

Supplementary Information

UV-visible-NIR active smart photocatalytic system based on $\text{NaYbF}_4:\text{Tm}^{3+}$ upconverting particles and $\text{Ag}_3\text{PO}_4/\text{H}_2\text{O}_2$ for photocatalytic processes under both light on/light off conditions

York E. Serge-Correales^a, Sajjad Ullah^{b,*}, Elias P. Ferreira-Neto^a, Hernan D. Rojas-Mantilla^a, Chanchal Hazra^a, Sidney J.L. Ribeiro^{a,*}

^a Institute of Chemistry, São Paulo State University (UNESP), 14800-060, Araraquara-SP, Brazil

^b Institute of Chemical Sciences, University of Peshawar, PO Box 25120, Peshawar, Pakistan

* Corresponding authors: S.J.L.R (sidney.jl.ribeiro@unesp.br) and S.U (sajjadullah@uop.edu.pk)

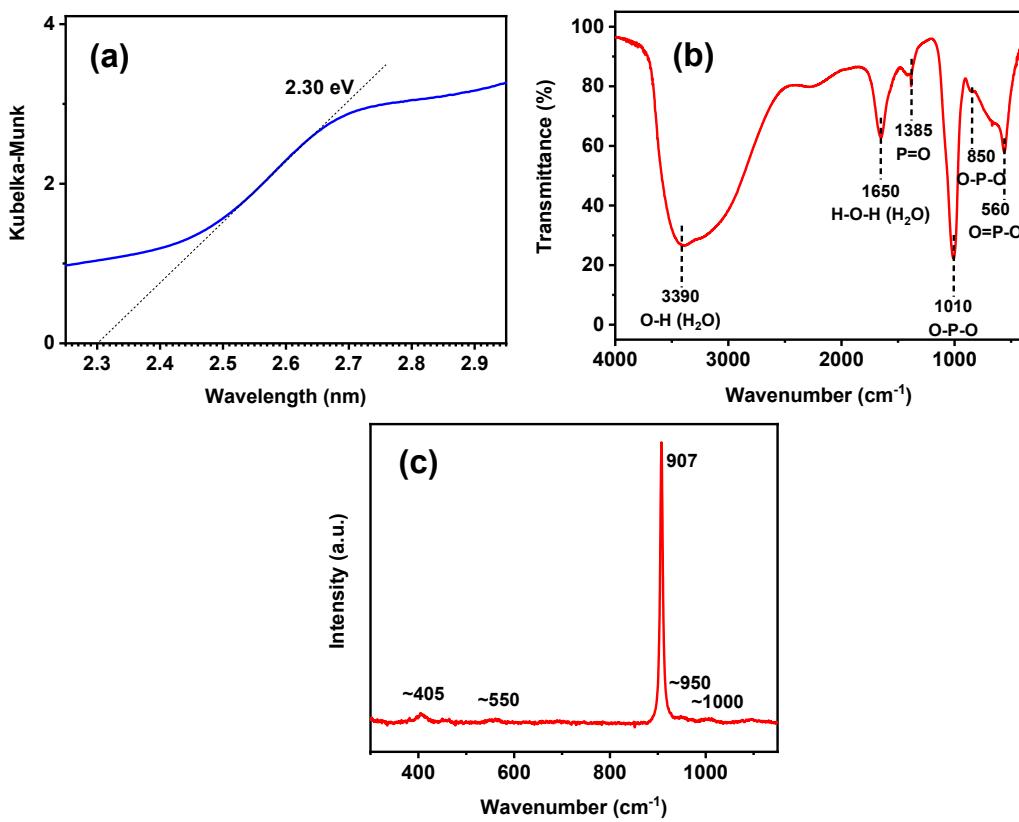


Figure S1. (a) Kubelka-Munk transformed reflectance spectrum and estimated optical bandgap, (b) FTIR spectrum and (c) Raman spectrum of Ag_3PO_4 photocatalyst.

