RV College of Engineering®

Centre for Hydrogen and Green Technology [CH_2GT]

Driving India towards clean energy technology

Vision

Development of reliable, affordable and sustainable Hydrogen energy systems and solutions

Mission

- Providing green energy solutions to industrial and societal needs
- Developing well to wheel carbon neutral renewable/green hydrogen energy systems
- Promoting the implementation of renewable energy systems

Need for the Centre

Sustainable development goals of the United Nations: An urgent call for action by all countries

- Create an avenue for affordable, reliable, sustainable and modern energy
- Combat climate changes and its impacts
- Revitalize the global partnership for sustainable development

National Hydrogen Energy Mission: A Govt. of India initiative

- Focus on generation of hydrogen from green power resources
- To link India's growing renewable capacity with the hydrogen economy

GOVERNMENT OF INDIA
MINISTRY OF NEW AND RENEWABLE ENERGY

7 AFFORDABLE AND CLEAN ENERGY

13 CLIMATE ACTION

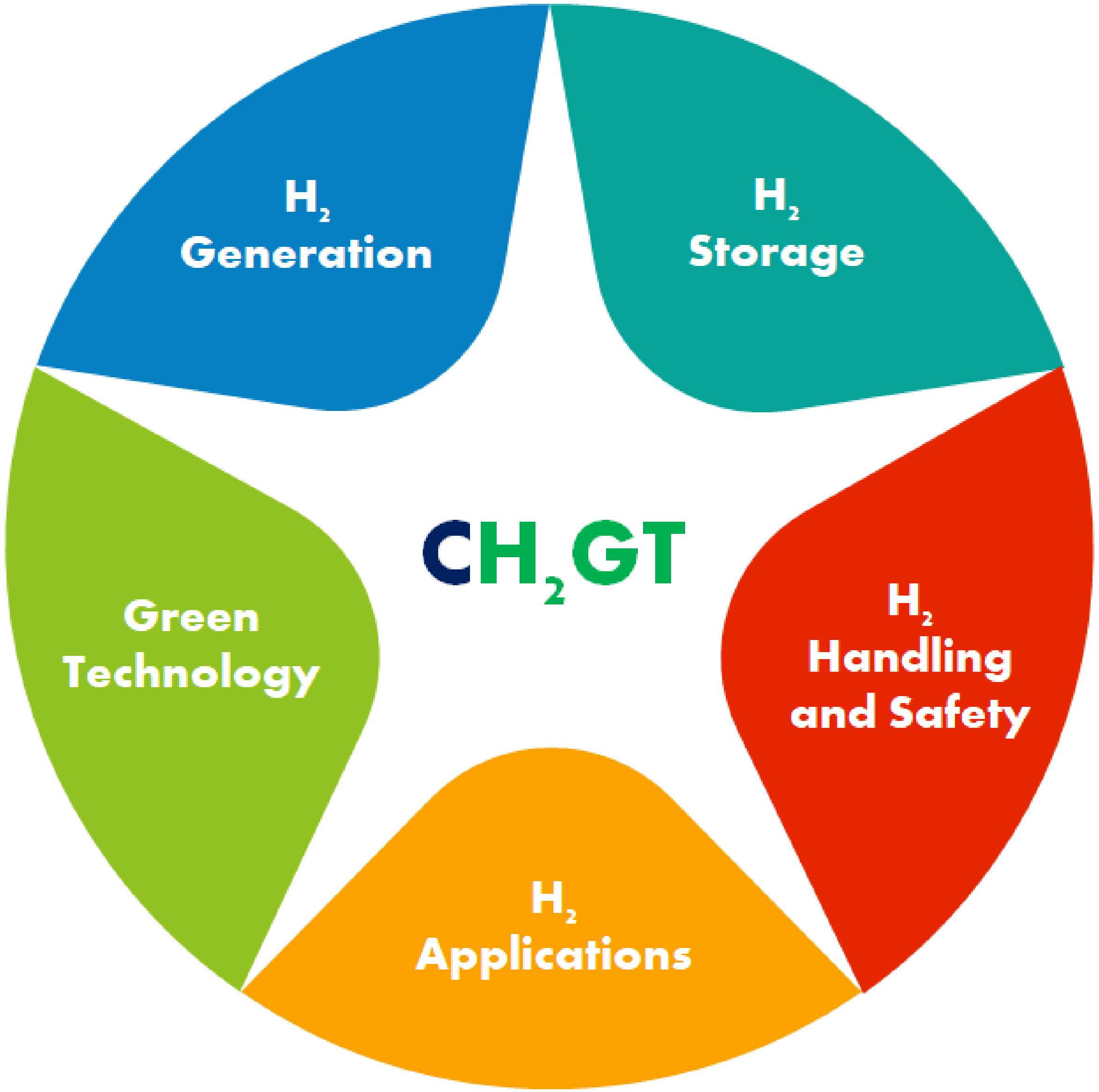
17 PARTNERSHIPS FOR THE GOALS

FH-W-S
Hochschule
für angewandte Wissenschaften
Würzburg-Schweinfurt

Team (12 members)

Name	Department	Expertise / Interests
K N Subramanya	Industrial Engineering & Management	Supply Chain Management, Lean Manufacturing, Operations Management
Manjunatha C	Chemistry	Inorganic Nanomaterials - Synthesis, Functionalization, Characterization, Green Hydrogen Generation
Ujwal Shreenag Meda	Chemical Engineering	Process and Product Design, Hydrogen Technology, Cloud Computing & Data Science
Radhakrishna	Civil Engineering	Geopolymer Composites, Construction Technology
R Suresh	Chemical Engineering	Solar Cells Fabrication, Biomass Gasification, Environmental Technology
Jagadish Patil	Chemical Engineering	Biofuels, Waste to Energy, Equipment Design
Basavaraja R J	Chemical Engineering	Carbon Capture, Combustion, Chemical Looping Combustion
Anupama Joshi	Chemical Engineering	Computational Fluid Dynamics, Thermic Fluids, Energy Storage
