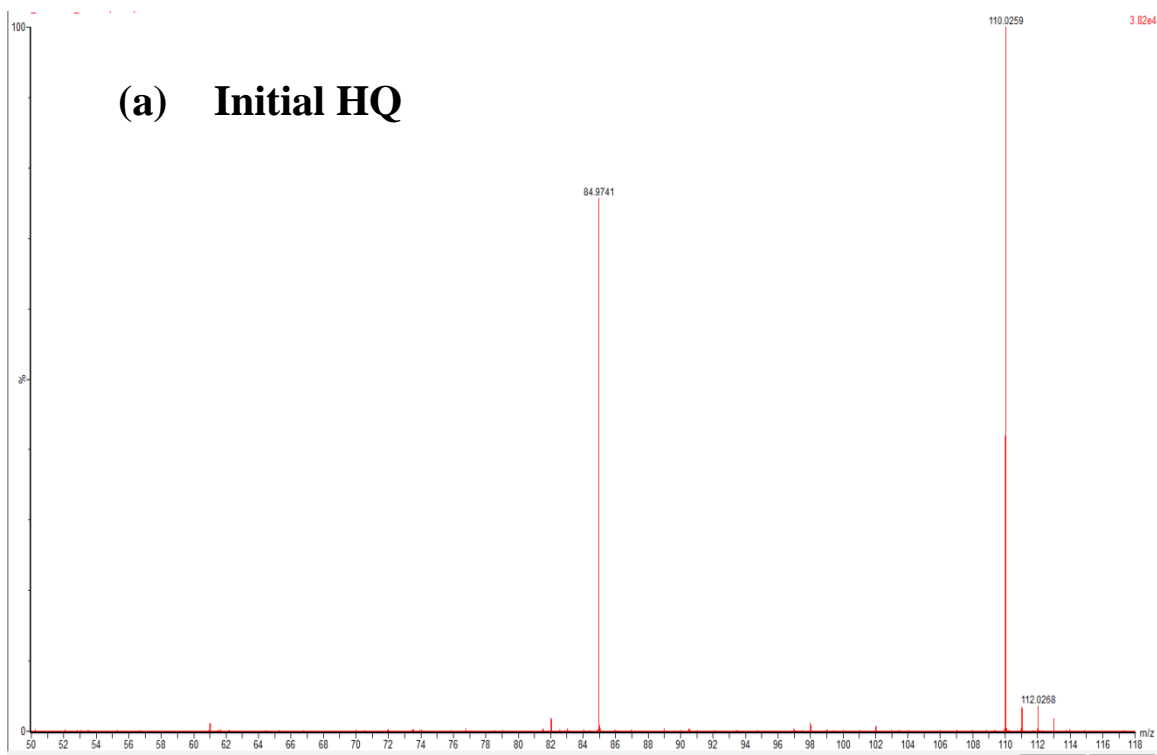


Fig. S5 COD removal for photocatalytic degradation of HQ in presence of CuS-MoS₂ (Catalyst dosage: 500 mg/L; HQ Conc. 0.01 M, pH 5)



