

Visible-light degradation of PFAS: Forever Chemicals are not forever anymore!

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PFAS: forever chemicals?!

- Per- or polyfluoroalkyl substances (PFAS) e.g., PFOS are known as forever chemicals.

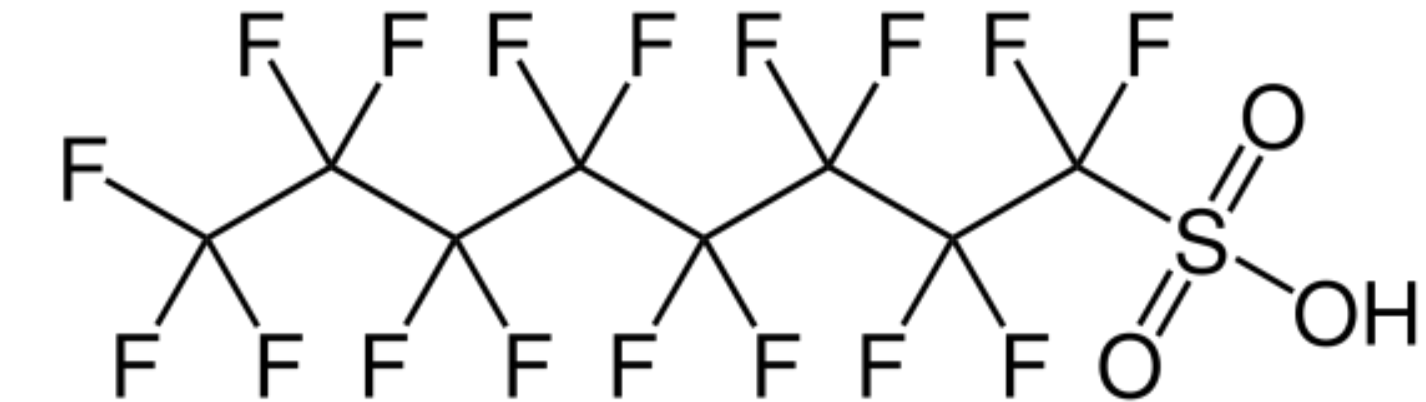


Fig.1 Chemical structure perfluorooctane sulfonate (PFOS).