Vinutha Moses	Chemical Engineering	Polymer Composites, Bioremediation, Sustainable Technology
Sushmita Sarkar	Electrical Engineering	Solar PV Systems, Renewable Energy, Power Systems Analysis
Madhu B R	Electrical Engineering	Solar Energy, Hydal Power, Power Electronics
Chandra Kumar	Mechanical Engineering	Bio Energy, Mechanical Design, IC Engines

Modules


H_2 Generation
H_2 Storage
CH_2GT
Green Technology
H_2 Handling and Safety
H_2 Applications

Overview

Sl.No.	Activities since March 2021	Count	Faculty Involved	Students Involved
1	Internship	3	8	99
2	Student Projects	10	3	17
3	Conference Proceedings	25	8	25
4	Q1 Publications	5	2	4
5	Patents	2	2	1
6	Tech Talks	7	1	7
7	External Collaborations	4	2	-
8	Funded Project	1	2	-
9	Courses	1	1	61
10	Proposals	5	3	-
11	MoUs	4	1	-

Activities under H_2 Generation

Sl.No.	Activity	Remarks
1	Nanocomposite based catalysts development to enhance OER performance	4 SCI Publications
2	Hybrid catalyst development for H_2 generation via electrochemical splitting	1 SCI Publication
3	Hydrogen generation via electrohydrogenesis	1 Ph.D Completed
4	A method to ehnance the performance of a microbial fuel cell	1 Patent published
5	Designing a solar pv module for powering an electrolyzer	1 Conference Proceeding | 1 student project

Designing a Solar PV Module For Powering An Electrolyzer

Aditi Pandey[1*], Ujwal Shreenag Meda[1,3*], Yashesh Vijay Rajyaguru[1], Manjunatha C[2,3]

[1]Department of Chemical Engineering, RV College of Engineering, Bengaluru, India

[2]Department of Chemistry, RV College of Engineering, Bengaluru, India

[3]Centre for Hydrogen and Green Technology Research, RV College of Engineering, Bengaluru, India

* Email: aditipandey.ch19@rvce.edu.in, ujwalshreenagm@rvce.edu.in

Introduction

- Need to reduce greenhouse gas emissions
- Hydrogen, a green and clean energy carrier can be generated via electrolysis
- Integration of the electrolyzer with a solar PV system can make the process fully sustainable

