2D-NMs PHOTOCATALYST HYDROGEN EVOLUTION

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CLIMATE CHANGE – MAJOR PROBLEMS
MITIGATING CO_2 EMISSION & RENEWABLE FUEL

Reduce **CO_2 Emissions**

Conversion into **Fuels/Chemicals,**

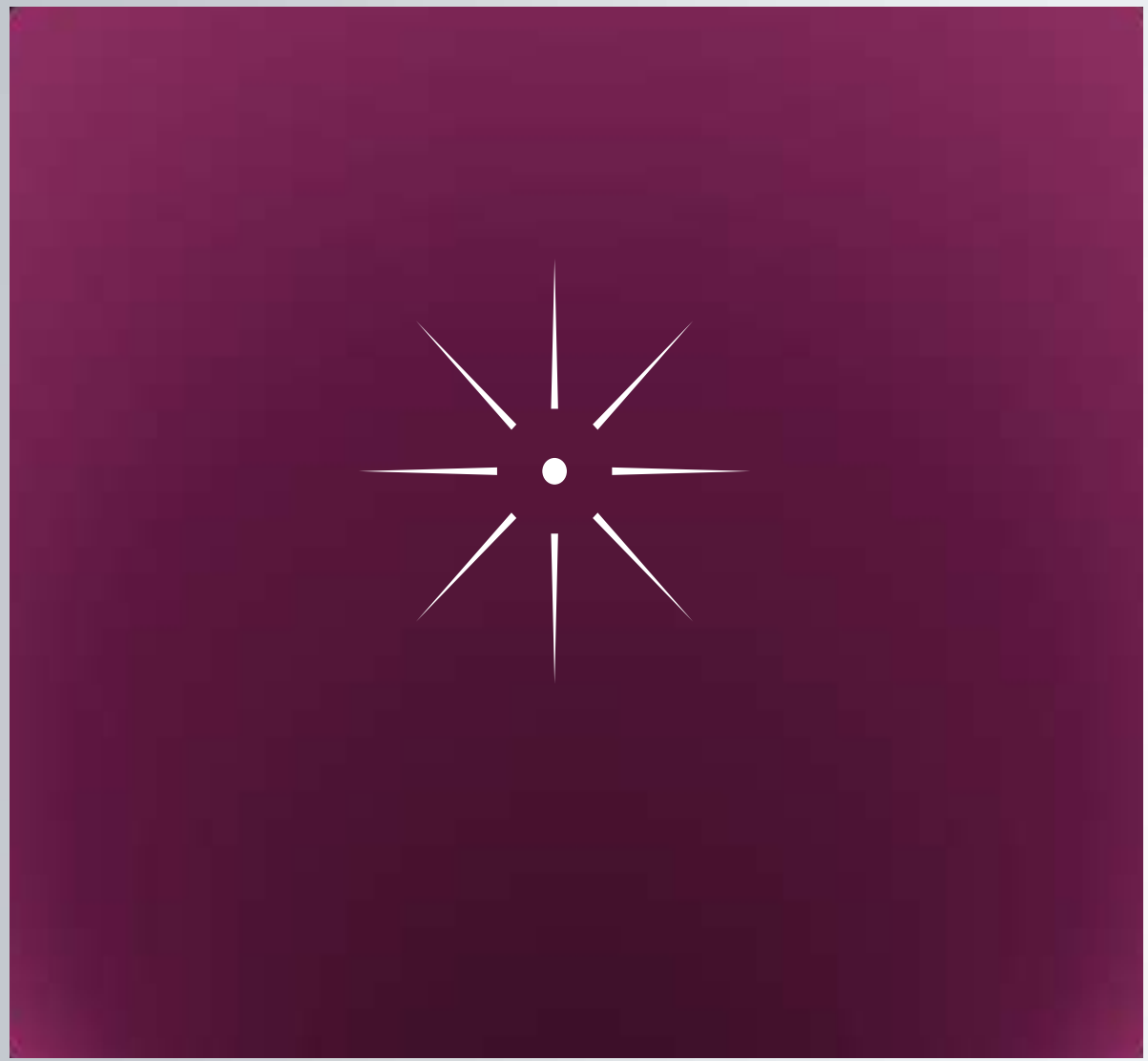
Produce H_2 - Photocatalytic Conversion

Efficient & Affordable **Photocatalysts**

A Necessary – Development

WHY HYDROGEN FUEL?