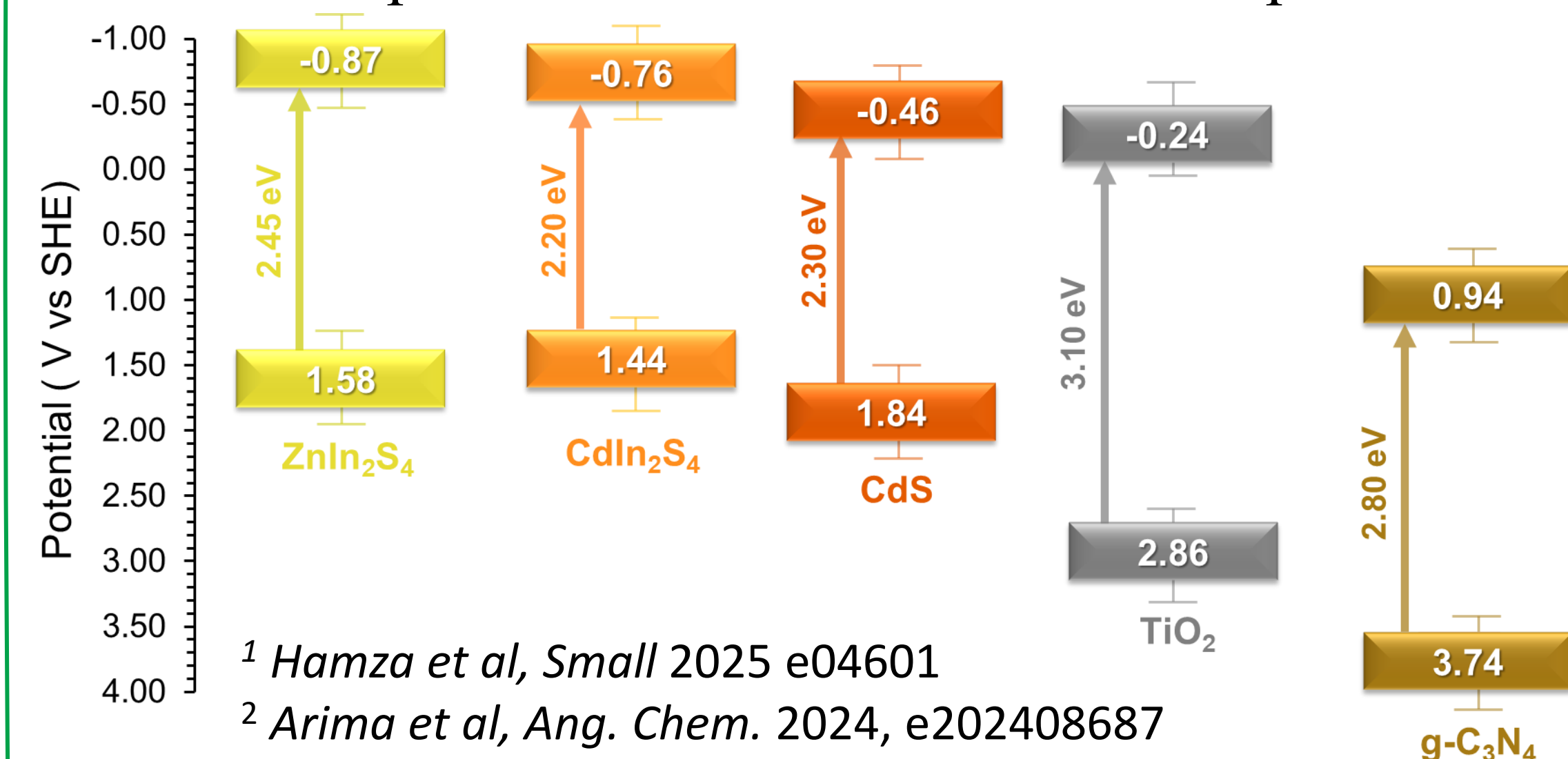
- PFAS are persistent to degradation by traditional methods owing to the presence of C-F bonds (the strongest bonds in nature).
- PFAS are bio-accumulative, toxic, and cause severe effects on the human health and environment. PFAS are everywhere now.
- Finding an efficient degradation route is unavoidable as per the **SDG 6 (especially target 6.3)** to ensure access to clean water and sanitation for all, reducing water pollution, and eliminating pollutants.



Photocatalysis

- Efficient
- Eco-friendly
- Low cost

- Oxidative degradation *via* direct oxidation or oxidation with hydroxyl radicals didn't achieve PFAS mineralization.
- Reduction pathways *via* direct electron transfer reduction or solvated electrons with higher reduction potential showed efficient PFAS mineralization. CdIn₂S₄ and CdS showed recent success.^{1,2}
- ZnIn₂S₄ (ZIS) is a visible-light active photocatalyst ($E_g=2.4$ eV) with a higher reduction potential of -0.9 V vs. NHE compared to -0.3 V in TiO₂.



Research question:
Can ZnIn₂S₄ achieve efficient photodegradation of PFAS?!

Fig.2 Band diagram of ZnIn₂S₄ compared to CdIn₂S₄, CdS, TiO₂, and g-C₃N₄.

