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Zn(O,S)-based nanosized-photocatalyst for photocatalytic hydrogen evolution, hydrogenation, and nitrogen reduction reaction

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Abstract

Photocatalytic method was widely used for hydrogen evolution reaction (HER) as well as for environmental remediation. We then developed zinc oxysulfide (Zn(O,S)) materials with metal doping to enhance the production of H₂. The amount of evolved H₂ were found to be ~12 mmol/g.h in 10% EtOH solution such photocatalyst. These results were two-fold higher than that achieved by TiO₂/Pt. At the same time, with various metal dopants in Zn(O,S), the reduction of Cr⁶⁺ to Cr³⁺, degradation of mixed-dyes, and detoxification of azobenzene can be done in mild condition.

Research Focus

Preparation of photocatalyst

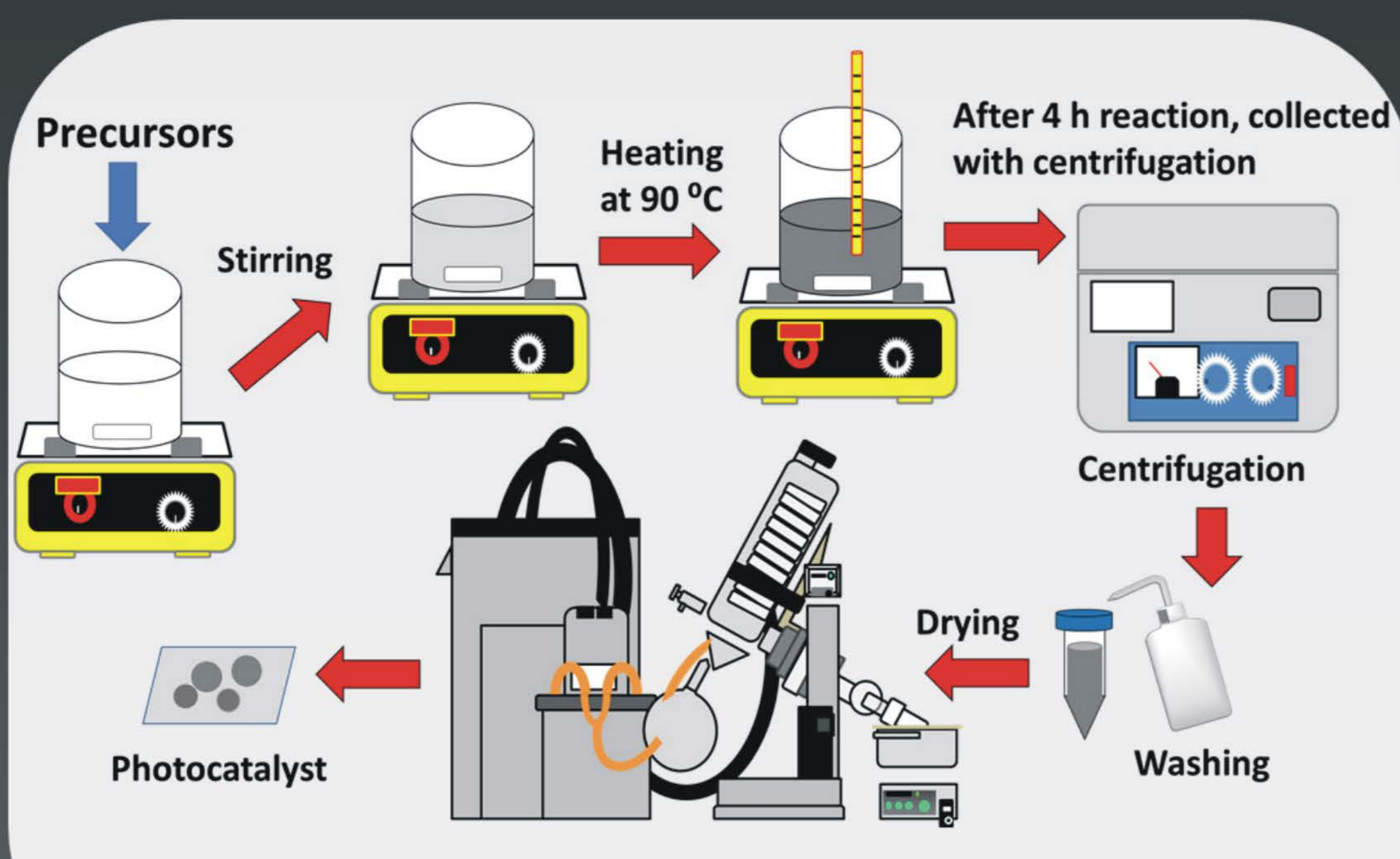


Fig. 1 Schematic illustration for the bimetal-doped Zn(O,S) preparation at mild condition