S. No.	Fuel	MJ/Kg
1.	Liquid Hydrogen	130
2.	Aviation Gasoline	46.8
3.	Premium Gasoline/Petrol	46
4.	Regular Gasoline/Petrol	47
5.	Jet Fuel (Kerosene)	47
6.	Jet Fuel (Naphtha)	46.6
7.	Diesel	48
8.	Biodiesel	39.9
9.	Liquefied Natural Gas	55
10.	E85 (85:15:: ethanol : gasoline)	~33
11.	Ethanol	31.1
12.	Methanol	19.9
13.	Vegetable Oil	37.7
14.	Gasohol (10:90:: ethanol : gasoline)	~45
15.	Liquid Petroleum Gas (LPG)	~51



Exploring 2D-Nanomaterials ?

Adjustable Charge Carrier Transport Carrier Lifetime…

OPTIMAL PHOTOCATALYST

Appropriate Band-Gap **Semiconductor**

Right Positioning – CONDUCTION/VALENCE Band

Satisfying – REDOX (**Reduction & Oxidation**)

CB/VB – More -ve/+ve – H_2O **Redox Potential**

ENERGY BG $\geq$ 1.23 eV – H_2O Split - **H_2 and O_2**

PHOTOCATALYTIC WATER-SPLIT

$h\nu \longrightarrow$ Chemical Energy

$H_2O \longrightarrow H_2 + 1/2\ O_2$

Efficiency – Semiconductor Band Structure

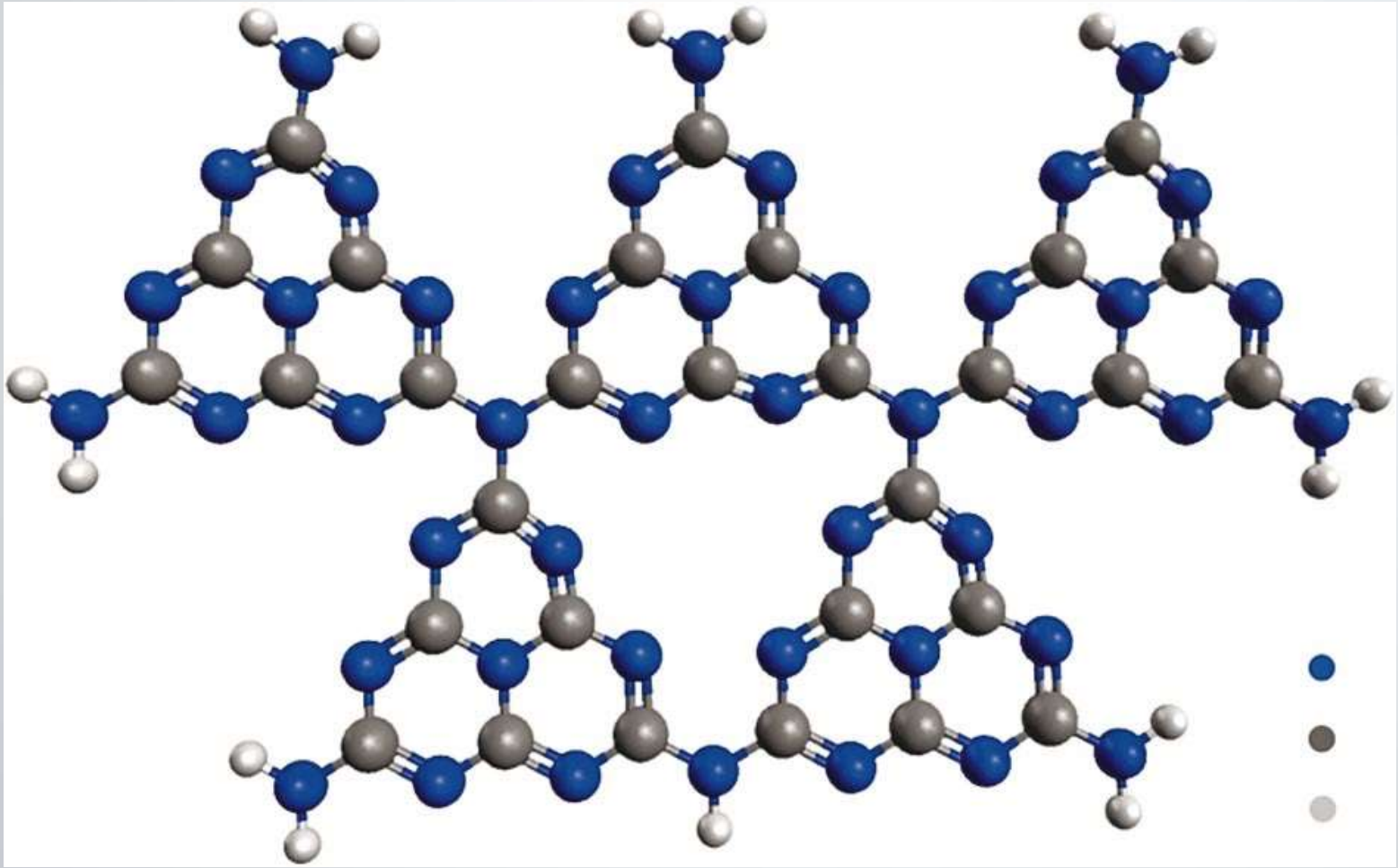
Efficient H_2 production - Visible-light-driven