Solar PV Technologies

Solar Cell Informal	Monomer Efficiency (%)	Module Efficiency (%)
Monocrystalline silicon	22	10-15
Polycrystalline silicon	18	9-12
Boron-Phosphorus compound	30	17
ThinFilm Amorphous Silicon	13	10
ThinFilm Cu-In	19	12
ThinFilm Cd-Te compound	16	9

Table 1. Comparison of efficiencies of solar cells

Working of a Solar Cell

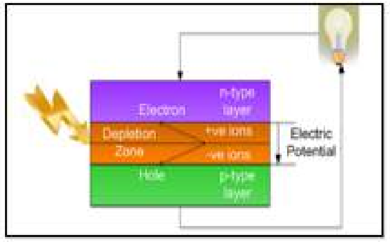


Fig 1. Typical representation of a solar cell

Design Procedure for a Standalone/ Off-Grid System

- Standalone systems require an inverter charge controller mechanism with a Maximum Power Point Tracker (MPPT) and batteries for storage of surplus electricity
- Systems which are widely used employ an inverter to convert D.C electricity produced by the modules into A.C electricity
- For such a system, the solar modules have to be designed larger than the load requirement
- The design process includes the following steps:

Load Assessment (Step 1) → Inverter Selection (Step 2) → Battery Sizing (Step 3) → PV Panel Selection (Step 4) → Land Area Calculation (Step 5)

Integration of Solar PV Systems with Electrolyzers

- Solar energy is ubiquitous, making it a viable contender for coupling with electrolyzers
- A PV-Electrolysis system has been developed, achieving a 48-h solar-to-hydrogen (STH) efficiency of 30%, thus demonstrating the potential of PV systems in the generation of green hydrogen
- Solar PV arrays can be directly coupled with PEM electrolyzers to improve the system efficiency
- The I-V characteristics of the PV-electrolyzer systems have to be accurately predicted

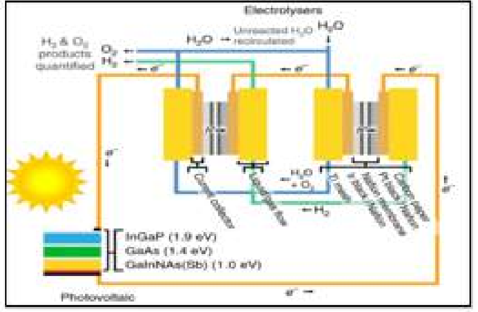


Fig 2. PV-electrolysis system comprising two PEM electrolyzers connected in series and a triple-junction solar cell

Challenges Associated

- Solar resource is intermittent and subject to fluctuations
- A storage system is required, which adds to the life cycle cost of the system
- High initial costs of setting up solar PV arrays, unpredictable output and lack of economical-efficient energy storage

Conclusion

- The mismatch between the Maximum Power Point of the solar cell and the I-V characteristics of the electrolyzer needs to be resolved
- Overcoming such challenges can lead to the successful integration of solar PV systems with electrolyzers

References

[1] B. P. Singh, S. K. Goyal, and P. Kumar, **43** , (2021)
[2] J. Jia et al., Nature Communications, **7**, (2016).
[3] C. H. Huang, H. Y. Pan, and K. C. Lin, Applied Sciences, **6**, (2016).

Activities under H_2 Storage

Sl.No.	Activity	Remarks
1	Challenges Associated with Hydrogen Storage Systems due to the Hydrogen Embrittlement of High Strength Steels	1 Conference Proceeding | 1 student projet
2	Metal Hydrides for Solid Hydrogen Storage – Opportunities and Challenges	1 article under review | 1 student project
3	Liquid Organic Hydrogen Carriers for hydrogen storage	1 student project

Hydrogen Impermeable Materials For Efficient Hydrogen Storage

Nidhi Bhat[1] , Chitra Agrawal[1] , Ujwal Shreenag Meda[1,2*]

[1] Department of Chemical Engineering, RV College of Engineering, Bengaluru, India
[2] Centre for Hydrogen and Green Technology Research, RV College of Engineering, Bengaluru, India
Email IDs: nidhibhat.ch19@rvce.edu.in, ujwalshreenagm@rvce.edu.in

Introduction

- Hydrogen is increasingly becoming a more viable clean transportation and energy storage solution. Efficient hydrogen storage systems are important for the adaptation of hydrogen as an alternate fuel.
- Hydrogen embrittlement (HE) is a major problem in steels, due to which high strength steels (HSSs) are avoided in applications. Efficient storage methods/materials are needed for preventing embrittlement.