SEM, TEM, and XPS analyses

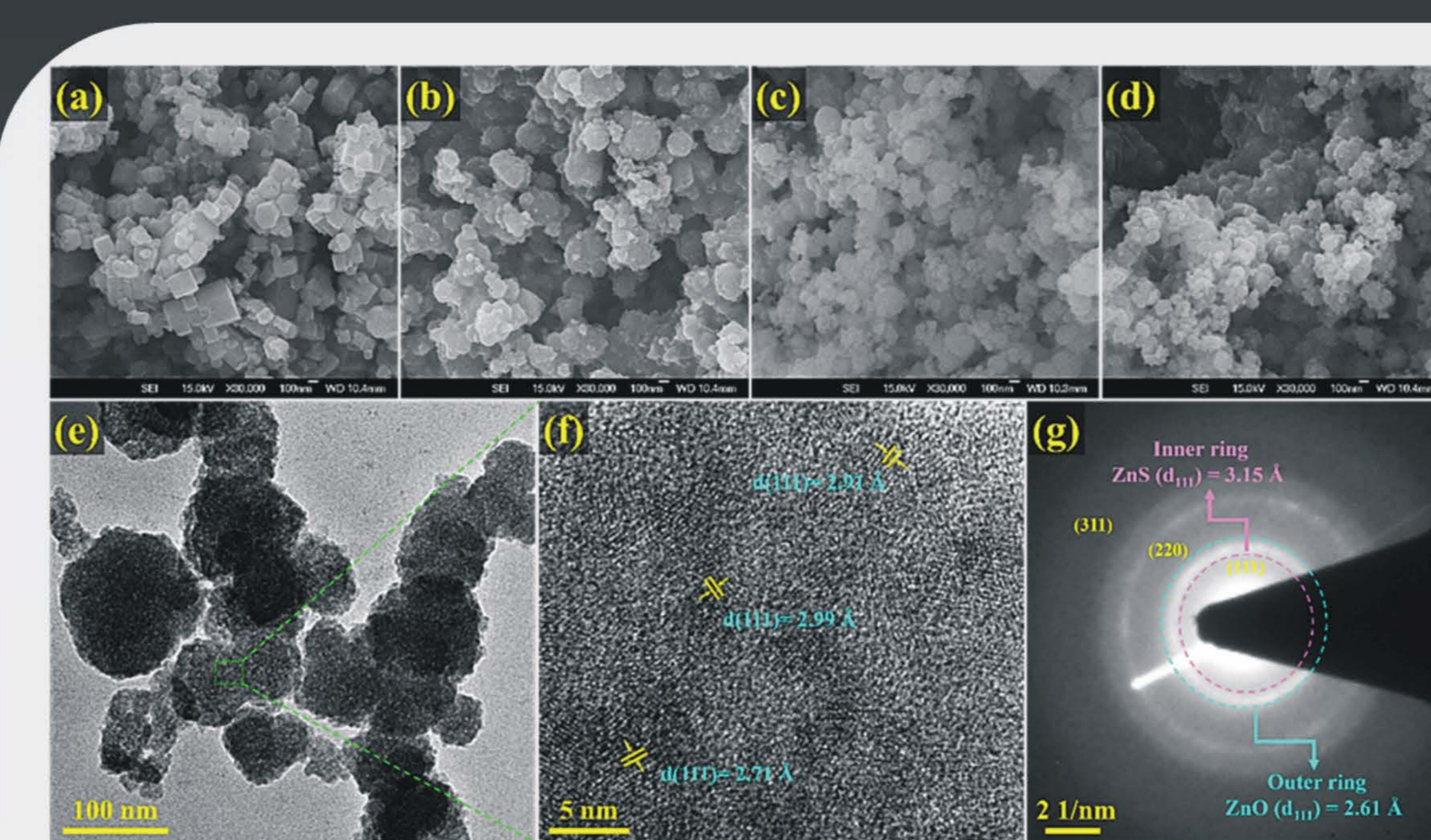


Fig. 2 (a-d) SEM images of bimetal-doped Zn(O,S) with various amounts of sulfur. (e) TEM images of bimetal-doped Zn(O,S) with (f) its lattice fringes and (g) SAED analysis

