Electronic Supplementary Material (ESI) for Nanoscale.

Electronic supplementary information (ESI)

Unique N doped Sn_3O_4 nanosheets as an efficient stable photocatalyst for hydrogen generation under sunlight.

Sagar Balgude[ab], Yogesh Sethi[a], Aarti Gaikwad[c], Bharat Kale[a*], Dinesh Amalnerkar[d], Parag Adhyapak[a*]

[a]Centre for Materials for Electronics Technology, Panchawati, Pashan Road, Pune-411008, India.
[b]D. Y. Patil College of Engineering, Ambi, Pune-410507, India.
[c]CSIR- National Chemical Labortory, Pune-411008, India.
[d]Institute of Nano Science & Technology, Hanyang University, Seoul-04763, South Korea.
* Corresponding Author: Dr. P. V. Adhyapak Email: adhyapak@cmet.gov.in, adhyapakp@yahoo.com,
Dr. Bharat B. Kale Email: bbkale@cmet.gov.in.

Table A1: Experimental details

Sr. No.	Tin precursor (Purity 99%)	Tin precursor conc.	Urea (Purity 99%) conc.	Hydro-thermal treatment time/ temp.	Yield (%)	Morphology observed
01	Stannous oxalate	0.34 mol	0.0000 mol	180°C/ 24 h	86.23	layered structure
02	Stannous oxalate	0.34 mol	0.0034 mol	180°C/ 24 h	84.33	irregular shaped premature partial nanosheet-like
03	Stannous oxalate	0.34 mol	0.0068 mol	180°C/ 24 h	88.46	mixed morphology i. e. Irregular shaped nanosheets and deposition of nanoparticles on it
04	Stannous oxalate	0.34mol	0.0102 mol	180°C/ 24 h	85.78	Utmost sheet-like
05	Stannous oxalate	0.34 mol	0.0136 mol	180°C/ 24 h	86.65	nanosheet-like
06	Stannous oxalate	0.34 mol	0.0170 mol	180°C/ 24 h	84.47	aggregated nanosheets

Table A2. Comparison of elemental analysis of 4% N doped Sn_3O_4.

Elements	XPS	EDS
	Atomic weight %	Atomic weight %
Sn	60.08	66.47
N	3.4	3.36
O	36.52	30.17

Supporting SI1: Raman Spectra

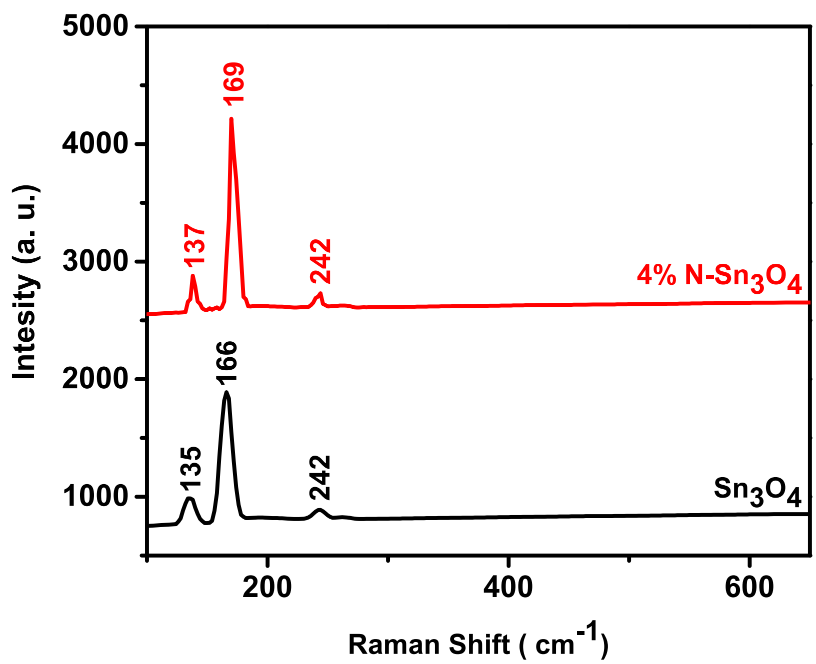

Figure SI 1 Raman Spectra of pristine (S1) and 4% N doped Sn_3O_4 (S5).