Hydrogen Storage and HE

- Hydrogen storage (as compressed gas, liquid hydrogen, cryo-compressed storage) using vessels made of steel and composites are heavy and expensive.
- Lightweight, compact, and durable methods/materials can be achieved with material-based storage methods.
- Hydrogen permeation and HE mechanisms (like Hydrogen Enhanced Decohesion Mechanism (HEDE), Hydrogen Enhanced Localized Plasticity (HELP)) must be understood.

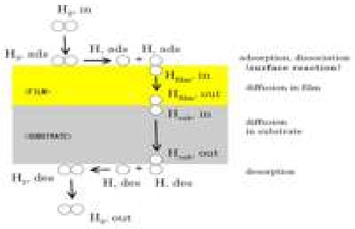


Figure 1. Hydrogen Permeation

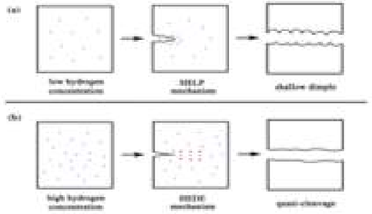


Figure 2. HE Mechanisms: (a) HELP (b) HEDE

Impermeable Materials

- Coatings like graphene, reduced graphene oxide (rGO), oxygen, carbon, nitrogen, MoS_2, TiC, TiN, TiAlN and TiAlN/TiMoN multi-layered coating can also reduce HE.

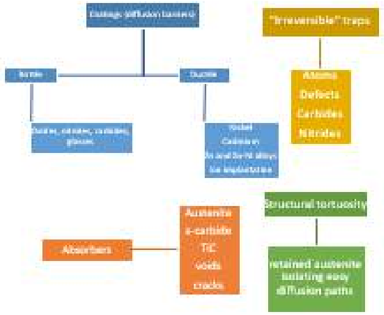


Figure 3. Mechanisms to modify steel to make it more resistant to hydrogen.

- Chemical vapor deposition (CVD), electroplating discharge (EPD), gas diffusion, plasma diffusion and high velocity oxygen fuel (HVOF) are common coating techniques. rGO is most promising for HSSs.

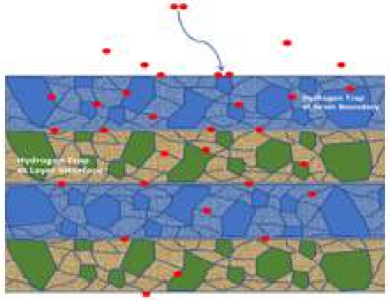


Figure 4. Hydrogen traps in multi-layered coatings to minimize permeability.

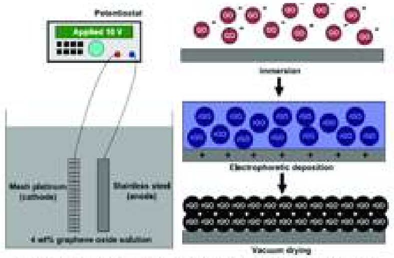


Figure 5. rGO coating using EPD technique.

Table 1. Coating Techniques

Material	Type	Deposition Technique
Al, Ni, Zn	On Top	Electroplating
Ti-DLC	On Top	Physical Vapor Deposition
Carbon, Nitrogen	Diffusion	Gas Diffusion
Oxygen	Diffusion	Plasma Diffusion

Conclusion

- Energy efficiency, material properties, durability, low energy density per unit volume, long refueling times, and high costs can be overcome by using better hydrogen impermeable materials.
- HSSs should be encouraged due to their high yield strength, high reliability and ability to reduce weight. Many techniques have not been tried on HSSs yet, but can be, especially with further knowledge on microstructures. This could help shift to green hydrogen technology.

References

1. Motonori Tamura, "Hydrogen Permeation Characteristics of TiN-Coated Stainless Steels," *J. Mater. Sci. Eng. A*, vol. 5, no. 6, pp. 197–201, 2015, doi: 10.17265/2161-6213/2015.5-6.002.
2. Ramin Moradi, Katrina M. Groth, Hydrogen storage and delivery: Review of the state of the art technologies and risk and reliability analysis, *International Journal of Hydrogen Energy*, Volume 44, Issue 23, 2019, Pages 12254-12269.