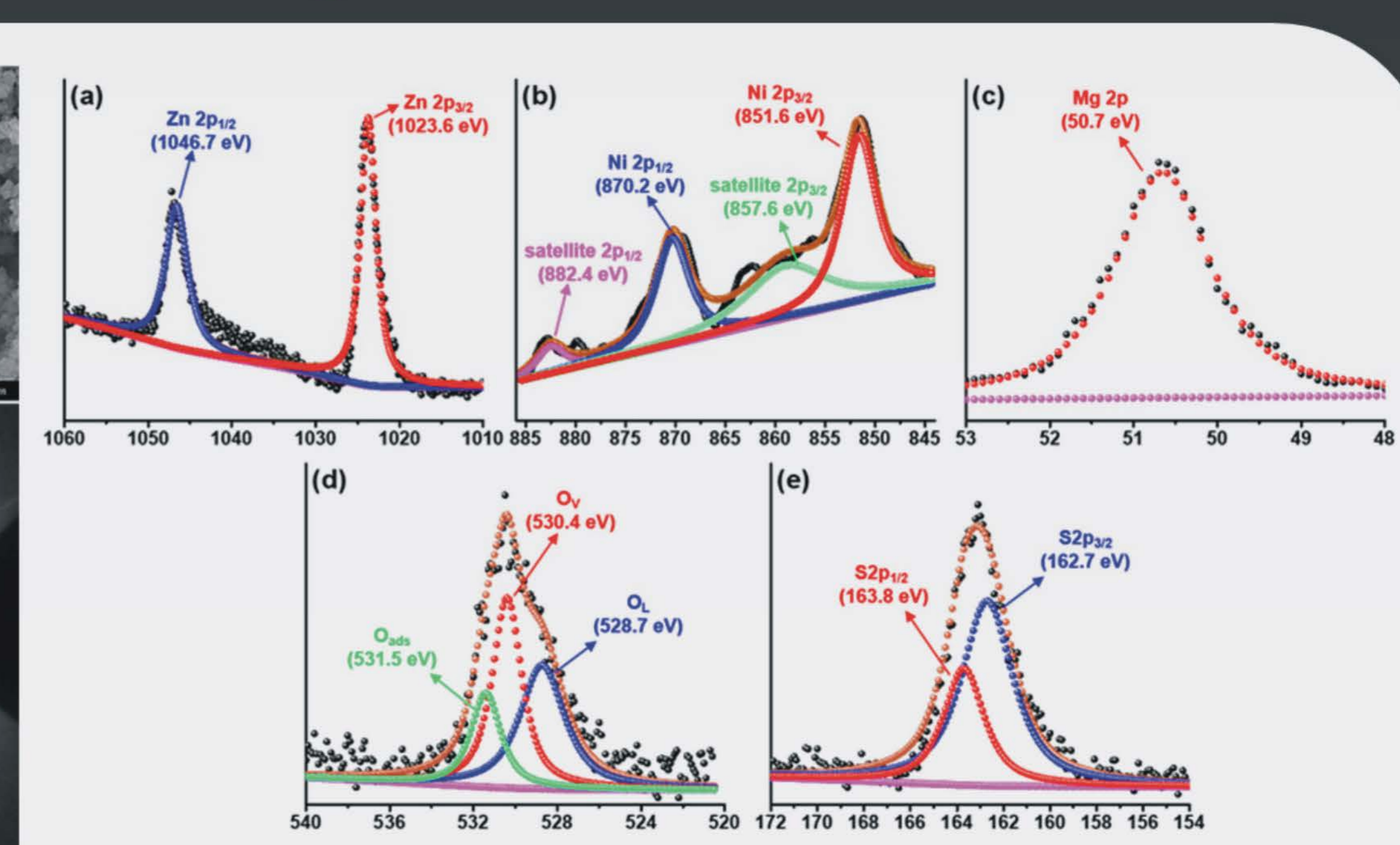


Fig. 3 High-resolution XPS spectra of (a) Zn 2p, (b) Ni 2p, (c) Mg 2p, (d) O 1s, and (e) S 2p.