Semiconductors - Bandgap - 1.23–3.0 eV

TWO-DIMENSIONAL NANOMATERIALS

- Since Discovery of **Graphene** from **Graphite** Exploration of **2D-NMs** Intensified
- Planar (Graphene), Quasi-planar Other NSs Form Family of Designer's Nanomaterials Programmable **Structure/Energy Band Gaps**

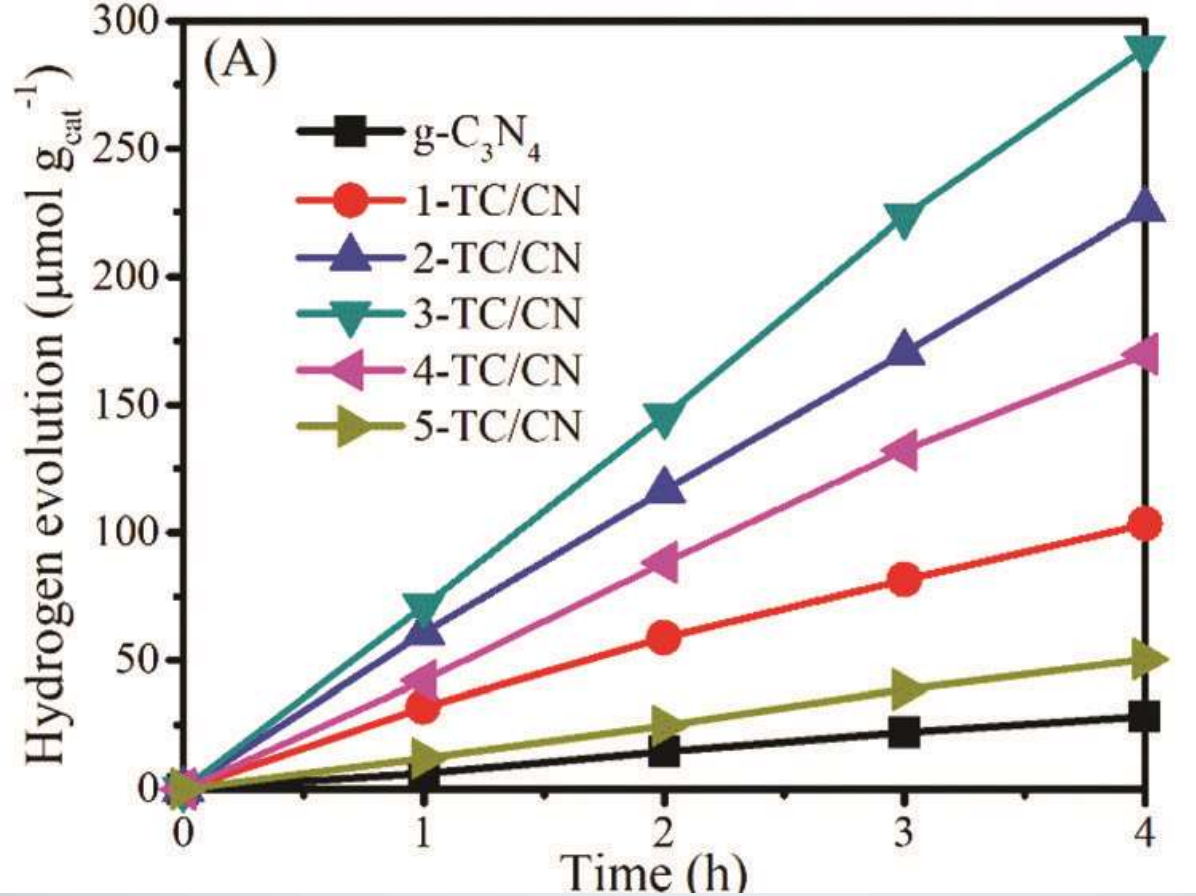
G-C3N4 GRAPHITIC CARBON NITRIDE



