

Electronic Supplementary Information (ESI)

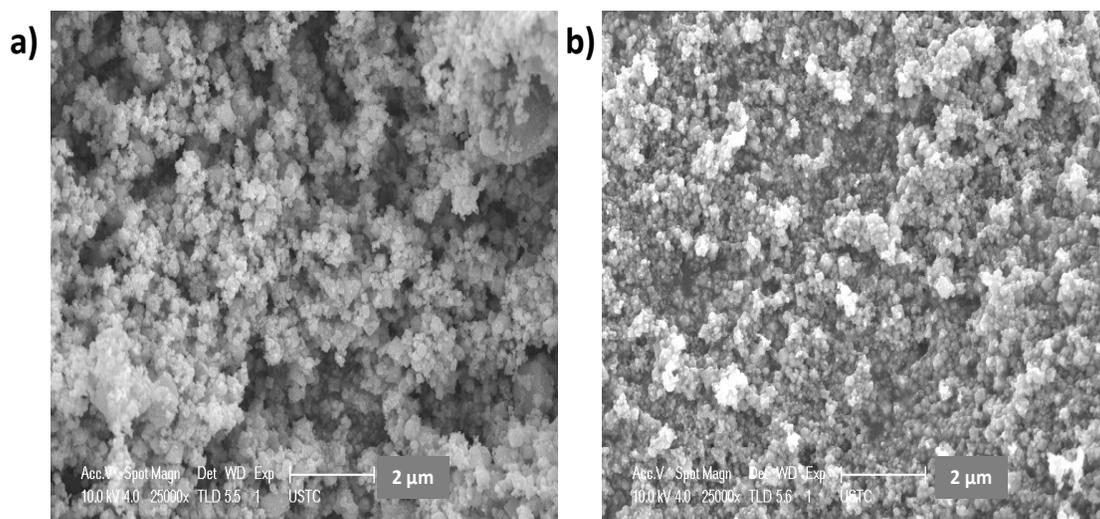


Fig. S1 SEM images of a) air-In₂O₃ and b) H₂-In₂O₃.

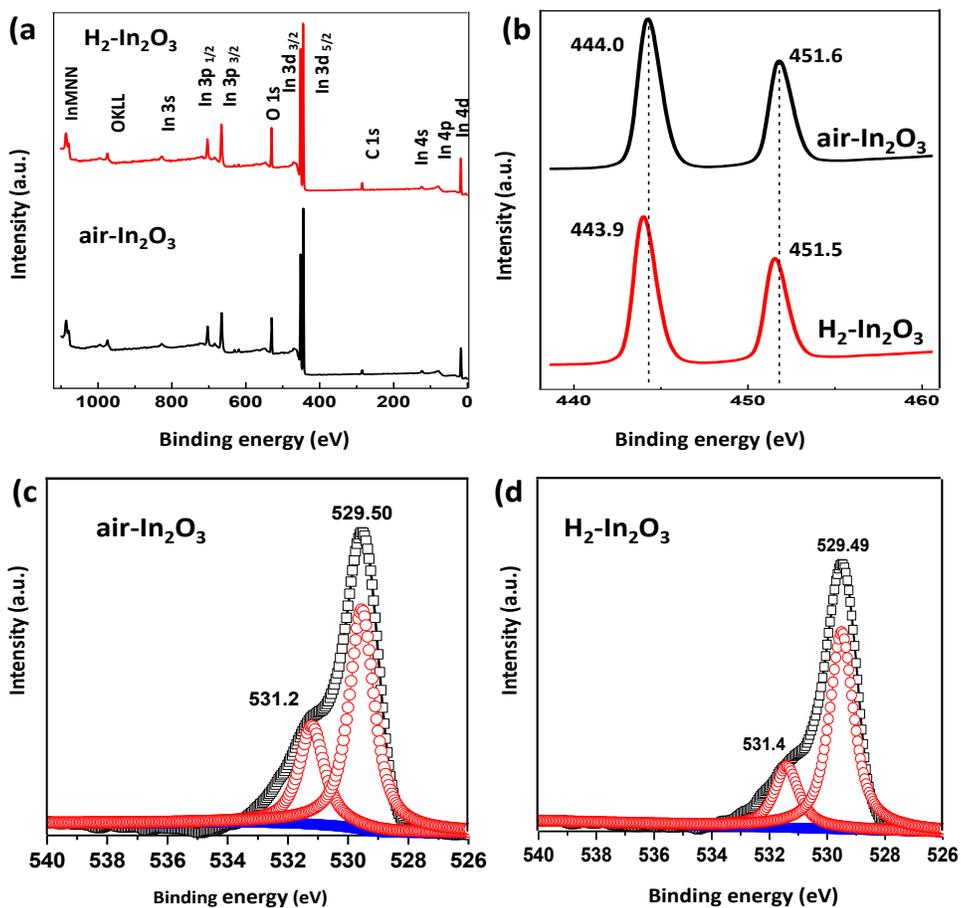


Fig. S2 Survey XPS spectra of air-In₂O₃ and H₂-In₂O₃ (a). In 3d core level XPS spectra of air-In₂O₃ and H₂-In₂O₃ (b). XPS spectra of O 1s peak of air-In₂O₃ (c) and H₂-In₂O₃ (d). Black lines are the experimental XPS data, which are further fitted into two peaks (shown by red lines).

