Supporting Information

2-D Transition Metal Trichalophosphogenide $FePS_3$ Against Multi-Drug Resistant Microbial Infections

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Key words: antibacterial, antimicrobial, bacteria, fungi, iron phosphorus trisulfide

Supplementary Material

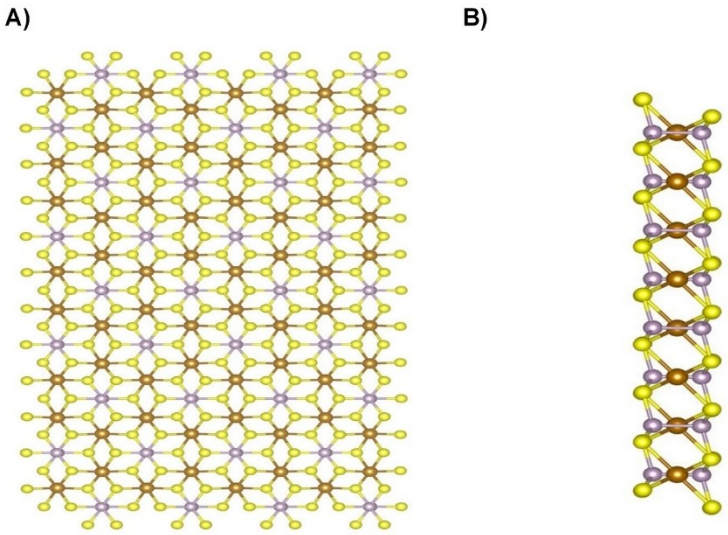

Figure S1. 3-D Structure of mechanically- exfoliated $FePS_3$ nanosheet (Monolayer)

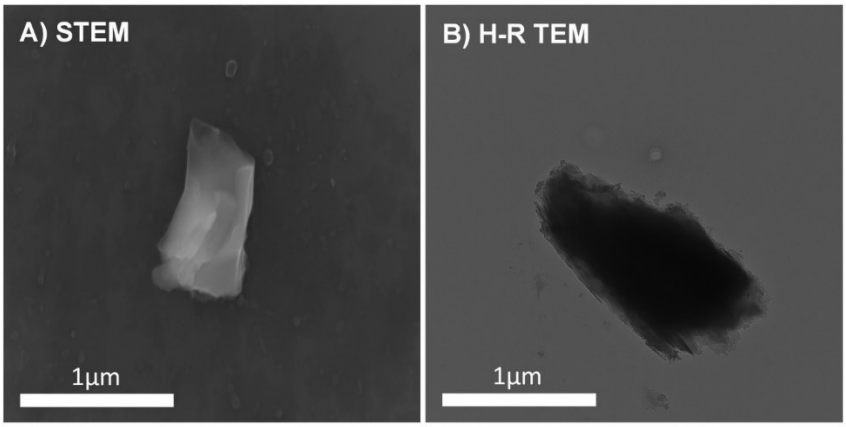

Figure S2. Additional Characterization of flakes A) STEM image, B) H-R TEM image

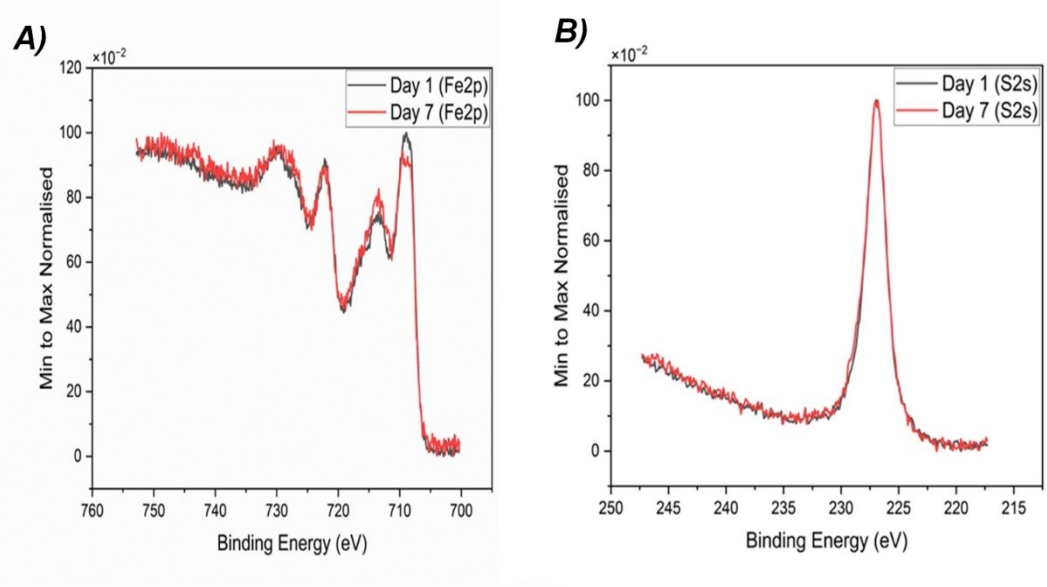

Figure S3. XPS analysis of the exfoliatd flakes showing peaks in the (A) iron and (B) sulphur components.