Supporting SI 2: Photoresponse study

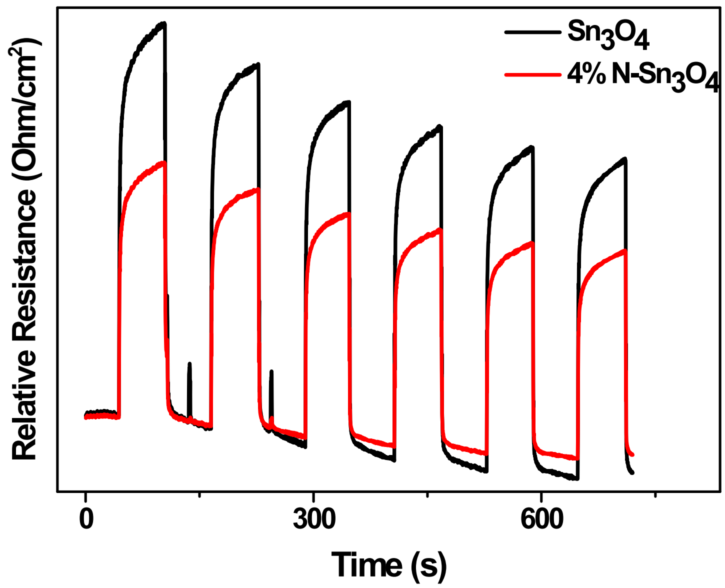

Figure SI 2 Photo response of Sn_3O_4 and 4% N-Sn_3O_4 under sunlight.

Supporting SI 3: Comparison with artificial light as source

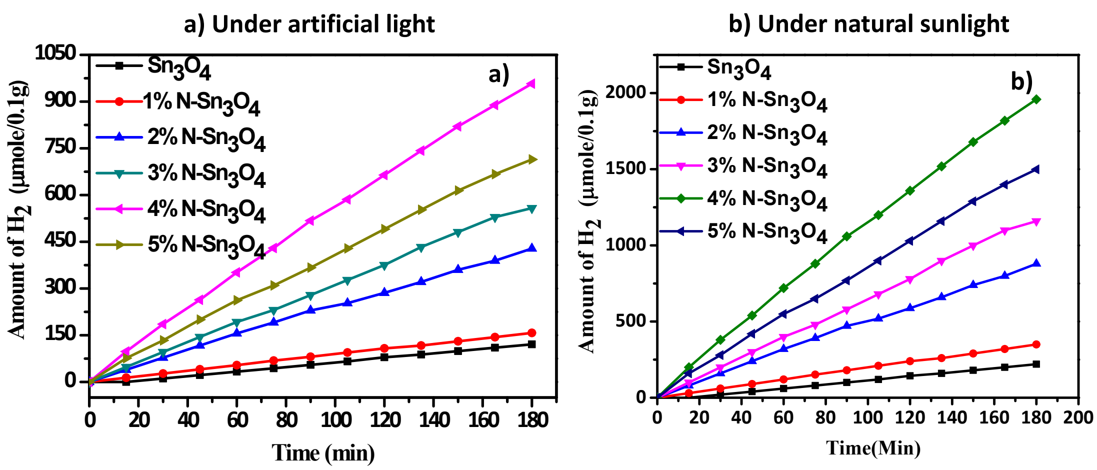

Figure SI 3 Hydrogen production as a function of irradiation time using undoped and N doped Sn_3O_4 sample under a) artificial light b) natural sunlight.