Optical and electrochemical properties

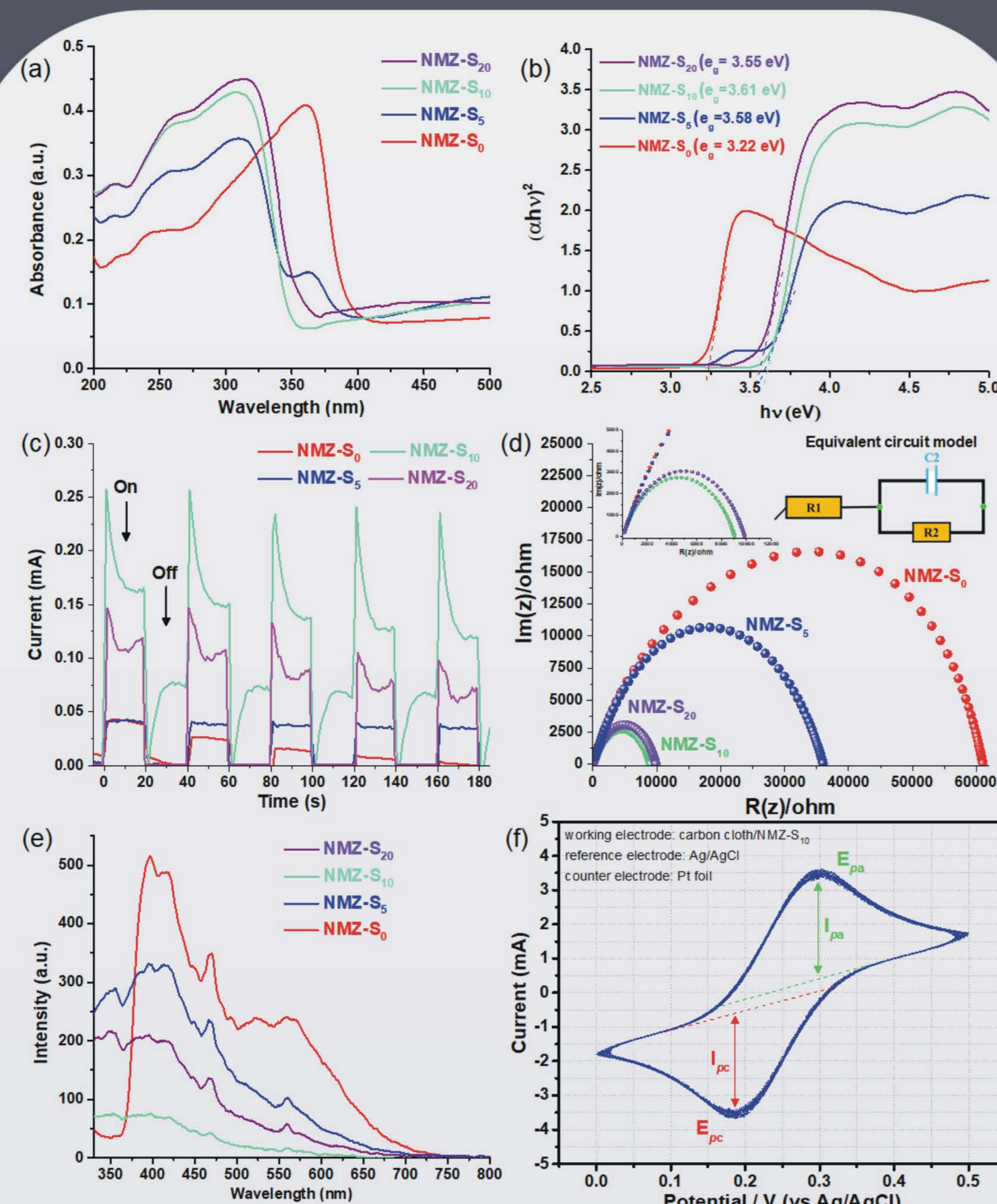


Fig. 4 (a) DRS spectra of bimetal-doped Zn(O,S) with (b) its Tauc plot. (c) photocurrent density of bimetal-doped Zn(O,S) under solar light irradiation. (d) EIS and (e) PL spectra of bimetal-doped Zn(O,S). (f) cyclic voltammogram of bimetal-doped Zn(O,S) scanned for 200 cycles to prove the stability under redox condition.