The XPS has been employed to detect the chemical states of air- and H₂-In₂O₃ samples. Only O, In and C (used as reference) signals appear in XPS survey acquired from air- and H₂-In₂O₃ (Fig. S2 a). As shown in Fig. S2 b In 3d peaks of H₂-In₂O₃ are very closed to the In 3d peaks of air-In₂O₃. However, after hydrogen treatment In 3d peaks at lower binding energy could be mainly ascribed to oxygen vacancies.^{1,2} Fig. S2 c and d presents the XPS spectrum for O 1s air- and H₂-In₂O₃ respectively and each O 1s curve can be fitted into two peaks. In both samples, highest binding energy peak located at 529 eV is corresponded to indium oxygen bond (In-O). In air-In₂O₃ the peak at 531.2 eV can be attributed to the O²⁻ ions in the oxygen deficient region or to the surface adsorbed oxygen.³ Whereas, in H₂-In₂O₃ the peak centered at 531.4 eV can be assigned to the oxygen defects.⁴ Furthermore, In 3d and O 1s regions evidenced no significant differences in the particle surface of air- and H₂-In₂O₃. This could be the reason that the green emission intensity is lower than blue emission.

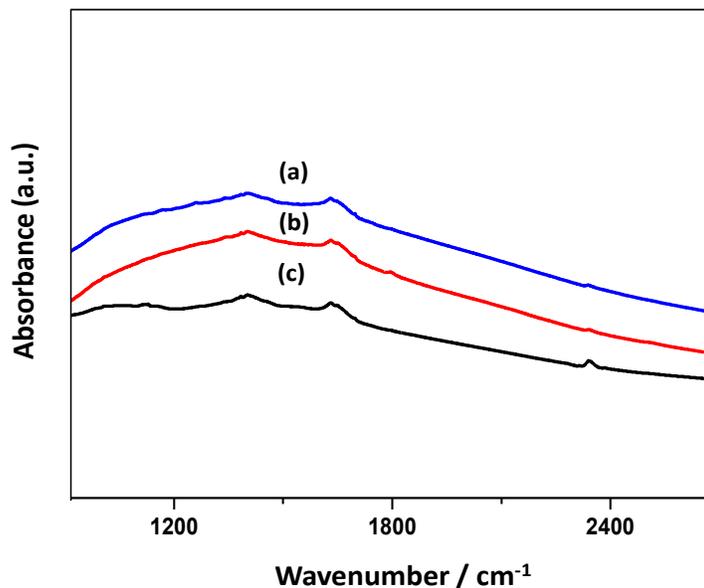


Fig. S3 (a) FT-IR spectra of $H_2\text{-In}_2O_3$ at 400 °C for 12 h and (b and c) after oxidative treatment at 200 °C for 6 h and 400 °C for 12 h, respectively. After oxidative treatment (from top to bottom b and c), there is a continuous decrease in IR absorption signals.

FT-IR spectroscopy is a useful technique to monitor the CB and shallow state electrons in n-type semiconductors. According to Drude theory the resonance frequency of electrons depends upon the number of free electrons (e^-) N . The absorbance at a particular wavelength (λ) is proportional to number of electron (N) in conduction band.

$$A(\lambda) \sim N \quad \text{eq (1)}$$

The increased absorption in IR spectra (Fig. 3S a) can directly attributed to the CB and shallow state electrons in $H_2\text{-In}_2O_3$, as a result of reducing atmosphere. In order to test this hypothesis the respective sample ($H_2\text{-In}_2O_3$) was oxidized at 200 °C for 6 h and 400 °C for 12 h (Fig. 3S b and c). The intensity of broad absorption in IR spectra decreased upon oxygen adsorption. The electrons in CB and shallow state combine with hole and cause recombination process. However adsorbed O_2 can act as an electron sink and prevent such recombination process.⁵ The adsorbed O_2 clearly affect or decrease the CB electrons and represent inactive IR species. Thus, the broad absorbance is quenched upon introduction of oxygen, which acts as an excellent electron (e^-) scavenger.

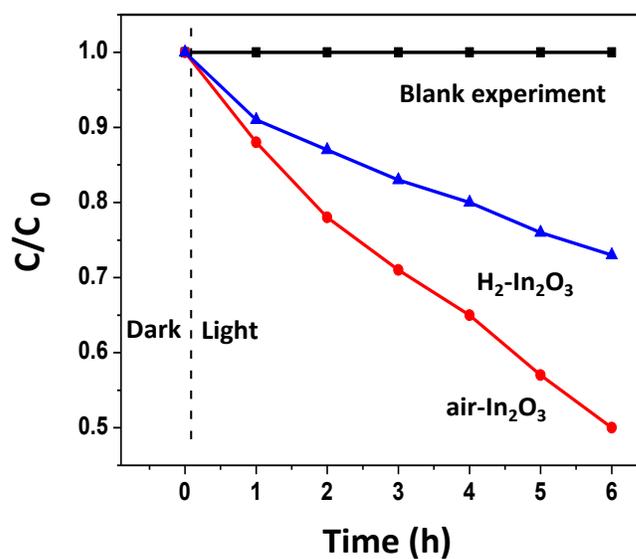


Fig. S4 Methyl orange degradation under irradiation > 400 nm with an optical power density 150 mW cm^{-2} using H_2O_2 as an oxidant. For blank experiment all parameters are same except sample addition.

References

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