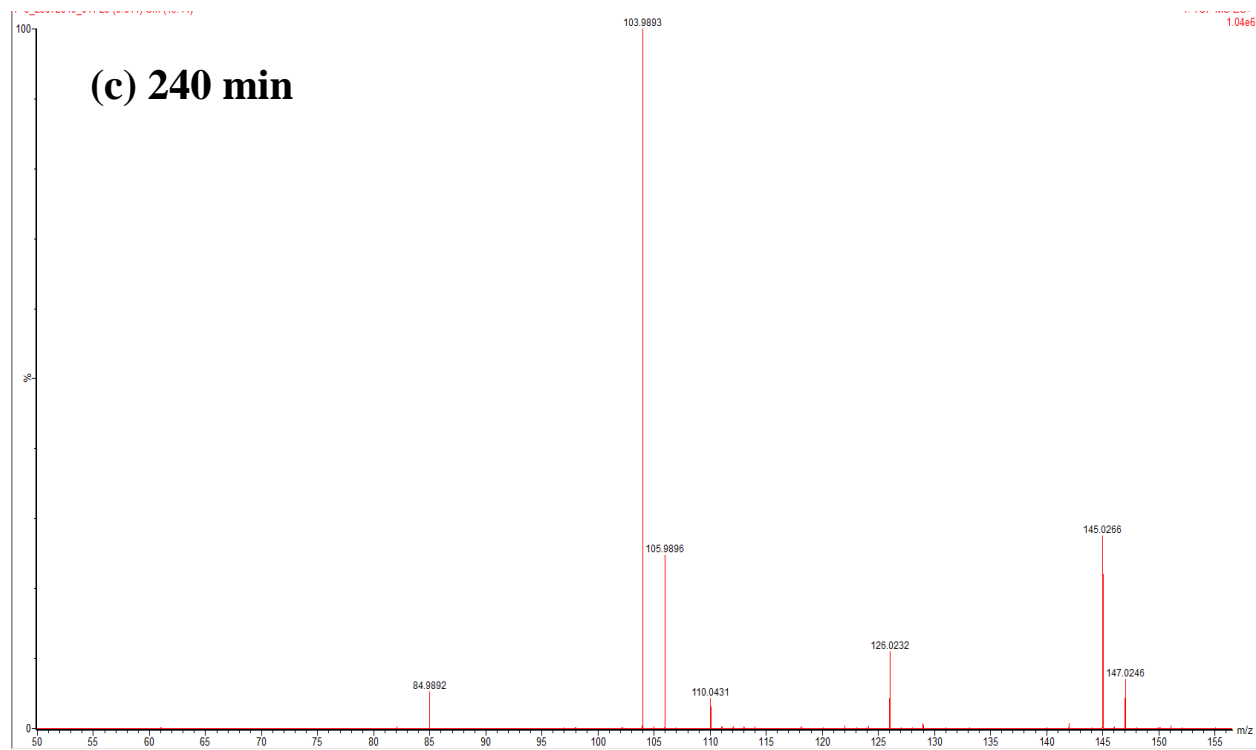
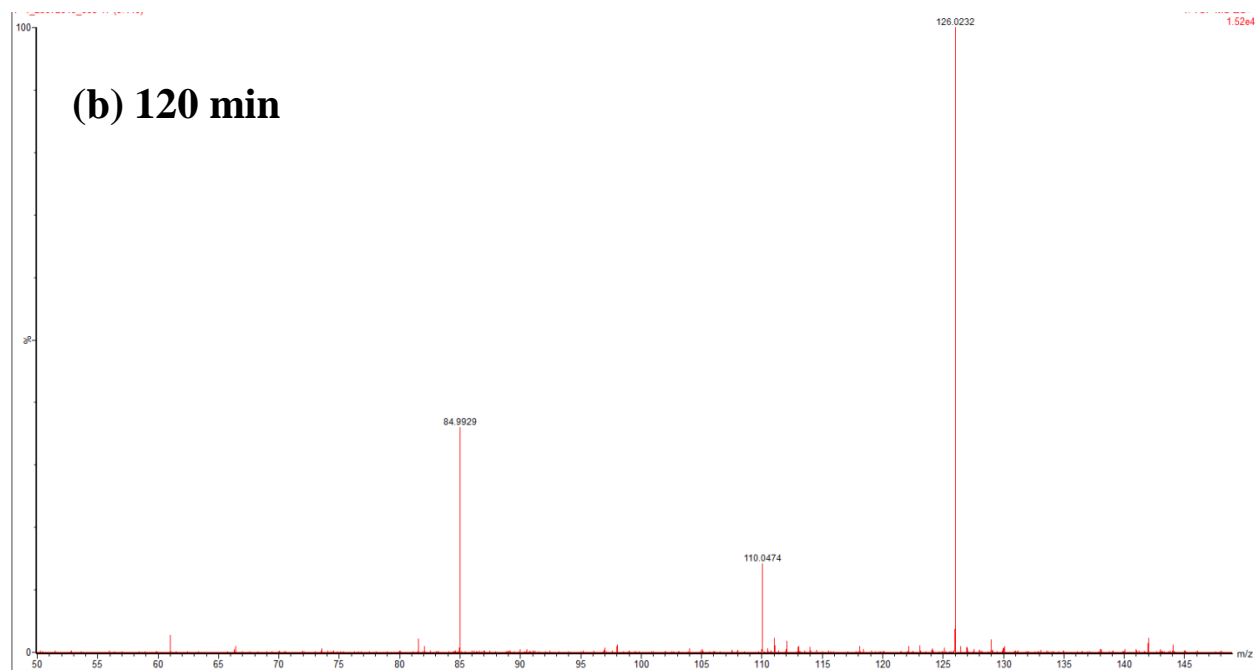


Fig. S6 HR-MS spectra of (a) initial HQ solution and (b) degradation products after 120 min and (c) 240 min.

