Networking and Brokerage Event

Horizon Europe

MSCA Staff Exchanges Call 2026

SOLAR FUEL GENERATION

16 February 2026

ATOMICALLY DISPERSED COCATALYST DECORATED CATALYST FOR SELECTIVE CO_2 CONVERSION TO VALUE-ADDED CHEMICALS

Dr Yatendra S Chaudhary

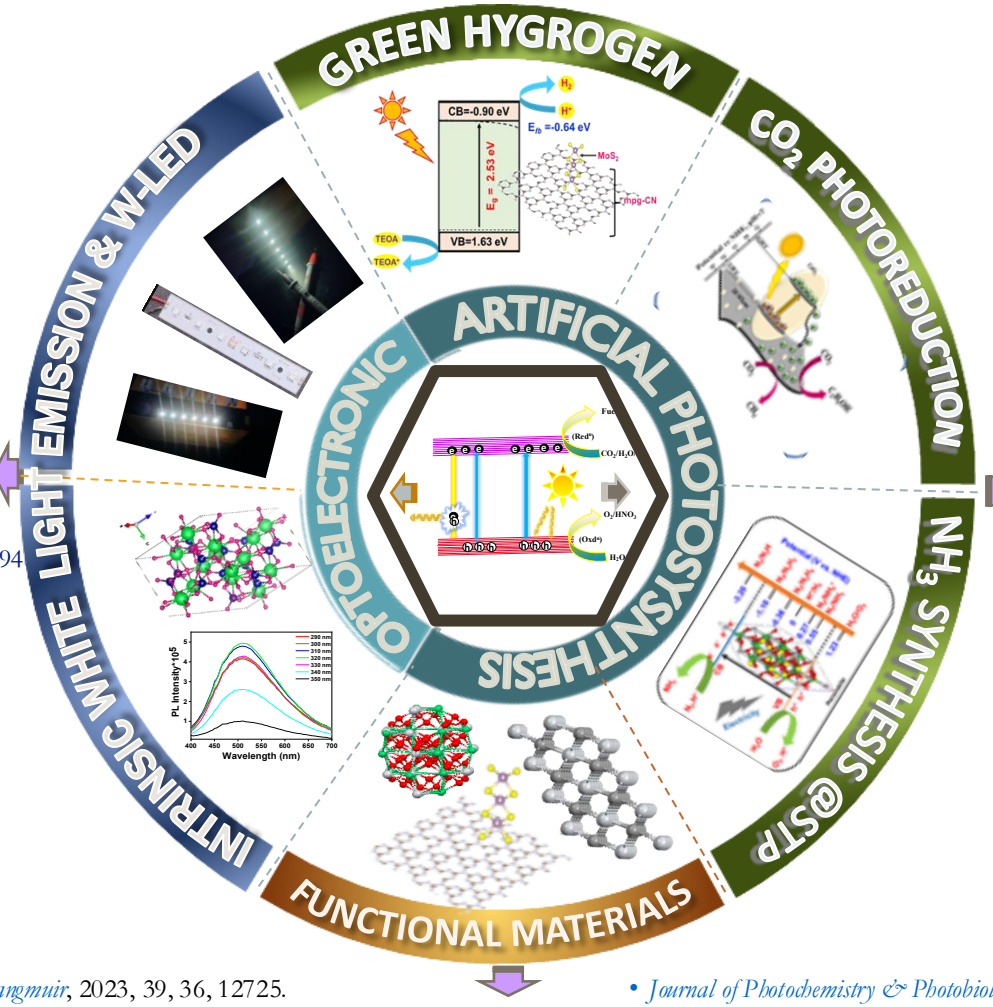
CSIR-Institute of Minerals and Materials Technology

INDIA

Email: yschaudhary.immt@csir.res.in Mob: +91-7205755894

http://immt-yschaudhary.weebly.com/

FUNCTIONAL NANOMATERIALS FOR SOLAR FUEL & OPTOELECTRONICS



- *J. Phys. Chem. B,* 2025, 129 (4), 1323-1330.
- *J. Mater. Chem. C,* 2024, 12 (44), 17807-17817
- *Journal of Luminescence*, 2024 269, 120546.
- *Inorganic Chemistry*, 2023, 62, 42, 17163.
- *Chemistry -An Asian Journal*, 2022, 17, e20220094
- *Applied Material Today*, 2022, 27, 102407.