Activities under H_2 Handling and Safety

Sl.No.	Activity	Remarks
1	Method and system to develop a polymer - hydrogel - metal oxide composite based sensor to detect and quantify hydrogen gas	1 Patent Granted
2	Method and system for developng a sensor to detect hdyrogen gas at ambient conditions	1 Patent Published
3	Product design of a hydrogen sensing system	1 Conference Proceeding
4	Developmetn of IoT enabled hydrogen sensing system	1 Conference Proceeding
5	Market study of hydrogen sensors and sensing systems	1 Conference Proceeding

Product Design Of A Hydrogen Sensing System

Sharanya Chakravarthi[a*], Akshit M Harti[a] and Ujwal Shreenag Meda[a,b*]

[a] Department of Chemical Engineering, RVCE, Bengaluru, India
[b] Centre for Hydrogen and Green Technology Research, RV College of Engineering, Bengaluru, India
* Email: sharanya.ch18@rvce.edu.in, ujwalshreenagm@rvce.edu.in

1. Introduction

In the era where fuel-celled vehicles are gaining importance, there is a growing need for hydrogen sensing systems which give quick and accurate information about the hydrogen gas that is both qualitative and quantitative. Effective product design of hydrogen sensing systems is essential to bring them to the market and target specific end users.

2. Objective

To develop a hydrogen sensing system by utilizing the principles of design thinking and highlighting various aspects of product design.

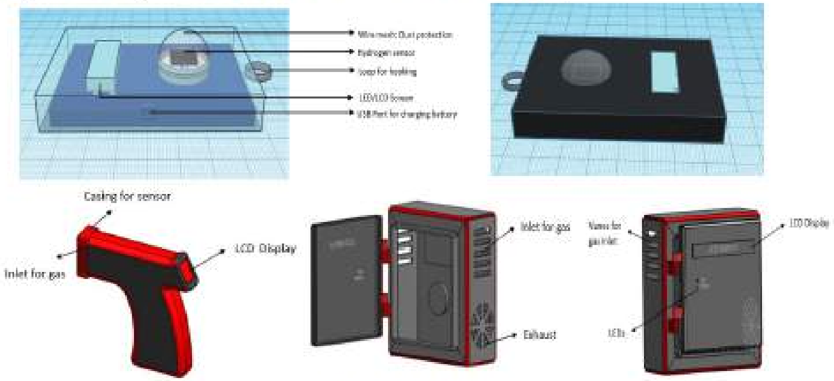
3. Methodology

Keeping design thinking at the core of our product design strategy, a few more steps were added to streamline the process.

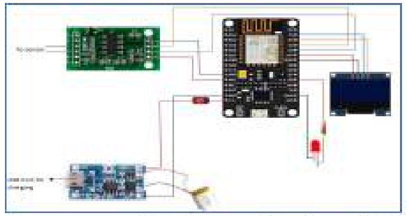
Steps taken during the product design phase

4. Results

Three robust designs were developed using Solidworks and Tinkercad Software. All the three designs were integrated with a Wi-Fi enabled circuit to enable IoT applications.



Designs 1, 2 and 3



Connection	Line colour
GND	
Vcc	
SDA	
SCL	

Circuit connections for a Wi-Fi enabled hydrogen gas sensing system

6. Conclusion

Design 1	Design 2	Design 3
Portable and can be hooked anywhere	Innovative product shape.	Flushing out gas is easy due to the exhaust fan.
Uses flexible electronics	High surface area for sensing	Higher area of sensing compared to Designs 1 and 2.

Problems	Solutions
Inadequate amount of literature pertaining to product design of gas sensing systems.	Implemented the design thinking methodology in product development
To address the problem of improper flushing of gas, which plays a crucial role in giving accurate readings of current hydrogen concentration by making sure the gas previously present is completely removed.	In design 3, the problem of flushing of gas was tackled by making use of an exhaust fan that facilitates forced convection hence, making the system free of gas before the next reading is taken.
The size of the sensor had to be very small to make it suitable for portable applications, but it was necessary to also make the circuit components fit inside the given Design.	A survey was done to find out the relevant commercially available circuit components that are smaller in size and also economical.