ZnIn₂S₄: synthesis, characterizations & performance

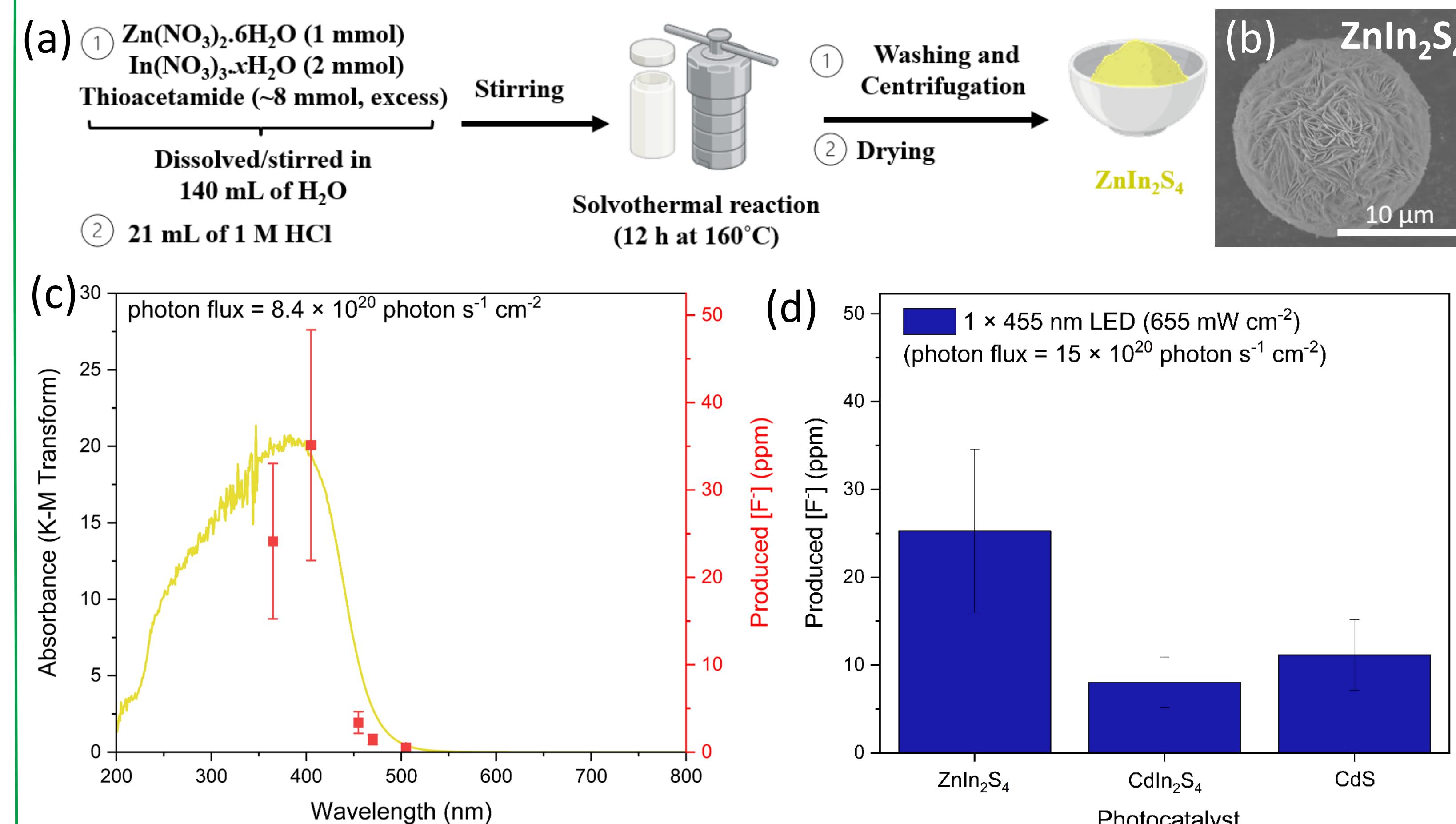


Fig. 3 (a) Schematic illustration of the facile solvothermal synthesis, (b) SEM images, (c) DRS spectra (along with F⁻ production using different LEDs) and (d) comparison of the F⁻ produced under 455 nm LED using ZnIn₂S₄, CdIn₂S₄, and CdS.