- *ACS Sustainable Chem. Eng.* 2026, 10.1021/acssuschemeng.5
- *Adv. Optical Mater.* 2026, e03043,
- *J. Mater. Chem. A,* 2026, 10.1039/D5TA08224B
- *Journal Material Chemistry A*, 2023, 11, 20839
- *ACS Applied Material Interfaces*, 2023, 15, 13052.
- *Langmuir*, 2023, 39, 40, 141893.
- *ACS Applied Polymer Materials*. 2023, 5, 12, 9918
- *Chemistry Select*, 2023, 8, e202301990.
- *Nanoscale*, 2023, 15, 10939.
- *ChemCatChem*, 2023, 15, e202300266.
- *ChemSusChem*, 2019, 12, 3383.
- *Surface & Coating Technology*, 2018, 349, 540.
- *ACS Sustainable Chemistry & Engineering*, 2016, 4, 2323.
- *ACS Applied Materials & Interfaces*, 2015, 7, 7970.
- *RSC Advances*, 2014, 4, 10928.
- *Journal of the American Chemical Society*, 2013, 135, 15026
- *Energy & Environmental Science*, 2012, 5, 7470.
- *Chemical Communications*, 2012, 48, 58.

- *Langmuir*, 2023, 39, 36, 12725.
- *Materials Research Bulletin*, 2023, 164, 112262.
- *The Journal of Physical Chemistry Letters*, 2023 13, 9411.
- *New Journal of Chemistry*, 2022, 46, 11851
- *ACS Applied Nano Materials*, 2020, 3, 9, 9064
- *WIREs Energy and Environment*, 2020, Wiley,

- *Journal of Photochemistry & Photobiology, B: Biology*, 2016, 162, 248
- *Journal of Applied Physics*, 2015, 117, 024303.
- *New Journal of Chemistry*, 2015, 39, 2612
- *Journal of Physical Chemistry C*, 2012, 116, 30
- *Journal of Materials Chemistry*, 2010, 20, 4949

CSIR-Institute of Minerals & Materials Technology, Bhubaneswar- 751 013
Email: yschaudhary.immt@csir.res.in

CO_2 CONVERSION TO VALUE ADDED CHEMICALS: ENERGETICS

CO_2 PHOTO-REDUCTION

One-electron reduction of CO_2 :

$CO2 + e^- \rightarrow CO2^{\bullet -}$ E = -1.90 V

linear bent

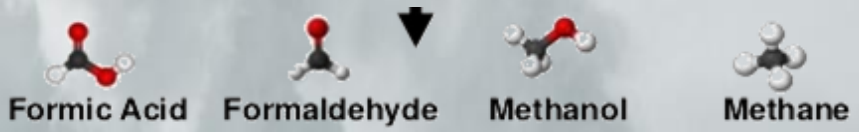
…but *multi-electron* reductions are much easier:

$CO2 + 2H^+ + 2e^- \rightarrow CO + H_2O$ E = -0.52 V

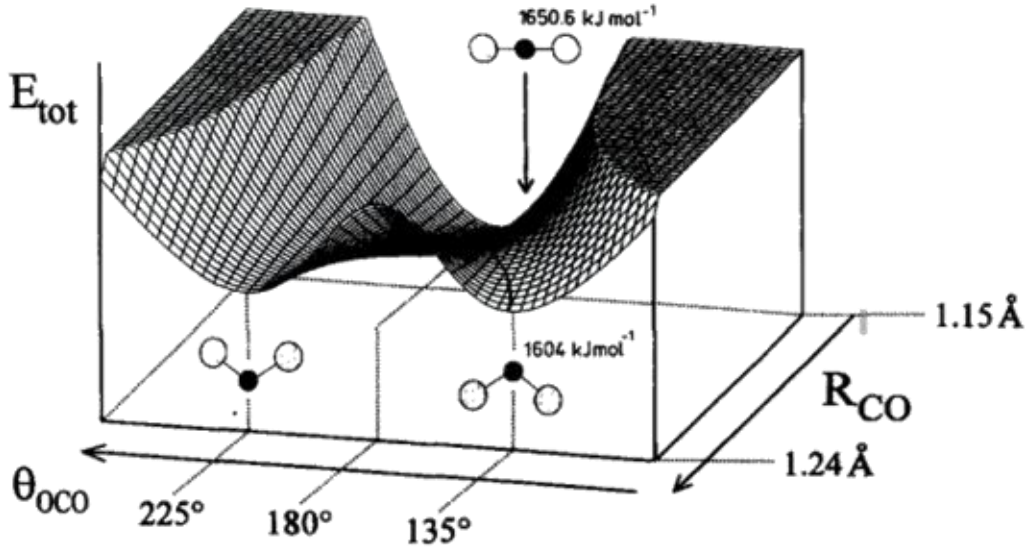
$CO2 + 4H^+ + 4e^- \rightarrow HCHO + H2O$ E = -0.48 V

$CO2 + 6H^+ + 6e^- \rightarrow CH3OH + H2O$ E = -0.38 V

$CO2 + 8H^+ + 8e^- \rightarrow CH4 + 2H2O$ E = -0.24 V



- ✓ **Charge Carrier Recombinations**
- ✓ **CO_2 activation & desorption**
- ✓ **Selectivity**