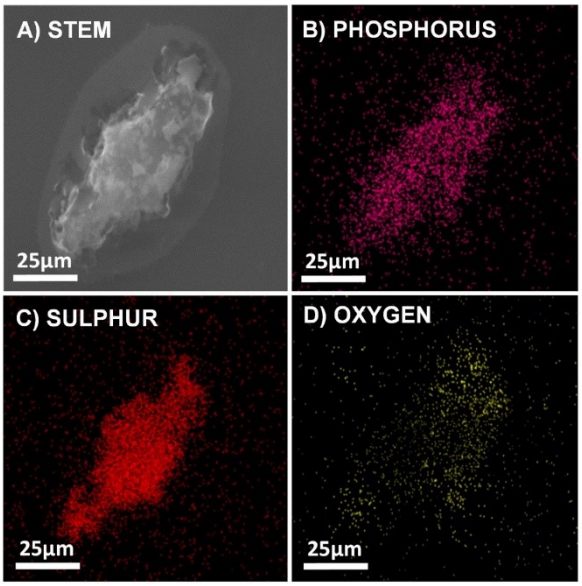

Figure S4. Degradation of $FePS_3$ nanoflakes. A) STEM image of a degrading $FePS_3$ nanoflake after 24 hours under ambient conditions. Corresponding EDS images showing B) phosphorus, C) sulphur, and D) oxygen components.

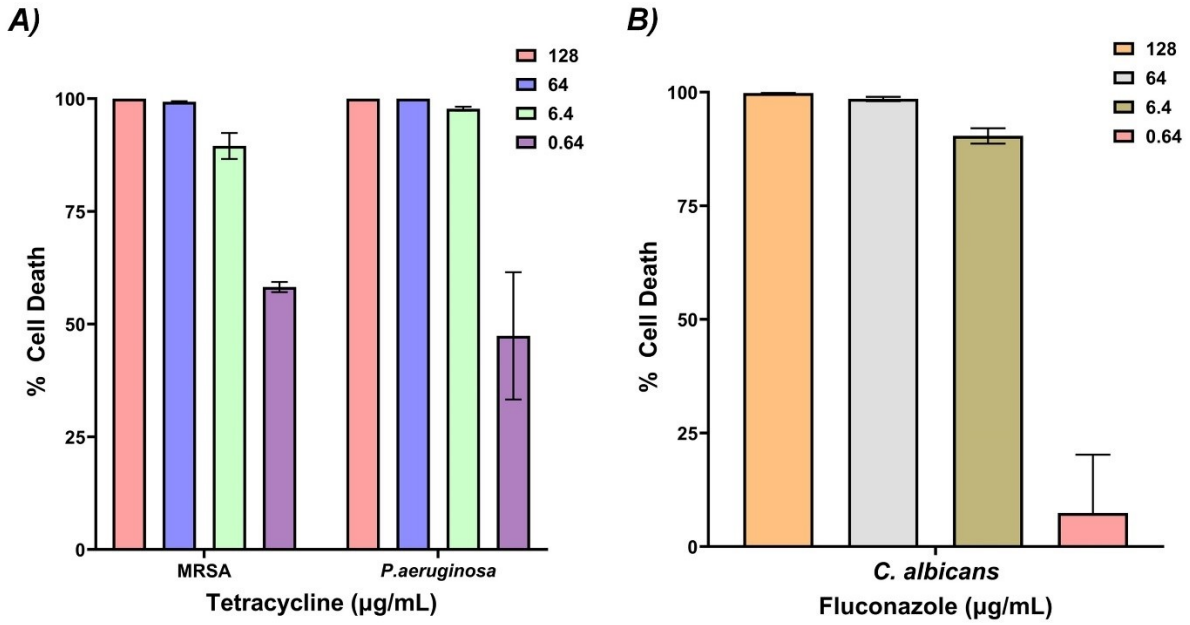

Figure S5: Antimicrobial efficacy of positive controls. (A) Tetracycline was used as a positive control for bacterial strains (MRSA and *P. aeruginosa*) and (B) Fluconazole for *Candida albicans*. The concentrations used for both positive controls are in a range of 0.64- 128 µg/mL. Values are mean ± SEM. n = 3.