References
1. T. Hübert, L. Boon-Brett, G. Black, and U. Banach, *Sensors Actuators, B Chem.*, 157, (2011)
2. A. Rangaswamy and G. L. Lilien, J. Mark. *Res.*, 34, (1997)
3. M. Rossi, D. Brunelli, A. Adami, L. Lorenzelli, F. Menna, and F. Remondino, *Proc. IEEE Sensors*, (2014)

Development Of IoT Enabled Hydrogen Sensing System

Sourav Adithya[a*], Ujwal Shreenag Meda[a,b]

[a] Department of Chemical Engineering, RV College of Engineering, Bengaluru, India

[b] Centre for Hydrogen and Green Technology Research, RV College of Engineering, Bengaluru, India

* Email: souravadithya.ch18@rvce.edu.in

Abstract

The world's fossil fuel reserves are running out at a fast pace. A renewable and cleaner source of energy such as hydrogen is the need of the hour. Hydrogen is highly flammable, and has high detonation sensitivity, containment and confinement of hydrogen gas is a very precarious task. A rapid sensing mechanism to accurately detect, monitor, and quantify the hydrogen leaks on a real-time basis is extremely important. This article intends to provide a review of the various components required to help establish an efficient IoT-enabled hydrogen sensing system.

1. Introduction

- The primitive methods of hydrogen sensing are too slow or require huge infrastructural requirements.
- This gave rise to wide variety hydrogen sensors such as Pd-film and Pd-alloy films, metal oxide sensors etc. and their associated sensing systems.

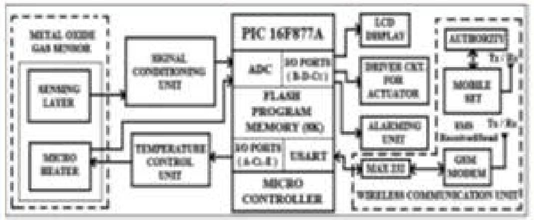


Fig 1. Block diagram of a typical Measuring system

1.1 Signal Conditioning Unit

- Signals are transformed using a combination of amplifier, mixer and filters.
- The analog front ends are generally integrated with the sensor or the ADC or between the sensor and the ADC.

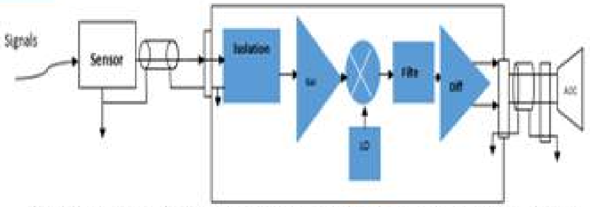


Fig 2. The main elements commonly found in analog front ends

1.2 Analog to Digital Convertor

- Embedded systems gather information pertaining to the external world with the help of an ADC.
- Non-traditional A/D conversion methods such as sigma-delta, pulse-width modulation and frequency to digital (F/D) conversion are highly compatible with Smart Sensing Systems and are extremely cost efficient.
- The present trend involves the use of discrete A/D conversion methods in combination with a low cost microcontroller.

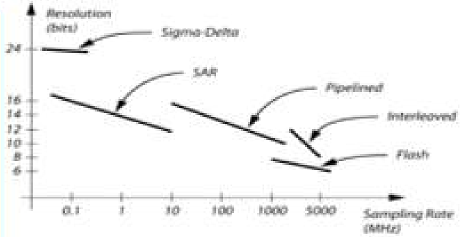


Fig 3. Comparison of ADC techniques in terms of spectrum of resolution versus sampling rate.

1.3 Microcontroller

- The microcontroller is coded to act as the brain of the sensing system to make required decisions and trigger processes to send data and alerts.
- The microcontrollers available in the market today such as the Arduino and PIC series have built in ADC and on board storage facilities thus enabling easy integration with sensors and cloud storage platforms.

1.4 Data Communication Systems

- The communication mode have to be chosen keeping in mind the parameters like security, mobility, energy consumption and area of coverage.
- ZigBee is preferred for short range wireless communication due to its easy deployment and lower power consumption compared to Wi-Fi and Bluetooth.
- LoRa should be considered as a relevant alternative in future solutions given its promising characteristics and its longer range.