Successful facile synthesis of visible-light-active ZIS micro-sphere/nanosheets outperforming CdIn₂S₄ and CdS toward PFAS mineralization

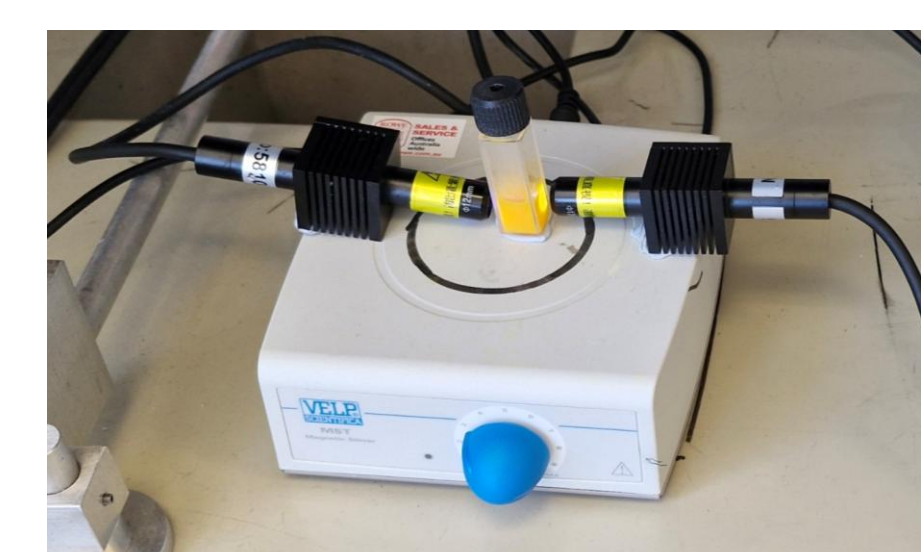
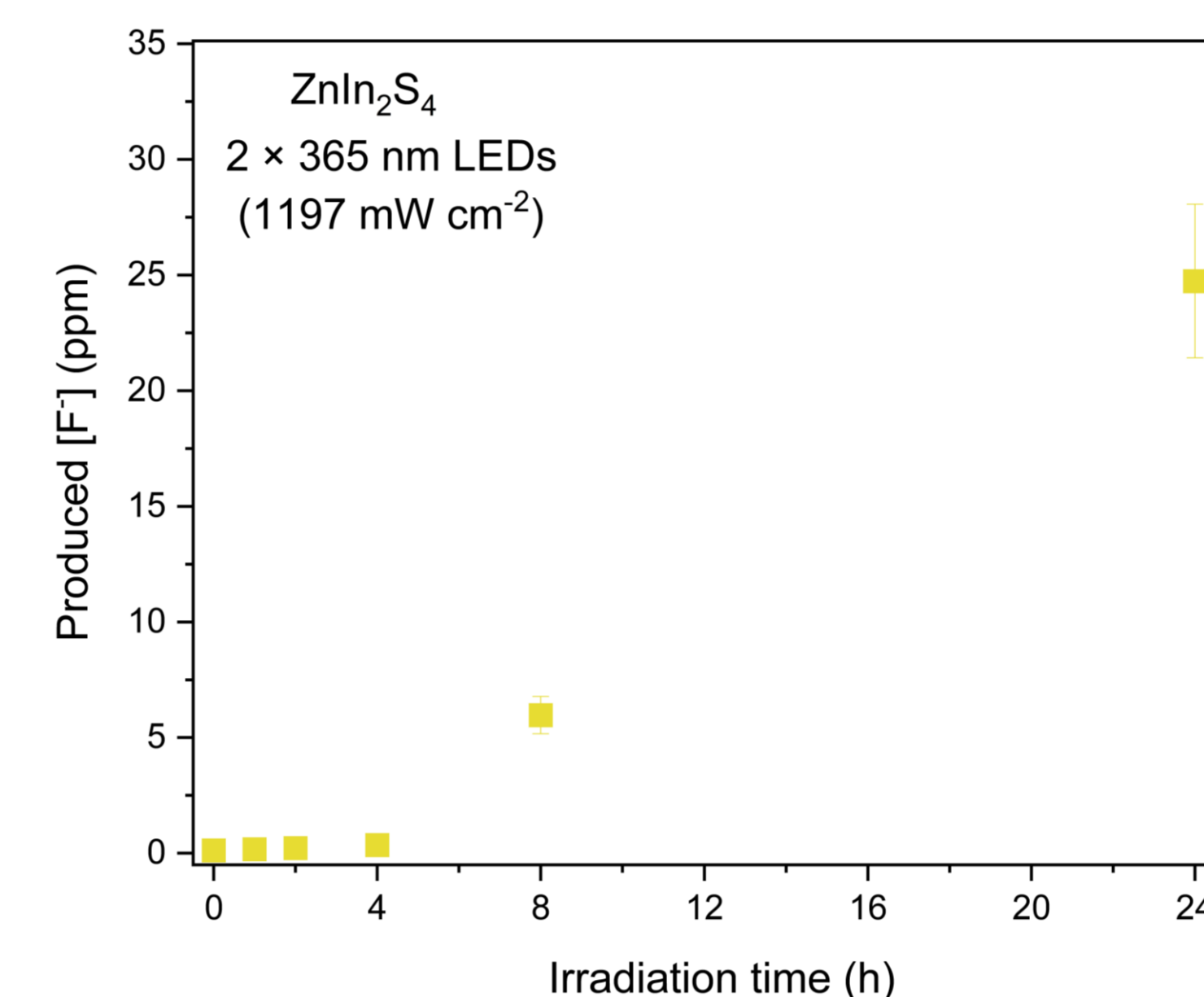