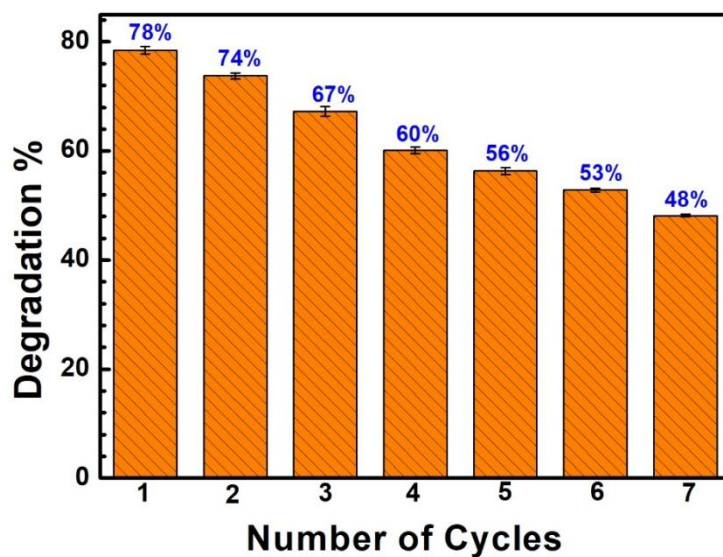


Fig. S7 Reusability study of CuS-MoS₂ photocatalyst towards HQ degradation (Catalyst Conc.: 500 mg/L; HQ Conc.: 0.01 M; pH 5, Time: 240 min)

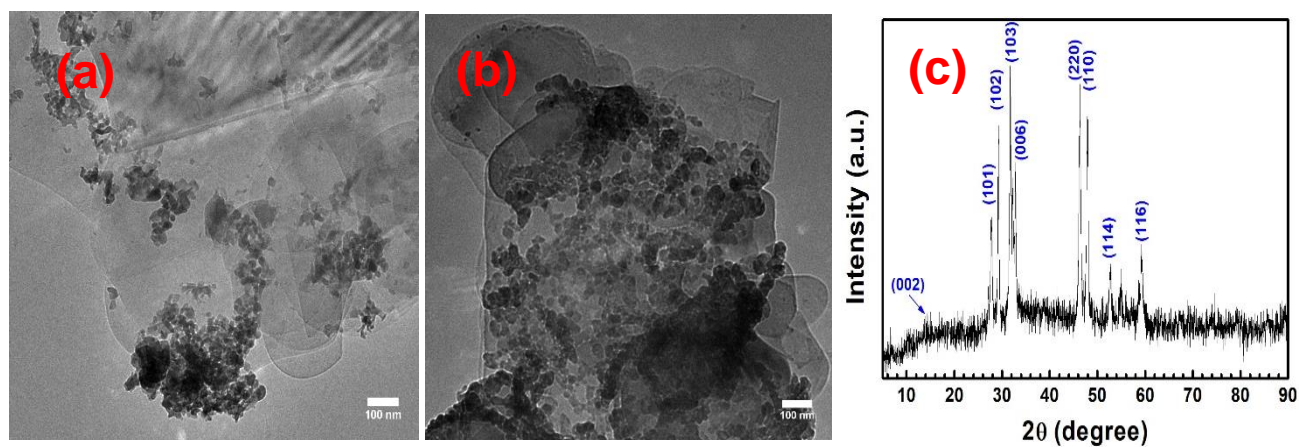


Fig. S8 TEM images (a,b), XRD pattern of CuS-MoS₂ after use in 5th repeated cycle as photocatalyst

Table S1 Specific Surface Area, Pore Volume, and Pore Radius of different species

Catalysts	Specific surface area (m²/g)	Pore volume (cm³/g)	Pore radius (Å)
MoS ₂ sheets	10.582	0.046	17.686
CuS nanoparticles	3.435	0.008	17.682
CuS-MoS ₂ nanocomposite	18.264	0.076	43.261

Table S2 Comparative colorimetric detection of HQ in presence of different nanozymes

Catalyst	Detection method	LOD	Ref
ZnO/ZnFe ₂ O ₄ /graphene foam	Colorimetric	3.75 μM	1
NiCo ₂ O ₄ microspheres	Colorimetric	2.7 μM	2
Au nanoparticles	Colorimetric	0.53 μM	3
CuS-MoS ₂	Colorimetric	3.68 μM	Present study

Table S3 Degradation efficiency of different photocatalysts towards HQ degradation

Photocatalyst	Light source	Power	Light intensity	Photodegradation efficiency (%)	Time	Rate of degradation	Ref.
PVFF-TiO ₂ -Fe oxide/H ₂ O ₂	Solar light	---		97	120 min	----	4
Au/TiO ₂ /RGO nanostructures	visible light	500 W		77	1 h	0.0174 min ⁻¹	5
	UV light	30 W		90		0.0518 min ⁻¹	
NanoTiO ₂ /ACS PCR	UV light	25 W		80	3 h	0.01003 min ⁻¹	6
CuS-MoS ₂	Sunlight	-----	780 W/m ²	83	4 h	0.0078 min ⁻¹	Present study

References

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