The photocatalytic activity of the as-synthesized samples (S1-S6) for hydrogen evolution via. H_2O splitting was performed. Cumulative H_2 production using undoped and N doped Sn_3O_4 sample under artificial and natural sunlight is shown in figure SI3. This study was performed in the presence of a co-catalyst and sacrificial agent. The volume of H_2 generated was observed by gas chromatograph (GC) with respect to time. Pure Sn_3O_4 shows less activity under a xenon lamp since UV radiation is eliminated. The Sn_3O_4 shows 79.41 $\mu mol^{-1}h^{-1}0.1g^{-1}$ hydrogen production under natural sunlight because of availability of both UV and visible light. Amongst all catalysts, 4% N-Sn_3O_4(S5) showed the highest rate for H_2 generation under xenon and natural sunlight i.e., 542.44 and 654.33 $\mu mol^{-1}h^{-1}0.1g^{-1}$, respectively. S2, S3, S4, and S6 show H_2 generation of 86.25, 237.18, 307.12, and 401.02 $\mu mol^{-1}h^{-1}0.1g^{-1}$, under the xenon lamp and 122.86, 318.10, 404.24 and 562.43 $\mu mol^{-1}h^{-1}0.1g^{-1}$, under natural sunlight, respectively. Table A1 lists results of H_2 generation in $\mu mol^{-1}h^{-1}0.1g^{-1}$ under xenon and natural sunlight.

Supporting SI 4: Effect of Pt loading

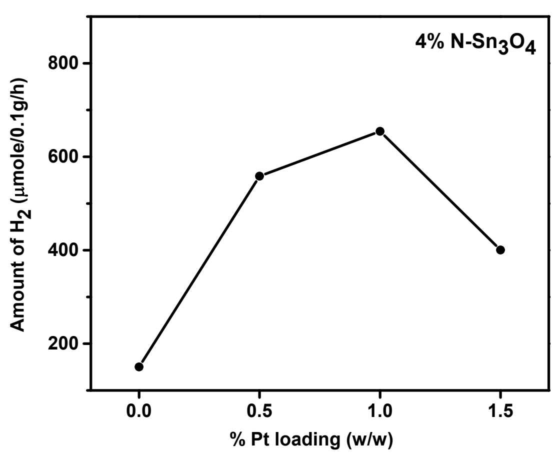

Figure SI 4 Effect of Pt loading on photocatalytic H_2 evolution under sunlight.

Table A3. Photocatalytic hydrogen evolution in $\mu mol^{-1} h^{-1} 0.1 g^{-1}$

Photocatalyst	**Band gap Energy (eV)**	**Under Xenon lamp H_2 (μmol/h/0.1g)**	**Under Natural sunlight H_2 (μmol/h/0.1g)**
0% N-Sn_3O_4(S1)	2.83	66.14	79.41
1% N-Sn_3O_4(S2)	2.69	86.25	122.86
2% N-Sn_3O_4(S3)	2.57	237.18	318.10
3% N-Sn_3O_4(S4)	2.53	307.12	404.24
4% N-Sn_3O_4(S5)	2.36	542.44	654.33
5% N-Sn_3O_4(S6)	2.45	401.02	562.43

Table A4. Summary of recent research reports to photocatalytic hydrogen evolution via. H_2O splitting.

Sr. No	**Photocatalyst material**	**Light source used**	**Hydrogen evolution (μmol/h)**	**References**
01	N doped Sn_3O_4	300W Xe lamp	542.44 $\mu mol\ h^{-1}\ 0.1g^{-1}$	*Current work*
02	Sn_3O_4/TiO_2	300 W Xe arc lamp	83.5 $\mu mol\ h^{-1}\ 0.2g^{-1}$	*Chen et al [26]*
03	Sn_3O_4/N-TiO_2	300 W Xe lamp	32 $\mu mol\ h^{-1}\ 0.1g^{-1}$	*Xin Yu et al [25]*
04	Sn_3O_4	300 W Xe arc lamp	40 $\mu mol\ h^{-1}\ 0.3g^{-1}$	*Manikandan et al [29]*