G-C_3N_4-HETEROSTRUCTURE - PROBLEMS

- Design of Band Structure Alignment
- Positioning for REDOX Reaction
- Enhancement of Efficiency
- Cost Effective Precursors

COMPRARISION OF HYDROGEN EVOLUTION



TC - Ti_3C_2

CN - $g\text{-}C_3N_4$

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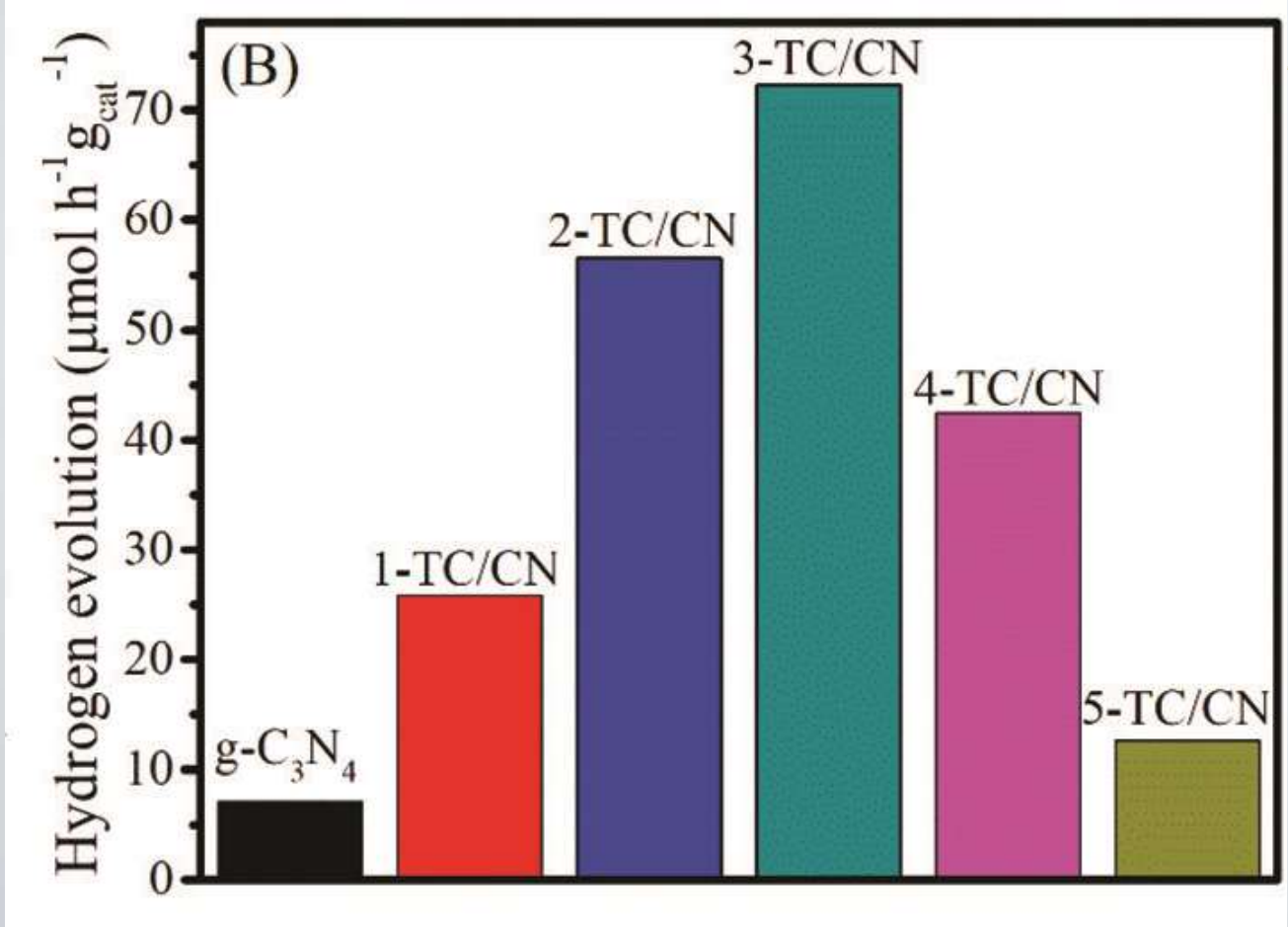