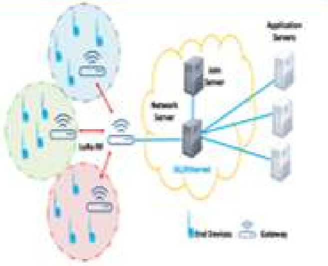


Fig 4. LoRaWAN network architecture

1.5 Data Logging and Analysis Systems

- Sensing systems requires efficient framework for system monitoring and threat detection on real time basis.
- Open source cloud storage applications such as ThingSpeak and Open.Sen.se provide an economical solution.

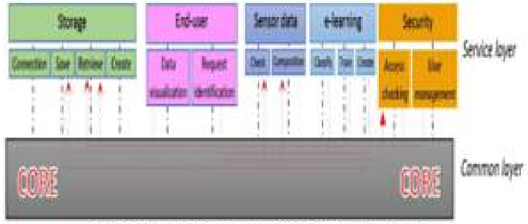


Fig 5. Cloud sensor network framework

2. Conclusion

- To establish an IoT enabled sensing system we require a sensor connected to signal conditioning unit and analogue to digital convertor for efficient data acquisition, a microcontroller unit to make required decisions and trigger processes, a wireless communication system to efficiently send the collected data and a cloud storage system for real time analysis and threat detection.
- More research should be conducted for the creation of miniaturized and self-calibration capable hydrogen sensing systems.

References

1. Y. S. H. Najjar, "Hydrogen leakage sensing and control: (review)," Biomed. J. Sci. Tech. Res., vol. 21, no. 5, 2019..
2. H. Hashtroudi, P. Atkin, I. D. R. Mackinnon, and M. Shafiei, "Low-operating temperature resistive nanostructured hydrogen sensors," Int. J. Hydrogen Energy, vol. 44, no. 48, pp. 26646–26664, 2019

Market Study of Hydrogen Sensors and Sensing Systems

Sripriya[1*], Ujwal Shreenag Meda[2*]

[1]Department of Chemical Engineering, RV College of Engineering, Bengaluru, India

[2]Centre for Hydrogen and Green Technology Research, RV College of Engineering, Bengaluru, India

* Email: sripriyau.ch18@rvce.edu.in, ujwalshreenagm@rvce.edu.in

Introduction

The future of hydrogen is abundant with its numerous applications in refineries, fertilizer industries, nuclear plants and other upcoming technologies like environment friendly fuels. With the market for hydrogen being so dynamic and due to its peculiar properties such as high flammability, low viscosity, low density, high escape rate and the ability to burn with an invisible flame to naked eye, a sensing system in place becomes a prerequisite.

Growth of Hydrogen market

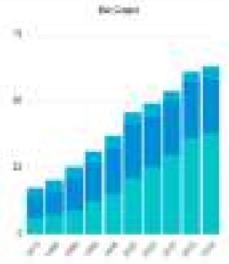


Fig1:Growth of Hydrogen market from 1975-2018

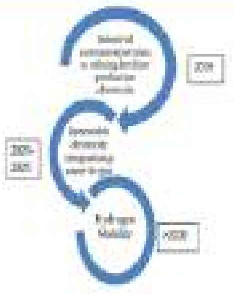


Fig2:Main demand of Hydrogen markets

However, its properties demand for a more rigid safety system. In the past there have been many accidents due to absence of a safety system In Japan and in the USA most of the accidents which occurred between the years 2005-2014 was due to leakage in the screw joints of the hydrogen carrying hose which could have been detected in the presence of a hydrogen sensing arrangement

Market Survey &Study of commercially available sensors

The US department of energy has classified hydrogen as the next alternative source of fuel among 6 others. However, a sensing system is a prerequisite for deployment of hydrogen as fuel. Presently there are a large variety of sensors available in the market. The usefulness of gas sensors predominantly depend on the factors such as sensitivity, selectivity, response time, accuracy, range of detection, durability and reliability. The best performance is obtained by using an optimal sensor for a particular application.