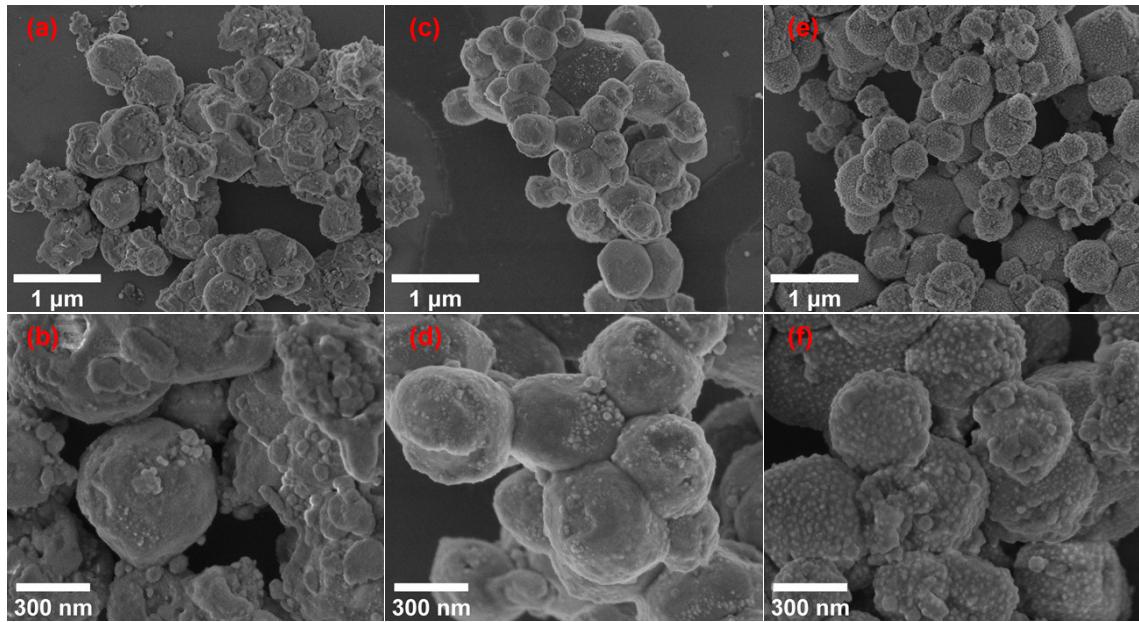


Figure S2. SEM images of Ag_3PO_4 photocatalyst after four photocatalytic cycles (a, b) in the absence of H_2O_2 , (c, d) in the presence of 6.6 mmol L^{-1} of H_2O_2 and (e,f) regenerated photocatalyst. Figs. S2a,b show that in the absence of H_2O_2 , the surface of the Ag_3PO_4 particles was severely deformed, while the presence of 6.6 mmol L^{-1} of H_2O_2 during the degradation experiments apparently prevented the damage to the photocatalyst surface (Figs. S2c,d). Additionally, the regenerated Ag_3PO_4 photocatalysts presented small particles on the surface, which might have formed from the oxidation of the photodeposited small Ag nanoparticles back to Ag^+ (Ag_3PO_4) by H_2O_2 employed as an oxidizing agent during the regeneration process.

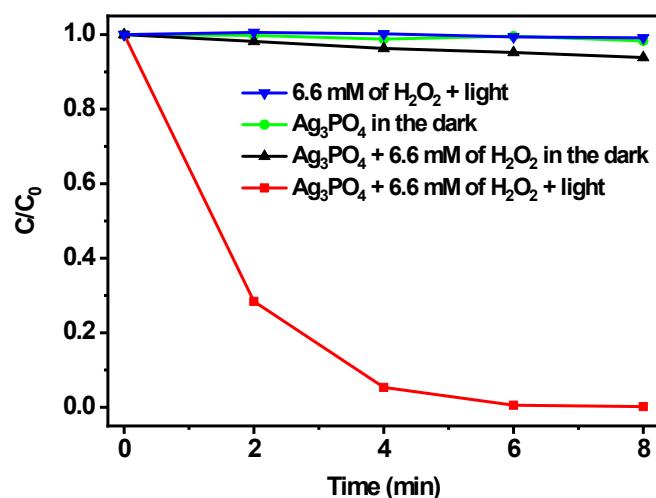


Figure S3. Temporal change in concentration of CV dye under different experimental conditions (shown in Figure labels) including illumination with blue LEDs in the presence of only H_2O_2 or $\text{Ag}_3\text{PO}_4 + \text{H}_2\text{O}_2$ as well under dark conditions (control experiments).