H.-J. Freund, M. W. Roberts~*Surface Science Reports* 25 (1996) 225-273

SELECTIVITY

ABOUT THE BENT STRUCTURE AND ENERGY

CO_2 PHOTOCATALYTIC REDUCTION: KEY CHALLENGES

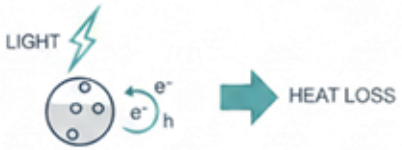
FROM MOLECULE TO MARKET

Therodanemtic Stability

- Strong C=O Bonds (≈806 kJ/mol)
- High Activation Barrir ~1.9V vs. NHE

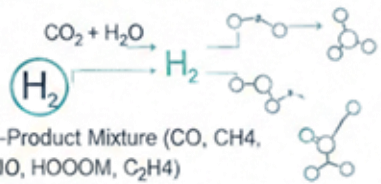
2. Charge Dynamics

- Rapid e-/h+ Recombation (ns)
- Short Diffusion Lengths



3. Selectivity Crisis

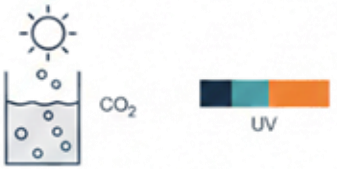
- HER Compettion
- HER Compettion (0V vs. NHE)



- Multi-Product Mixture (CO, CH4, HCOIO, HOOOM, C_2H4)

4. Mass Transfer & Light

- Low CO_2 Solubility (33mM)
- Limited UV Absorption (<5% Solar Spectrum)

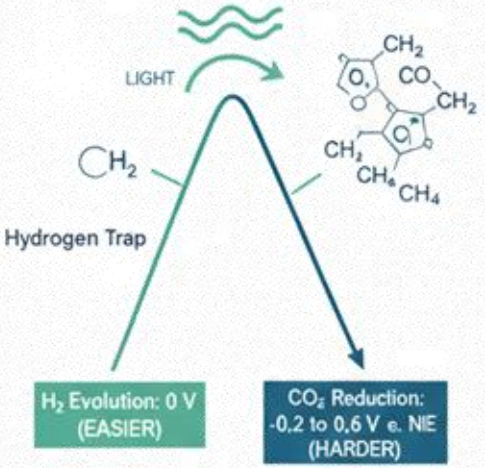


Summary of Strategies

THE SELECTEVITY CHALLENGE: CO_2 VS. H_2O

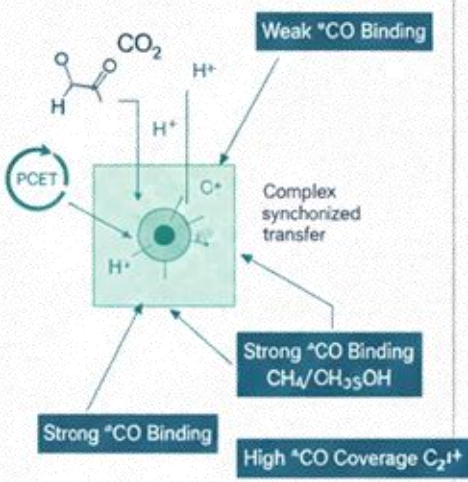
Why Hydrogen Evolution Reaction (HER) Dominates and How to Steer Product Formation

1. Thrrdomentic Overlap



Product	Reaction Path	Potential (E°
H_2	0.00 V	0.61 V
CO	HOCOM	-.63 V
HCOOM	-.63 V	0.24 V

2. Kinetic Bottlbnecks



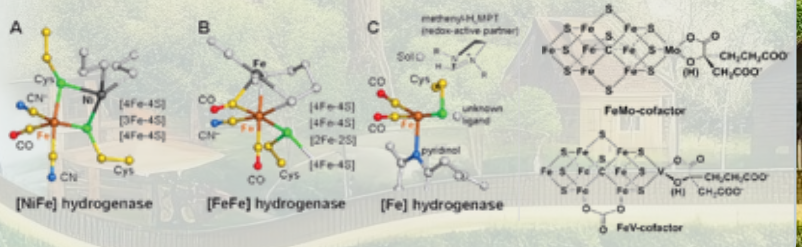
INSPIRATION FROM NATURE'S CATALYST: EARTH ABUNDENT METAL BASED