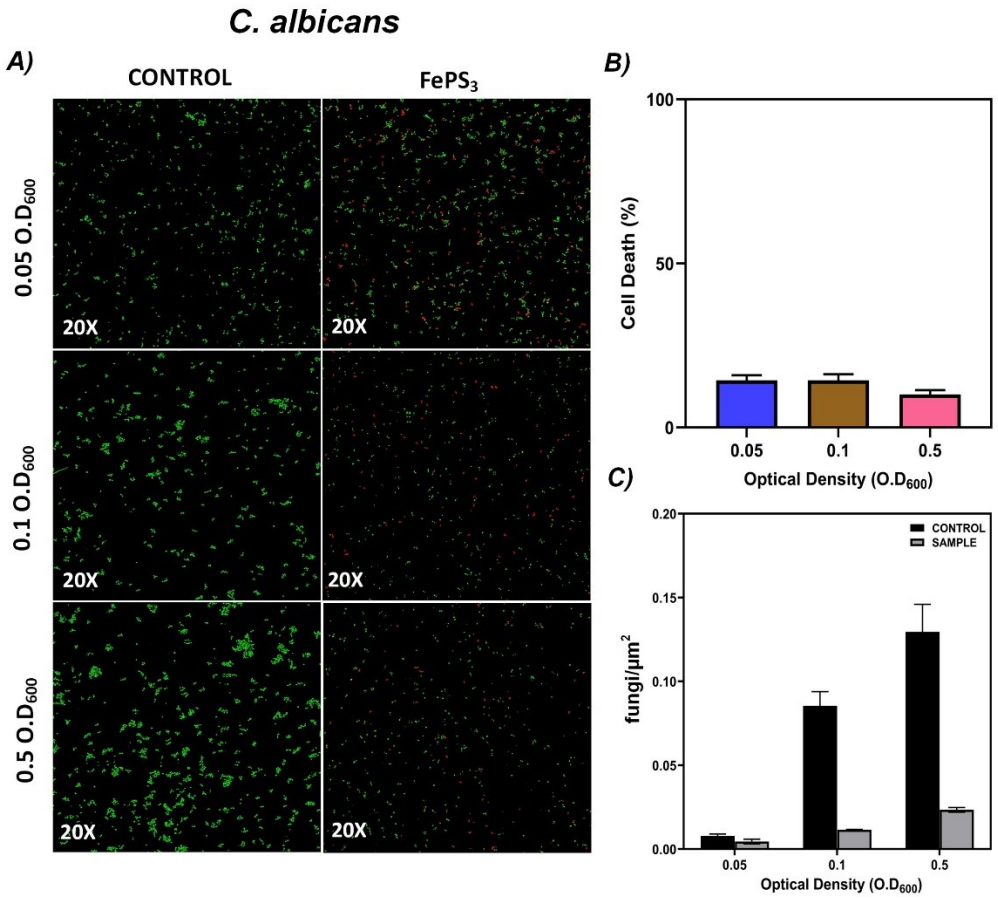

Figure S6. Antimicrobial properties of $FePS_3$ nanoflakes against a series of fungal population densities. (A) CLSM images of control and treated *C. albicans.* (B) Relative quantification of cell death in fungi. (C) Fungal surface density (number of fungi/µm²) of *C. albicans* at different optical densities in both control and $FePS_3$-treated groups

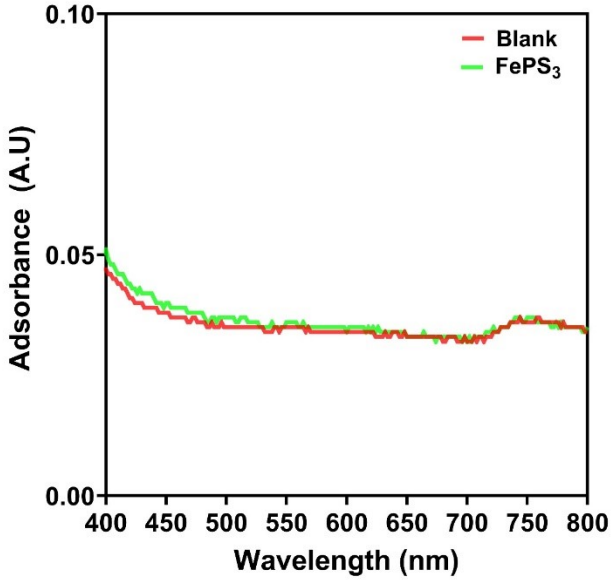

Figure S7. UV-Vis adsorbance spectra of blank (in red) and $FePS_3$ treated samples (in green).