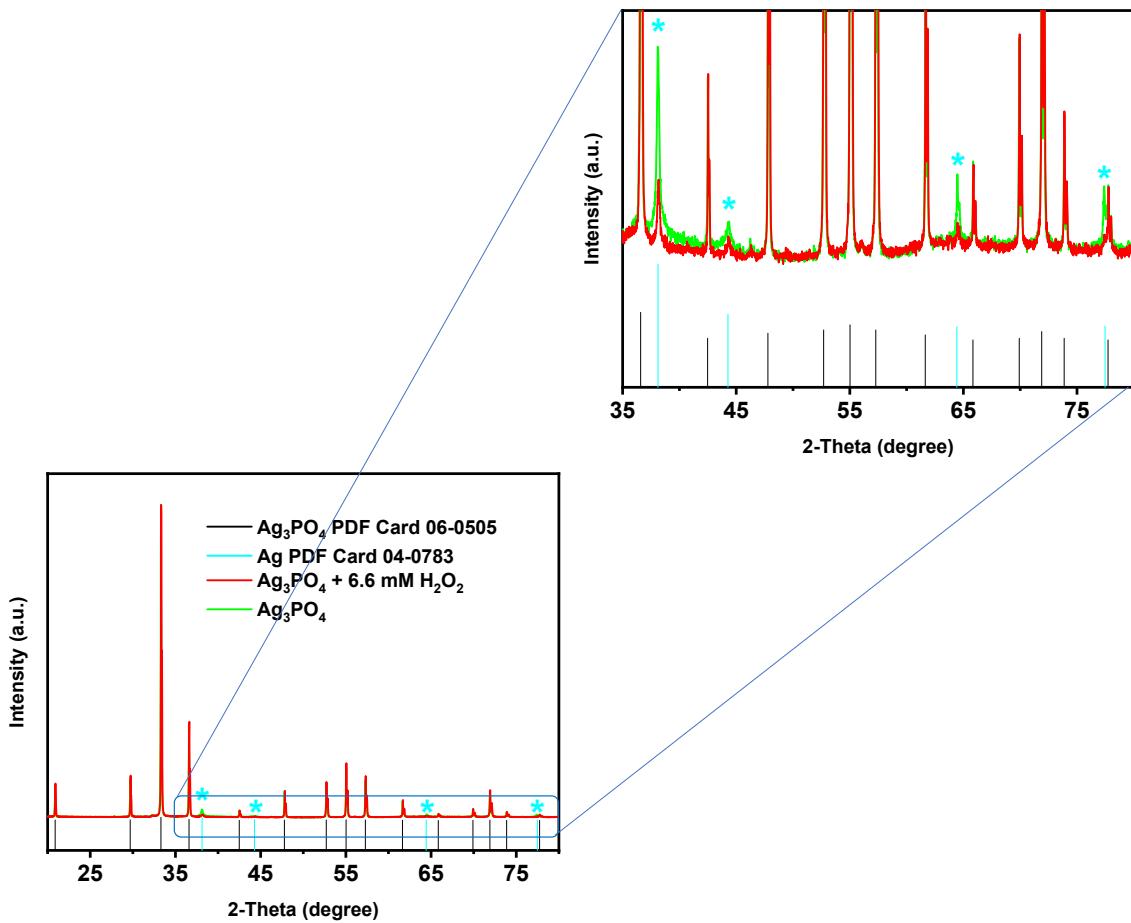


Figure S4. X-ray powder diffractograms of the recovered Ag_3PO_4 samples compared to the diffraction patterns of pure Ag_3PO_4 and Ag. The upper panel shows a zoom of the 2-theta region ($35\text{--}80^\circ$) for better visualization of the peaks pertaining to metallic silver. The intensity of the characteristics diffraction peaks of Ag^0 (marked with asterisks) are much lower for the binary $\text{Ag}_3\text{PO}_4\text{-H}_2\text{O}_2$ system than the one single component Ag_3PO_4 system, indicating the importance of H_2O_2 for the stability recyclability of Ag_3PO_4 during degradation tests.