22	23	24	25	26	27	28	29
Ti	V	Cr	Mn	Fe	Co	Ni	Cu

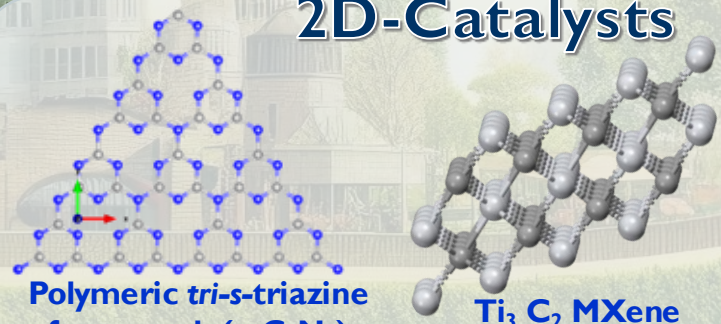
40	41	42
Zr	Nb	Mo

72	73	74
Hf	Ta	W

Enzymes



2D-Catalysts



CSIR-Institute of Minerals & Materials Technology, Bhubaneswar- 751 013
Email: yschaudhary.immt@csir.res.in

SOLAR FUEL GENERATION: CO_2 CONVERSION TO C1 COMPOUNDS

Journal of Materials Chemistry A

ROYAL SOCIETY OF CHEMISTRY

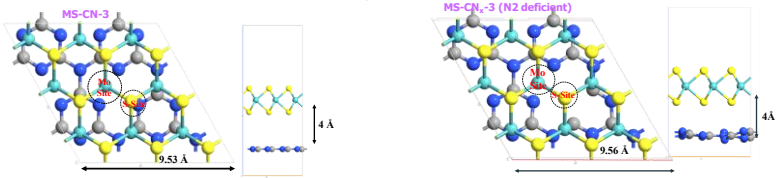
PAPER

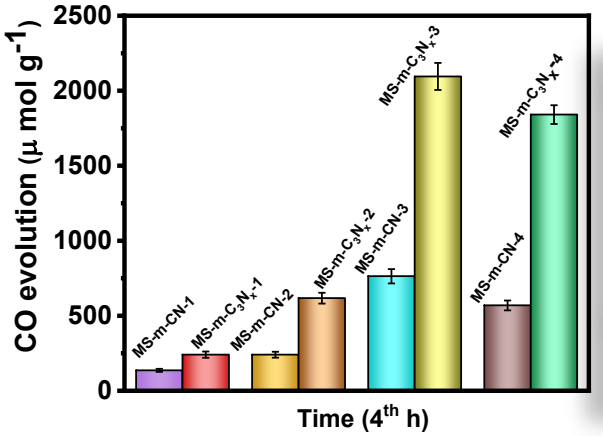
Check for updates

Cite this: J. Mater. Chem. A, 2023, 11, 20839

The synergistic chemical coupling of nanostructured MoS_2 with nitrogen-deficient 2-D triazine-based polymeric m-C_3N_x for efficient and selective CO_2 photocatalytic conversion to CO†

Niharika Kumar,[ab] Rajashree P. Mishra,[ab] Bibek Dash,[c] Sweta Bastia[ab] and Yatendra S. Chaudhary[*ab]





- Higher CO formation rate and **FE of ~31%, 3-fold higher** than those of MS–m-CN (11%).
- Selective- Single Product formation and Stable