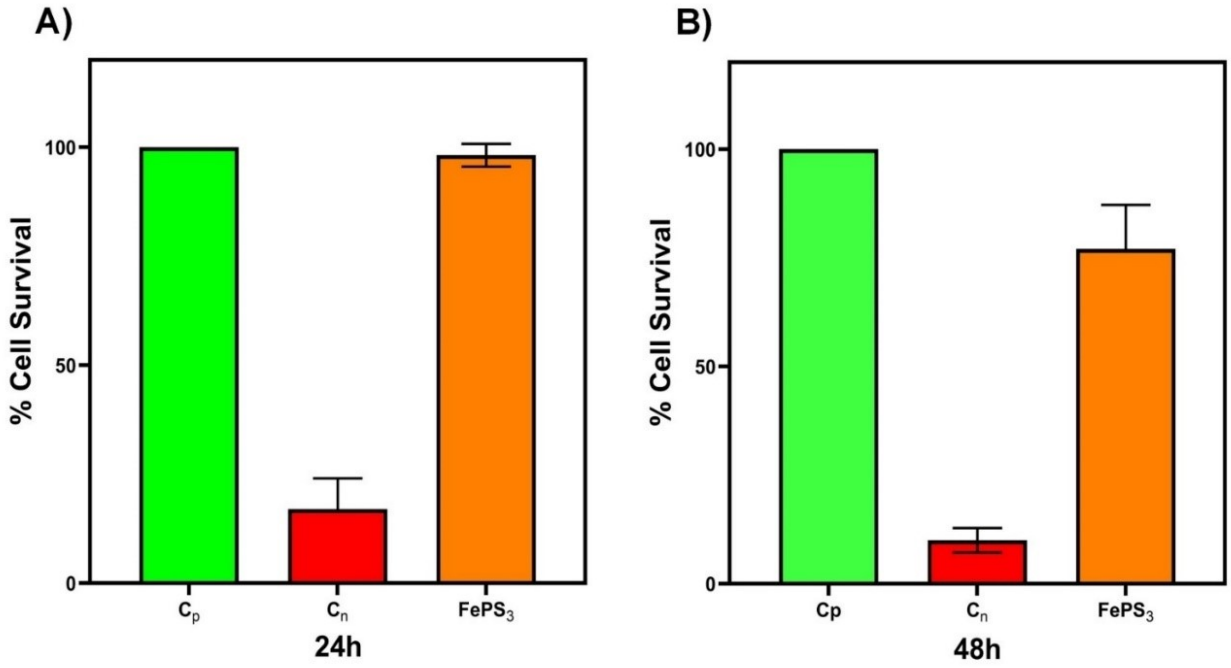

Figure S8. Hemolysis assay of $FePS_3$ nanoflakes against red blood cells. (A) 24 h and (B) 48 h. Cp corresponds to the positive control (C_p), and C_n negative control (treated with 100% ethanol).

Table S1. Table is recreated from Shaw *et al.*, 2021[1]. Comparative antimicrobial activity of commonly investigated nanomaterials. Abbreviations: BP: black phosphorus, NMP: N-methyl-2-pyrrolidone, DMPI: N,N′-dimethylpropyleneurea, PPMS: 4-pyridonemethylstyrene, NPs: nano-particles, NB: Not bactericidal, N/A: Not applicable, NR: Not reported. Material 1 highlighted in blue is that of this study.