XRD analysis

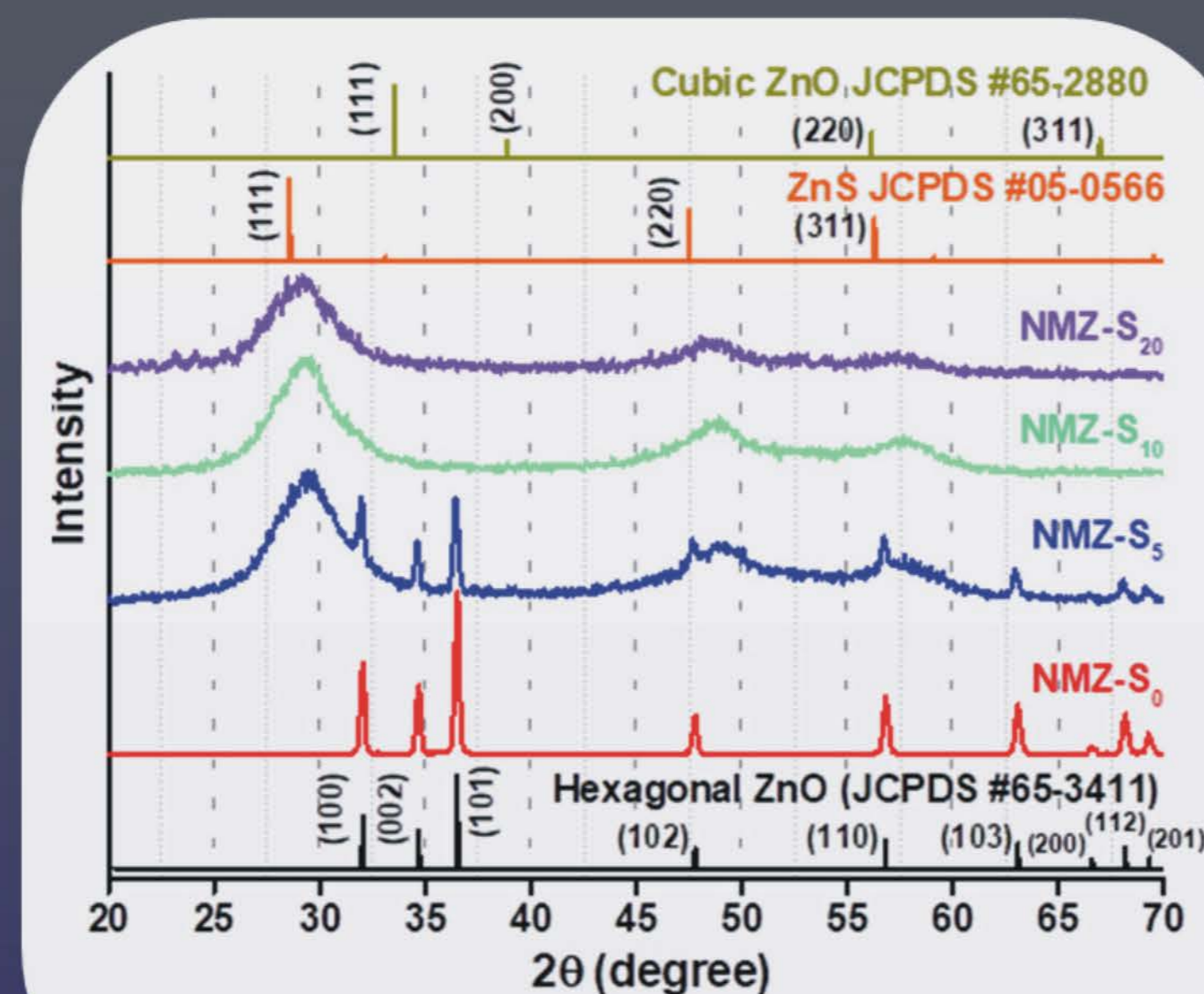


Fig. 5 XRD patterns of bimetal-doped Zn(O,S) with different contents of sulfur.