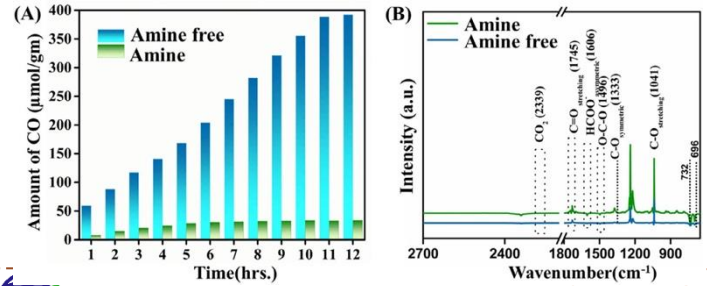
RESEARCH ARTICLE

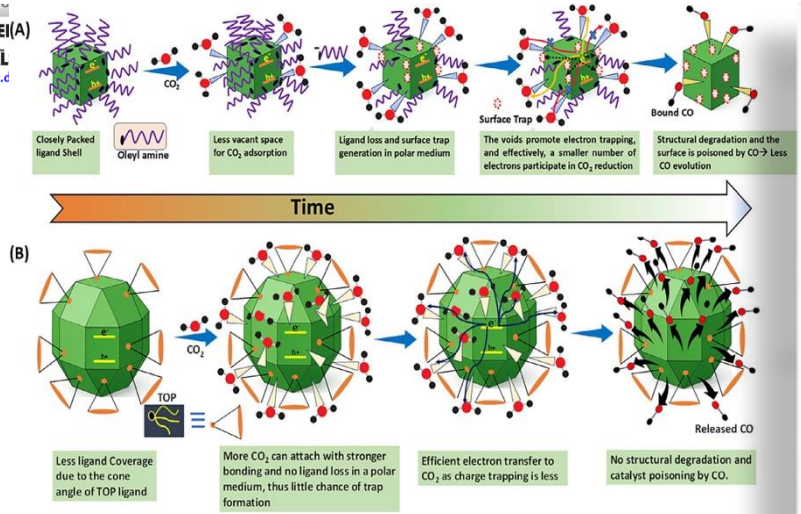
ADVANCED OPTICAL MATERIALS

www.advopticalmat.de

Co-Catalyst Free Efficient Photocatalytic CO_2 Reduction Using Facet-Engineered Polyhedral $CsPbBr_3$ Perovskite Nanocrystals

Subarna Biswas, Rajashree P. Mishra, Jit Satra, Ram Sewak, Jyotisman Rath, Anirban Mondal, Yatendra S. Chaudhary, and Nimai Mishra**





- Larger poly- hedral $CsPbBr_3$ exhibit superior activity over smaller cubic-shaped ones,
- An amine-free exhibit better activity than amine-capped $CsPbBr_3$

Email: yschaudhary.immt@csir.res.in

The C–C Coupling Challenge: Moving Beyond C1 to High-Density Liquid Fuels

1. Therlbomentic Escalation

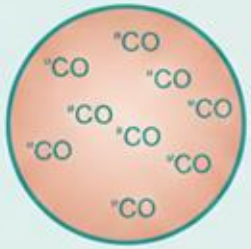
Ethylene (C_2H_4):
$2CO_2 + 12H^+ + 12e^- \rightarrow C_2H^* + 4H_2O$

Ethanol ($C_{25}OH$) + 12e → $C_2H^* + 3H_2O$
$CO_{24_5}OH$

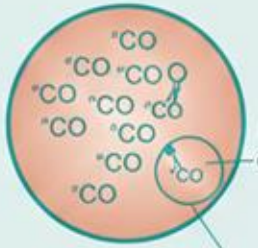
Ethanol (C_2H_4) + 12e → $C_2H^* + 3H_2O$

High Energy Input for C_{2+}

2. The Critical Intermediate: *CO Surface Coverage"



Low Coverage: CO gas desorption

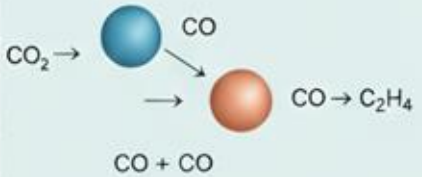


High Coverage: CO gas desorption

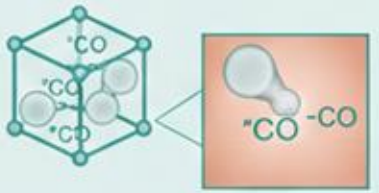
High Coverage: Dimerization (CO + *CO) → C_{2+}

3. Key Surface Engineering

Dual-Active Sites



Confinmeion Effects



Cu(100) facet

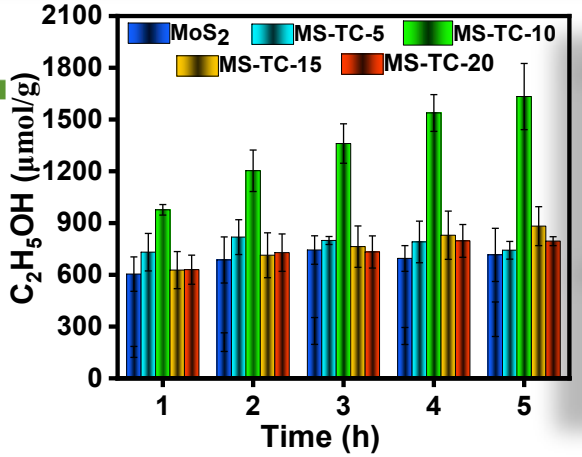
SOLAR FUEL GENERATION: CO_2 CONVERSION TO C2 COMPOUNDS

ACS Sustainable Chemistry & Engineering
pubs.acs.org/journal/ascecg
Research Article

Synergistic Coupling of MoS_2 with Electron-Rich MXene for CO_2 Conversion to Ethanol under Visible Light

Rajashree P. Mishra, Niharika Kumar, Sweta Bastia, Asish K. Dehury, Urmila Baral, and Yatendra S. Chaudhary*

Cite This: https://doi.org/10.1021/acssuschemeng.5c09725
Read Online



- MS-TC-10 heterostructure, 1.8 times higher than bare MoS_2
- Predominant ethanol formation (58.12% selectivity)