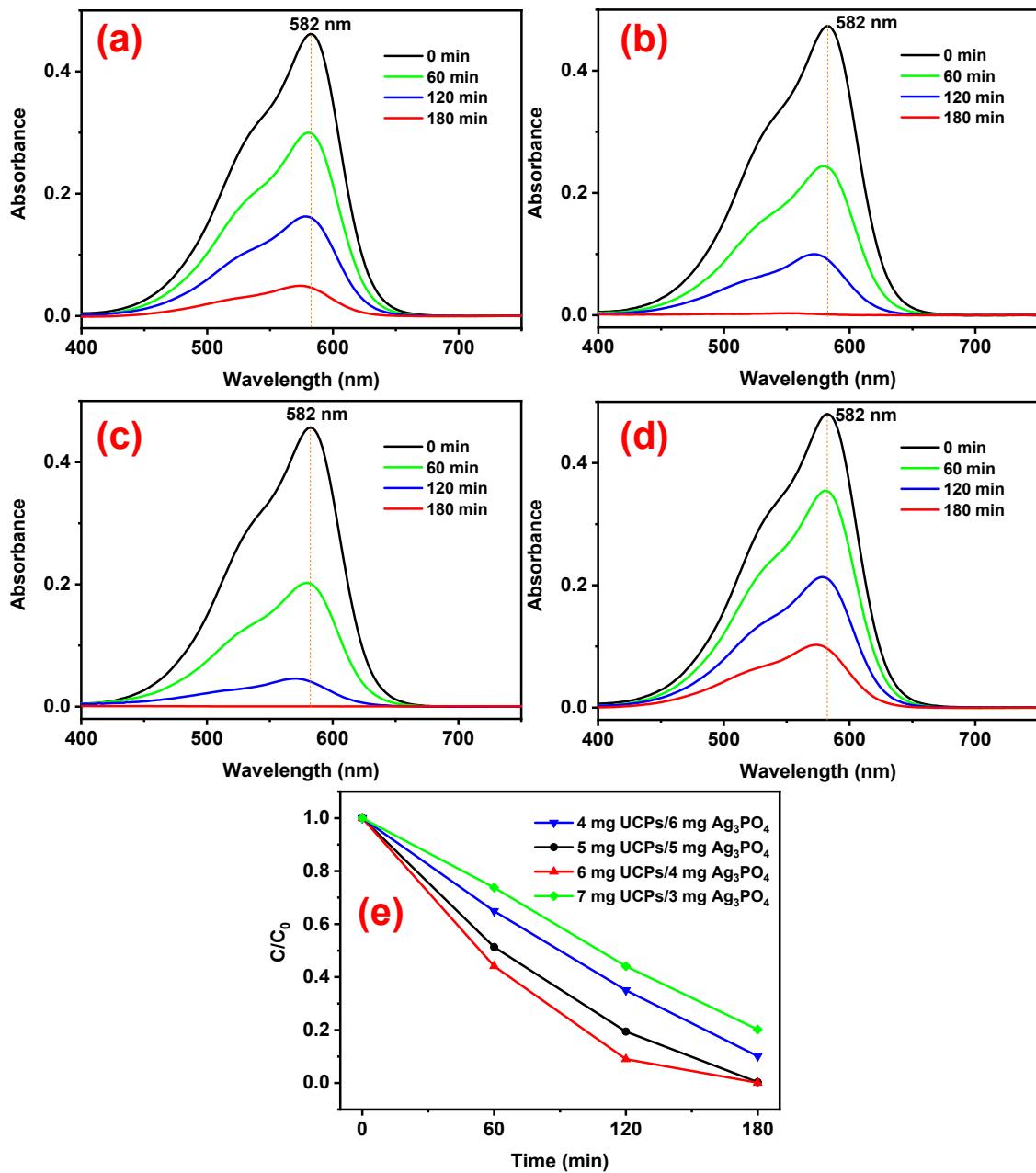


Figure S5. Temporal decrease in the absorbance of CV dye under 980 nm laser irradiation in the presence of different UCPS/ Ag_3PO_4 ratios (total amount of UCPS+ Ag_3PO_4 = 10 mg): (a) 4 mg/6 mg, (b) 5 mg/5 mg, (c) 6 mg/4 mg and (d) 7 mg/3 mg. (e) Comparison of the decrease in concentration of CV dye as a function of 980 nm laser irradiation time in the presence of the above ratios.