Photocatalytic performances

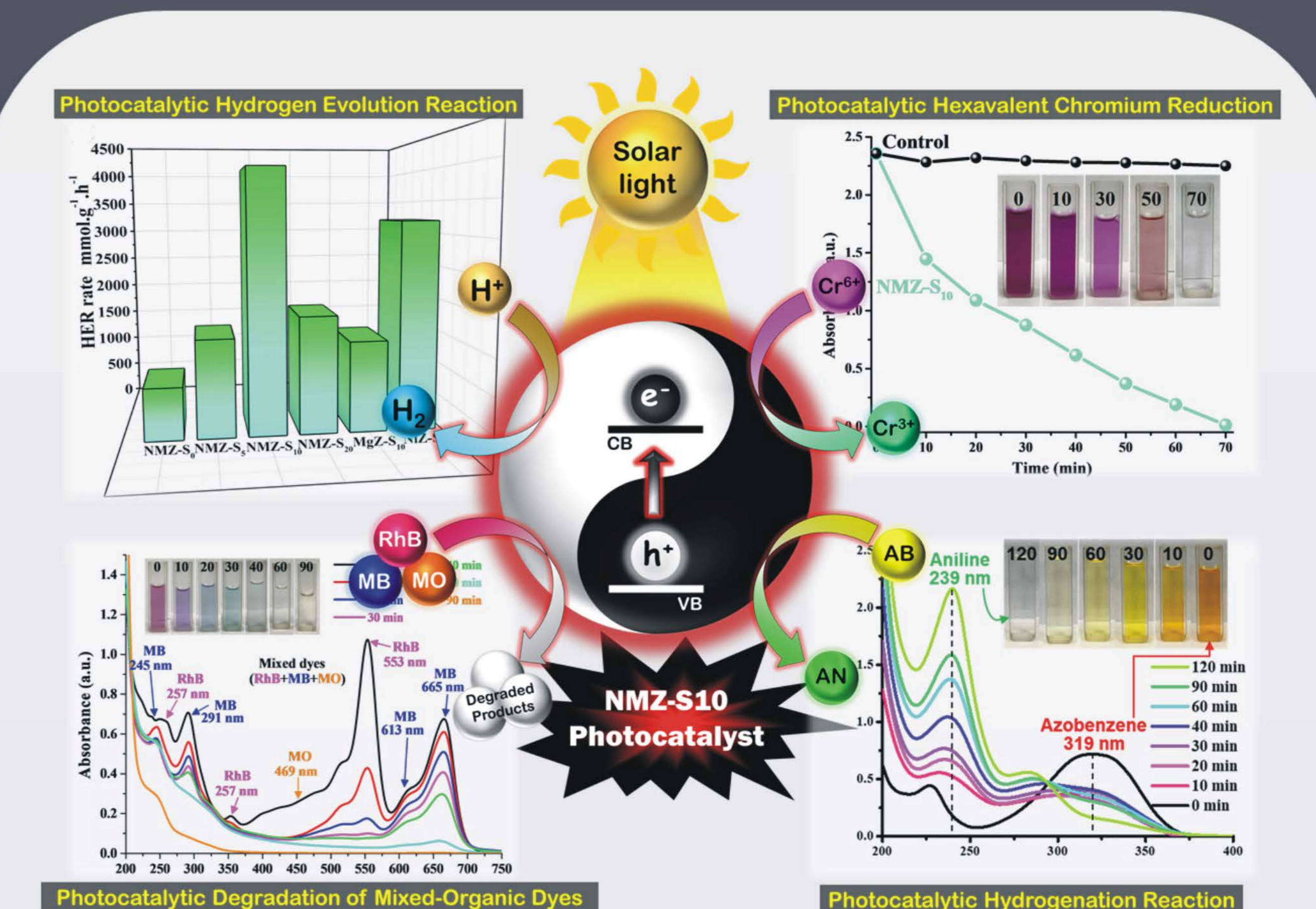


Fig. 6 Photocatalytic performances of bimetal-doped Zn(O,S) to evolve H₂ gas, detoxify Cr⁶⁺ to Cr³⁺, hydrogenation of azobenzene, and mixed-dyes degradation under solar-light irradiation at mild condition

Selected publications

- Shuwanto, H., Abdullah, H., Kuo, and D. H., Gultom, N. S. *Appl. Surf. Sci.*, 2020, 552, 149508 (Q1; IF: 6.707)
- Shuwanto, H., Gultom, N. S., Abdullah, H., and Kuo, D. H., *ACS Appl. Energy Mater.*, 2020, 12, 12692-12702 (Q1; IF: 6.024)
- Shuwanto, H., Abdullah, H., and Kuo, D. H., *Catal. Sci. Technol.*, 2021, 11, 7200. (Q1; IF: 6.119)
- Abdullah, H., Gultom, N. S., Shuwanto, H., Kebede, W. L., and Kuo, D. H. *ACS Appl. Mater. Interfaces*, 2020, 12, 43761-43770. (Q1; IF: 9.229)
- Abdullah, H., Gultom, N. S., Chiao, C. S., Shuwanto, H., and Kuo, D. H., *ACS Appl. Energy Mater.*, 2021, 4, 3869-3880 (Q1; IF: 6.024)

Summary

- The defect (oxygen vacancies) in Zn(O,S) play the significant role in the photocatalytic systems.
- The fabricated bimetal-doping Zn(O,S) photocatalyst could perform HER and environment-related applications in mild condition
- Metal-doped Zn(O,S) exhibited high reusability performances, retains >90% even after 5 cycles.



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