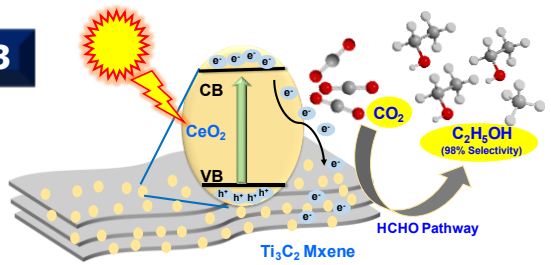
LANGMUIR
pubs.acs.org/Langmuir
Article

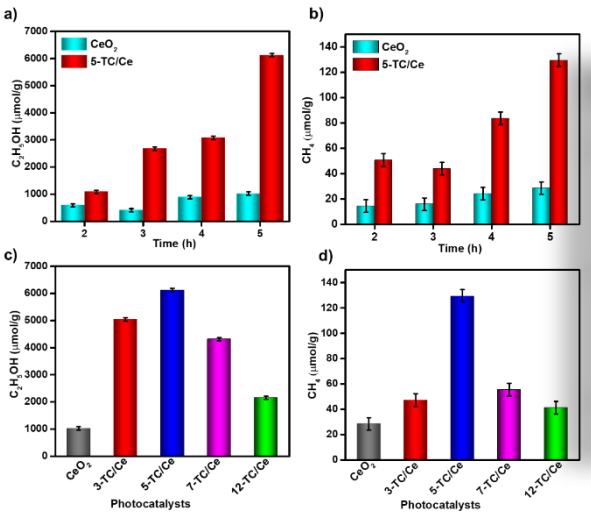
Efficient Photocatalytic CO_2 Reduction with High Selectivity for Ethanol by Synergistically Coupled MXene-Ceria and the Charge Carrier Dynamics

Rajashree P. Mishra, Madoori Mrinalini, Niharika Kumar, Sweta Bastia, and Yatendra S. Chaudhary*

Cite This: https://doi.org/10.1021/acs.langmuir.3c01064
Read Online

TRL: 3





SELECTIVE CO_2 CONVERSION

- Highly selective CO_2 Conversion to Ethanol with 98 % selectivity by 2-D MXene-based photocatalyst.
- Selective CO_2 conversion to CO (100% selectivity) by 2-D Photocatalysts.
- Efficient & selective conversion of CO_2.

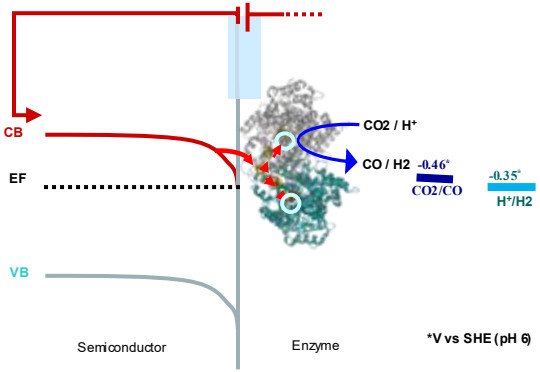
BIO-MEMETIC PHOTOCATALYSTS FOR H^+ AND CO_2 REDUCTION

JACS JOURNAL OF THE AMERICAN CHEMICAL SOCIETY

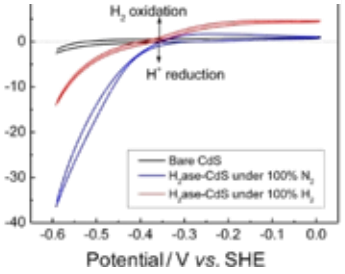
Bachmeier *et. al.*, ***J. Am. Chem. Soc.*** 2013, **135**, 15026−15032

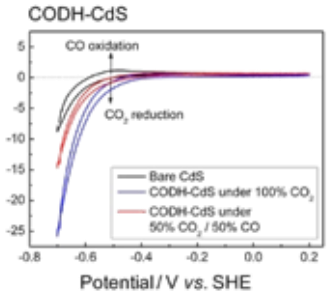
Terms of Use CC-BY

How Light-Harvesting Semiconductors Can Alter the Bias of Reversible Electrocatalysts in Favor of H_2 Production and CO_2 Reduction