Fig. 4 The temporal fluoride (F⁻) evolution (resulting from PFOS mineralization) and a schematic illustration of the experimental setup

ZIS achieved ~100% PFOS removal and ~70% mineralization in 24 h

Mechanism and application vs. field-derived PFAS sample

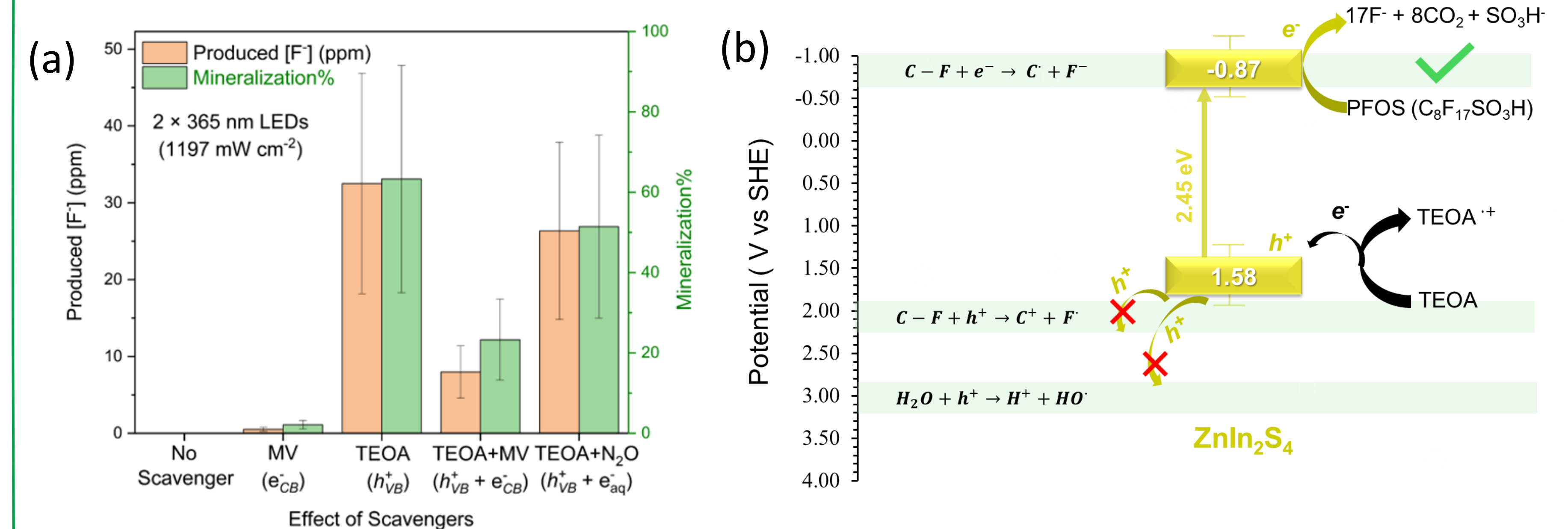


Fig. 5 (a) Effect of scavengers on the photodegradation of PFOS in terms of amount of F⁻ produced and the corresponding PFOS mineralization% and (b) the proposed reductive degradation mechanism.