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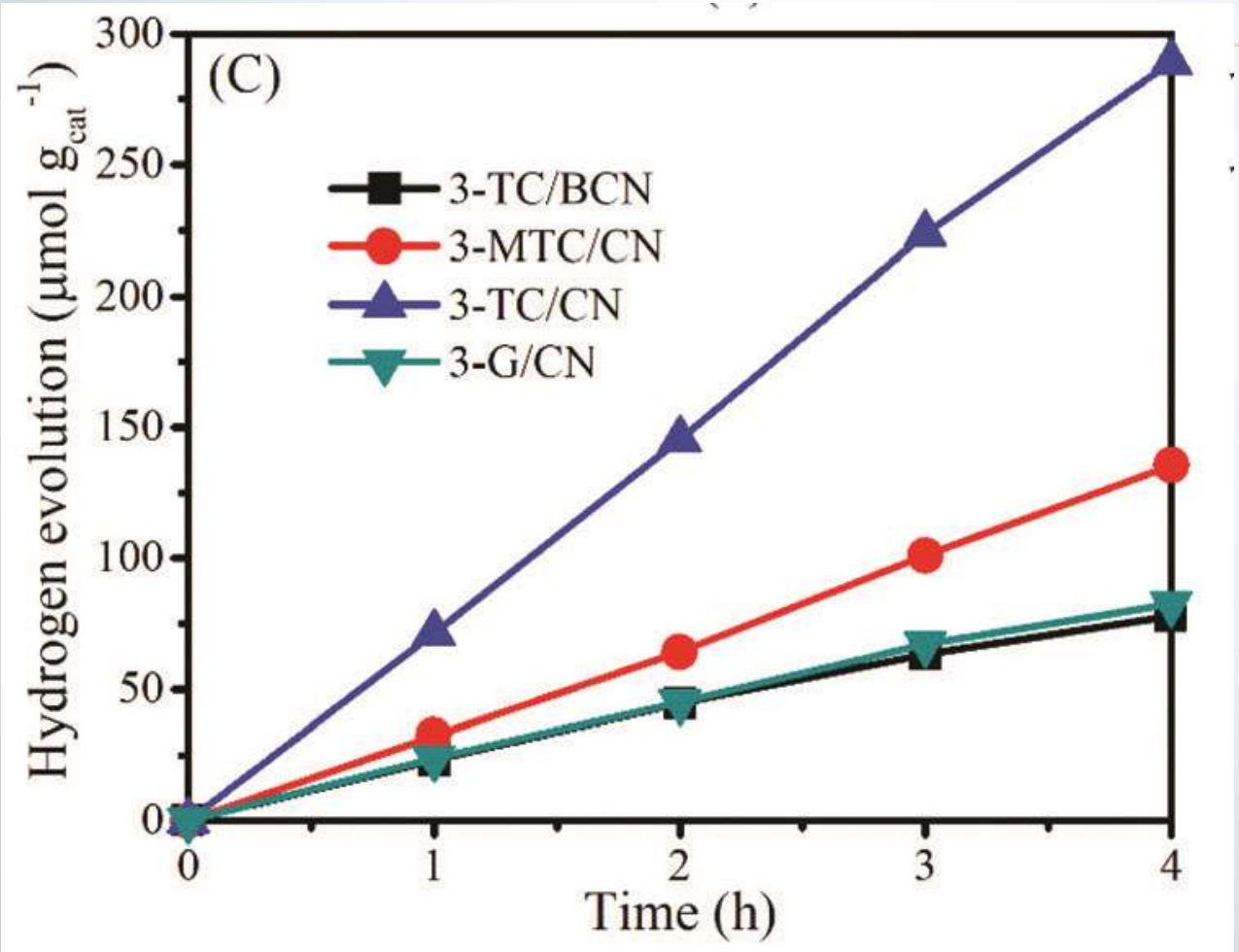