Schematic representation of the band bending when Eappl.< Efb





ChemComm

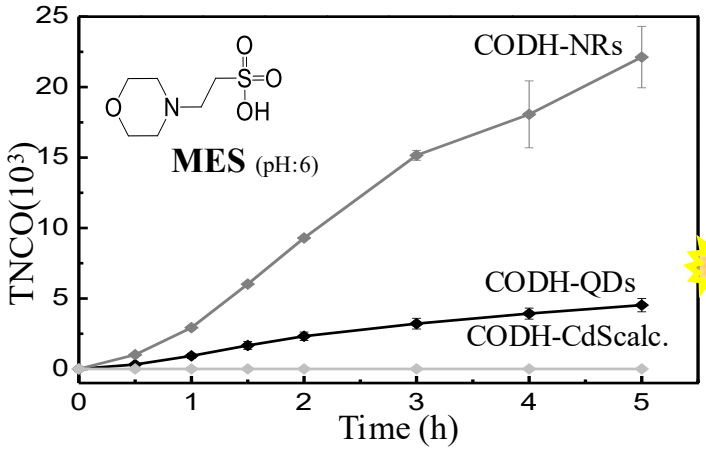
Cite this: *Chem. Commun.*, 2012, **48**, 58–60

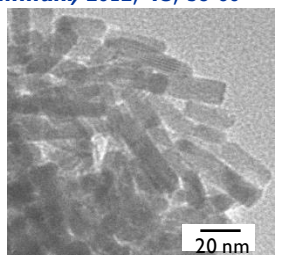
www.rsc.org/chemcomm

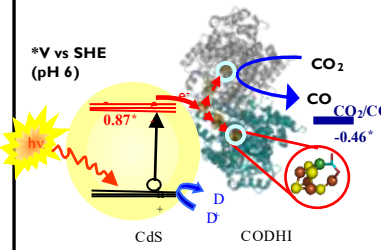
COMMUNICATION

Chaudhary *et. al.*, ***Chem. Commun.,*** 2012, **48**, 58-60

Visible light-driven CO_2 reduction by enzyme coupled CdS nanocrystals†‡





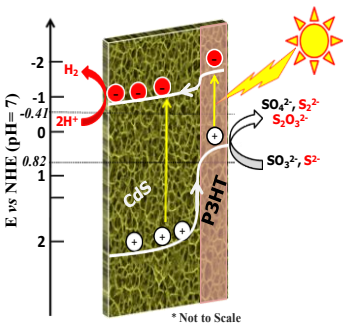


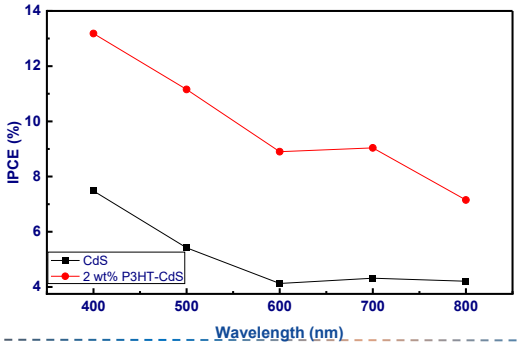
ACS APPLIED MATERIALS & INTERFACES

Nanda *et. al.*, ***ACS Appl. Mater. Interfaces,*** 2015, **7**, 7970-7978

www.acsami.org

Enhanced Photocatalytic Activity and Charge Carrier Dynamics of Hetero-Structured Organic−Inorganic Nano-Photocatalysts

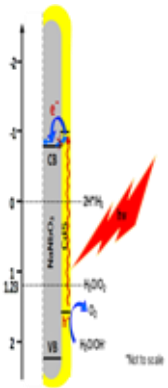




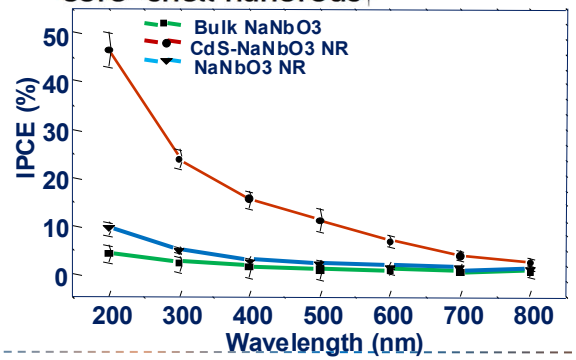
RSC Advances

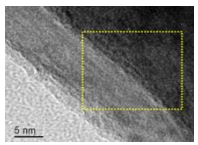
Nanda *et. al.* ***RSC Advances,*** 2014, **4**, 10928-10934.