Electron are most reactive species confirming reductive degradation mechanism

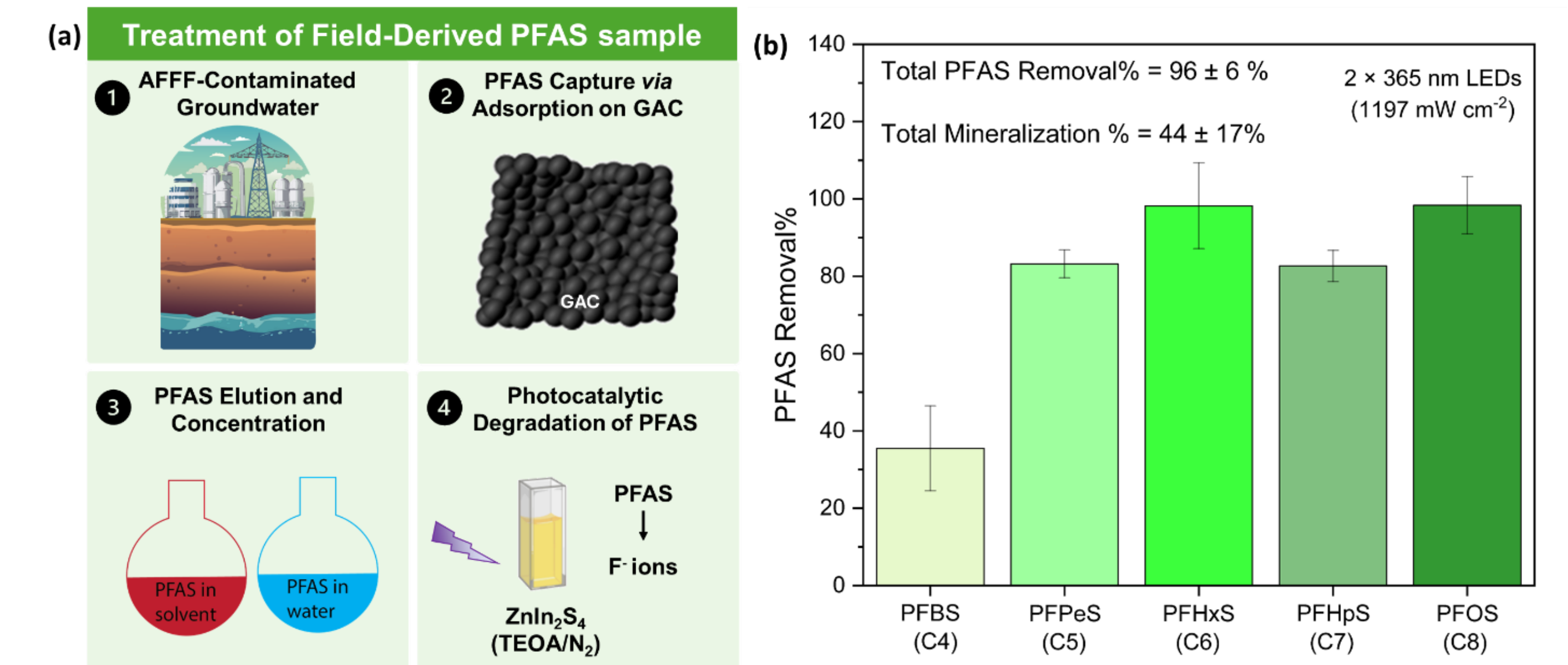


Fig. 6 Scheme of the treatment of the photodegradation of different PFAS in a field-derived PFAS sample collected from contaminated water in South Australia using ZnIn₂S₄.

ZIS achieved ~97% PFAS removal and ~50 mineralization of field-derived PFAS sample; PFAS are not forever chemicals anymore!

Outlook

- Enhancing the stability and activity toward PFAS degradation.
- Enhancing the performance toward short-chain PFAS molecules.