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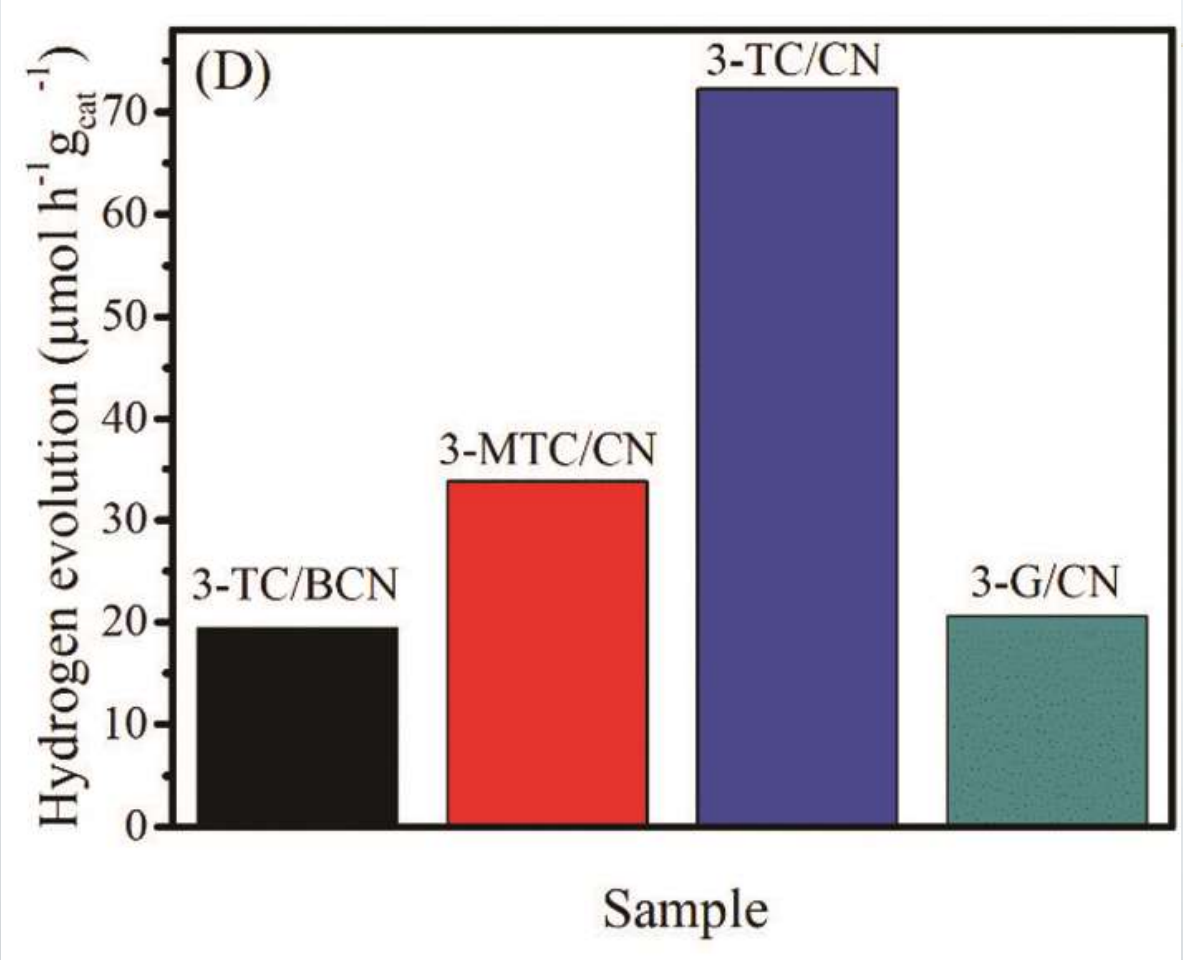
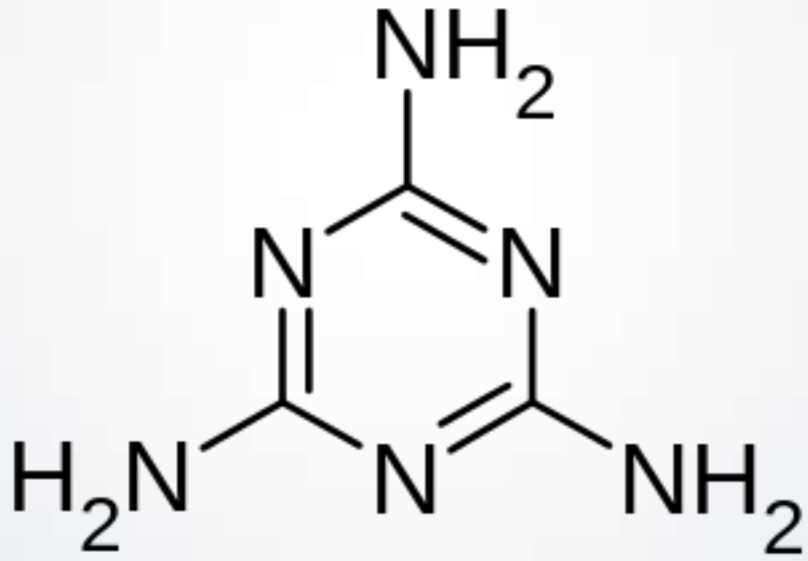