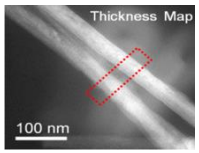
PAPER



Facile synthesis and the photo-catalytic behavior of core−shell nanorods†





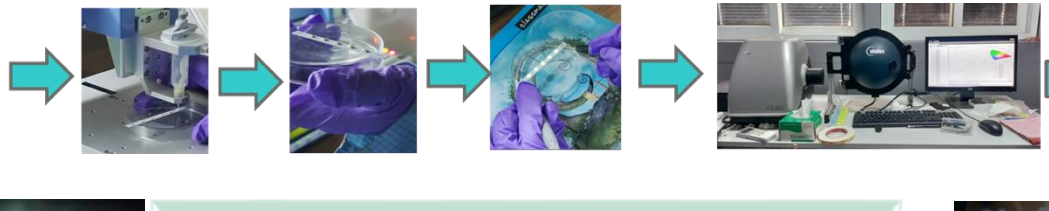


Email: yschaudhary.immt@csir.res.in

SALIENT POINTS OF THE DEVELOPED SINGLE PHASE PHOSPHORS:

- **Single phase phosphors that emit white light with high CRI, QE and are stable.**
- Eliminate use of multiple phosphors
- Improved colour balance & devoid of a bluish tinge
- Enhanced color rendering index (upto 95) and brightness
- Facile synthesis

Phosphor
Binder+
Phosphor

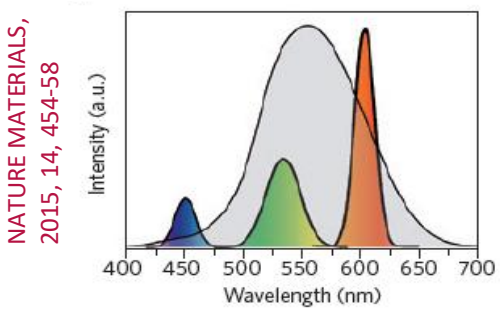


CCT = 5289-5913 K
CRI = 88-95 Ra
CIE =(0.33, 0.35)
~136-176 Lumens/Watt

PATENT: Filed-International-PCT, Ref No. *Chaudhary et al.* PCT/IN2023/050822 on 31st August 2023); India, Ref No. *Chaudhary et al,* 202211051217 on 9th July, 2022)

CONVENTIONAL WHITE LEDs

- Uses multiple phosphors (combination of blue and red LEDs and a green pc-LED) to get white light
- Bluesish tinge damages the retina.
- Low CRI: 75-80



GLOBAL BENCHMARKING PARAMETERS

Different Light Source (luminous efficacy)		For commercial LEDs	
Type	(lm/W)	CRI	CCT
Incandescent	12-18	72 to 80	2700 to 6500K
Halogen	10-20		
LED	75-110		

GAP: COLLABORATION OPPORTUNITIES

MECHANISICK INSIGHTS: THE KINETIC BLACK BOX

Bridging the Gap Between Reactants and Products

1. The "Black Box" Box Problem

- Complex PCET steps
- Transent Intermediates *COOH, *CO)
- Multiple Competing Routes

2. Operando Spectroraocy

- Real-time monitoring
- Identify active sites
- Track intermediate formation

3. Computational Chemistry (DFT)

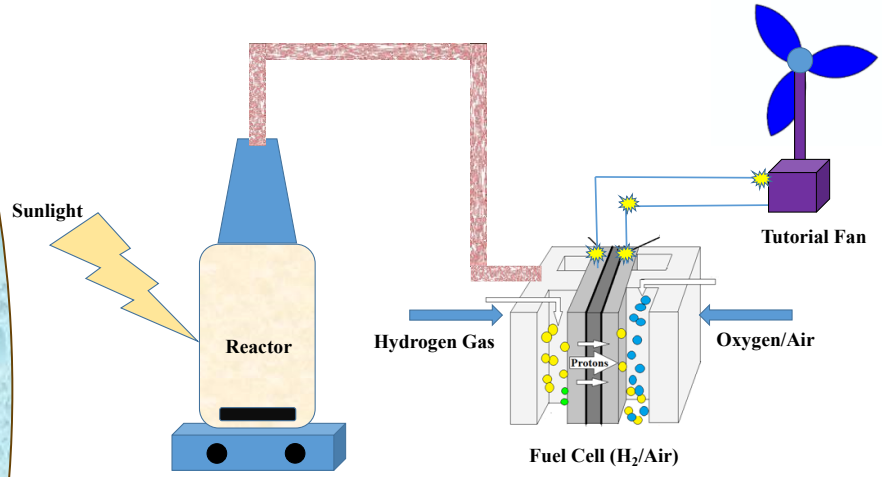
- Simulate reaction pathways
- Predict energy barriers
- Design new catalists

THANK YOU !

Email: yschaudhary.immt@csir.res.in

Fan Running on H_2 Being Generated Using Cost-Effective Photocatalyst

- Rapid Ni-modification- 10 minutes
- Highly efficient H_2 generation, under solar simulator and sunlight
- STH ~ *16%, however using electron donors.*



PATENTS:

- Chaudhary *et al*. **International-PCT, Ref No. PCT/IN2023/050556 on 13th June 2023**).
- Chaudhary *et al.* **Filed in India, Ref No. 202211034151 on 14th June 2022**).