				Bacteria	Fungi	Cytotoxicity	Bactericidal Activity	Bacterial Treatment Times	Fungicidal Activity	Bactericidal Treatment time
Mechanically Exfoliated $FePS_3$	Size: 2-4µm Thickness: 65nm	816.7 ng/cm²	No	MRSA, *P.aeruginosa*	*C.albicans*	No	99.99% (MRSA) and 99.9% (*P.aeruginosa*)	4 hours	50% (*C.albicans*)	4 hours
Mechanically Exfoliated BP	Size: 500 nm - 5 µm Thickness: 15 – 90 nm	~900 ng/cm²	No	*E. coli*, *P. aeruginosa*, *MRSA*, *S. typhimurium,* and *B. cereus*	*C. albicans*, *C. auris* and sensitive, fluconazole-resistant, and Amphotericin B-resistant *C. neoformans*.	No	96.3% (*E.coli*) and 96.2% (*P. aeruginosa*)	2 hours	99.92% (C. albicans) and 99.3% (C. neoformans {F^R})	2 hours
NMP - BP with $Ti\text{-}SA_4$[2]	Size: 220 nm Thickness: 5 nm	50 µg/mL	No	*E. coli* & *S. aureus*	No	NR	99.2% (*E. coli*), 94.6 % (*S. aureus*).	3 hr	NR	NR
DMPU - BP[3]	Size: 0.1 - 4 µm. Thickness: 2 - 15.4 nm	160 µg/mL	Yes, NIR irradiation at 808 nm.	*E. coli* & *S. aureus*	No	NR	99.2%	3 - 10 min	NR	NR

Ag and BP nanosheets[4]	AgNPs: 30 nm BP: 220 nm Thickness: 4 nm	25 - 40 µg/mL	Yes; NIR irradiation at 808 nm.	MRSA	No	No	93%.	5 min	NR	NR
DCM - BP with PPMS[5]	Size: microns Thickness: 4.2 - 4.5 nm	100 µg/ml	Yes; irradiation at 660 nm	*E. coli* & *S. aureus*	No	No	99.3% & 99.2% (*E. coli*), 76.5% & 69.5% (*S.aureus)*.	10 min	NR	NR
Millipore water - BP	Size: 215.8 nm Thickness: 1.6 nm	50- 100 µg/mL.	No	*E. coli* & *B. subtilis*	No	NR	91.65% & 99.69%	6 - 12 hr	NR	NR
Au-BP Nanosheets[6]	Size: >100 nm Thickness: 2 nm	<10 µg/mL	No	*E. coli*	No	NR	94.7%	8 hr	NR	NR
BP-TiO_2[7]	NR	25 µg/mL	Yes; UV-vis	*E. coli* & *S. aureus*	No	NR	NR	70 min	NR	NR
MoS_2 Composites[8, 9]	Size: NR Thickness: 2.2 nm	≤1 mg/mL	Yes, NIR[8]	*E. coli* & *S. aureus*	No	Concentration & system dependent[10, 11]	100%	≤6 hr	NR	NR
Ag NPs[12]	Size: 4 - 24 nm	50 µg/mL	No	*E. coli*	Yes[13-16]	Yes; shape & concentration dependent[17]	100%	24 hr	Varying degrees.[15, 18]	NR
Au NPs[19]	Size: 10 - 200 nm	Widely Variant	No	Controversial[19]	Yes;[20, 21] controversial	Dose & size dependent[24]	NB	N/A	MIC: 4 - 48 µg/mL	NR
ZnO NPs[25, 26]	Size: 50 - 250 nm	0.25 g/L	Yes, UV-vis[25, 26]	*E. coli* & *S. aureus*	Numerous Species[27-29]	Yes[30-32]	Conditional, but >99%	2 hr	Yes[28, 29, 33]	NR

Graphene oxide (pure & reduced)[34]	Size: ~0.31 µm Size: ~2.75 µm	80 µg/mL	No	*E. coli*	Yes;[35] enhanced with NIR[36]	Morphology, chemistry, sys dependent[37, 38]	Pure: 90% Reduced: 80%	2 hr	IC_{50}: 50 – 100 µg/mL[35]	NR
Graphene oxide[39]	Size: 5 - 20 µm Thickness: 1.2 nm	200 µg/mL	No	None for pure graphene oxide	NR	NR	0%	N/A	NR	NR
TiO_2 NPs [40]	Size: 79 nm	1200 µM	UV-visible Light	*E. coli*	Yes[41], surface additive[42, 43]	Yes, concentration- & time-dependent manner.[44]	75% reduction	N/A	Yes[41, 45]	NR
Cu-TiO_2 NPs[46]	Size: 15-50 nm	1 mg/mL	UV-vis	*E. coli*	NR	NR	100% reduction	N/A	NR	NR
Au nanostar[47]	Size: 50 – 100 nm	Monolayer of nanostar on glass	NIR laser	*S. aureus*	NR	NR	99%	30 min	NR	NR
Au nanocross[48]	Size: ~100 nm	0.2 mg/mL	NIR laser	*P. aeruginosa*	NR	NR	99%	5 min	NR	NR

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