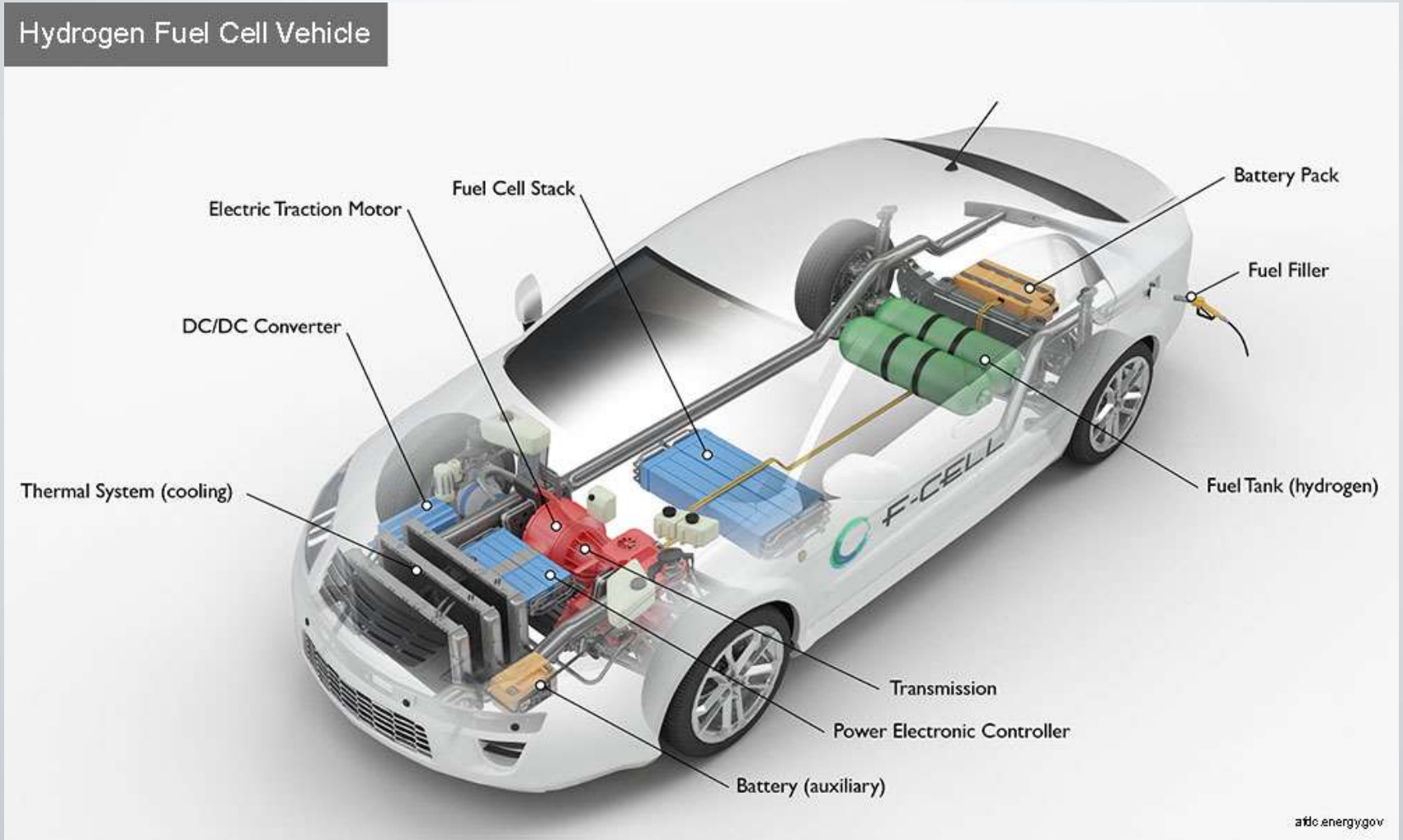
MELAMINE - PRECURSOR



DESIGN OF HETEROSTRUCTURES

- $Cu_2O/g\text{-}C_3N_4$,
- Graphene / $g\text{-}C_3N_4$,
- CdS / gC_3N_4 ,
- TiO_2 / $g\text{-}C_3N_4$.
- Untreated $g\text{-}C_3N_4$ / Sulfidized $g\text{-}C_3N_4$

H_2 FUEL CELL POWERED CAR



CHALLENGES

- **Durability/Stability** & Efficient Recycling
- **Better Precursors** – Critical Decision
- Newer **Heterojunction & Homojunction** – Needed
- **Carbonaceous Semiconductors**

Metal and Non-metal Doping, Defects, and Interaction Mechanisms of Multiple Functions – **Optimal Hydrogen Production and Cost Effective Catalyst**

CONCLUSIONS

2D–Semiconductor Nanosheets
Appropriate Photocatalyst
With Adjustable Parameters
Rugged System Possible
Right Kind of Precursor and
Processing – Necessary
Opportunities – Almost Unlimited