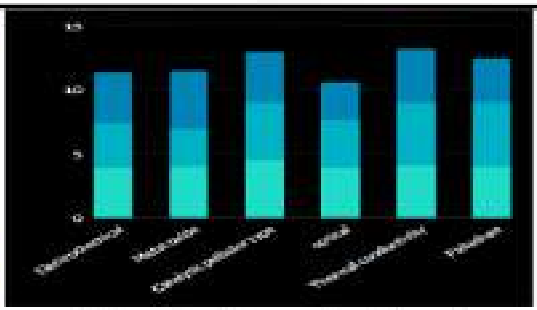


Fig3:Comparison between different types of sensors (with 0 being worst and 5 being best for detection, selectivity and response time)

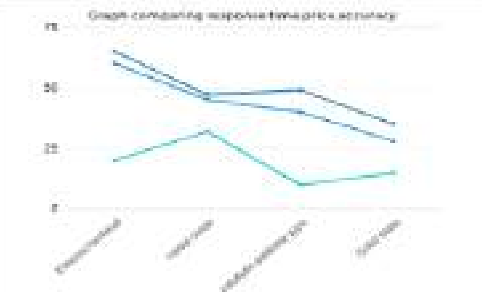


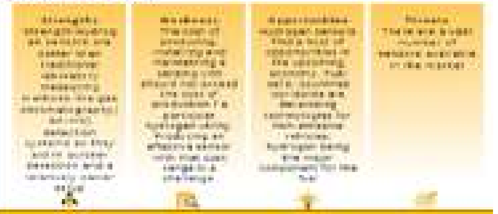
Fig 4:Relationship between accuracy, price and response time

Survey

TABLE:1 – Current types of sensors used in industries

Industry	Sensor type	Responce time	Accuracy
Nuclear power plant	Catalytic pellistor	<20sec	± 2 % Full Scale
Fertilizer	Metal oxide	<12sec	±5% Full scale
Polymer	Catalytic-pellistor	10-15sec	±3% Full scale

SWOT Analysis



Future of hydrogen sensors

Hydrogen is being quantified by using oxygen sensors to find the amount of oxygen being displaced.

Graphene gas sensors are combined with metal oxide nanoparticles to increase the selectivity and for fast response.

Sensors based on optical phenomena such as surface plasmon resonance where the structure has nano sized metal hydrides

Industrial Trucks (Forklifts)-Fuel cell energized industrial trucks is a technology in the near future using hydrogen as a fuel.

Conclusion

1)Many papers compare the different sensors in terms of their technical and economic feasibility and claim hydrogen and its sensing systems as the next big innovation

2)Socio-cultural and political factors like lack of policies which push the use of fuel cell powered vehicles and its economically viable production to attract customers, are not taken into consideration

References

1.L. Boon-Brett et al., "Identifying performance gaps in hydrogen safety sensor technology for automotive and stationary applications," *Int. J. Hydrogen Energy*, vol. 35, no. 1, pp. .

2.W. Buttner et al., "Hydrogen Safety Sensor Performance and Use Gap Analysis Preprint," no. November, 2017.Wikipedia is not a reference

Activities under H_2 Applications

Sl.No.	Activity	Remarks
1	Electrolyzers for green hydrogen generation and their integration with fuel cells	1 Conferene Proceeding | 1 student project
2	Alternatives to conventional platinum based catalysts in PEMFCs	1 Conferene Proceeding | 1 student project
3	Development of a PEMFC powered two wheeler	1 project proposal

Electrolyzers for Green Hydrogen Generation And Their Integration With Fuel Cells

Yashesh Vijay Rajyaguru[1*], Ujwal Shreenag Meda[1,3*], Aditi Pandey[1], Manjunatha C[2,3]

[1]Department of Chemical Engineering, RV College of Engineering, Bengaluru, India

[2]Department of Chemistry, RV College of Engineering, Bengaluru, India

[3]Centre for Hydrogen and Green Technology Research, RV College of Engineering, Bengaluru, India

* Email: yasheshvijayr.ch19@rvce.edu.in, ujwalshreenagm@rvce.edu.in

Introduction

Need to tackle pressing climate issues such as:

- ✓ Reduction of greenhouse gas emissions
- ✓ Establishing energy security
- ✓ Improving the quality of life
- ✓ Ending dependency on oil

Solution

Green hydrogen generation using and electrolyzer

- ✓ Ability to mitigate concerns about energy security
- ✓ Zero emissions during its entire process of production
- ✓ Is versatile and can be used innovatively

Electrolyzers systems

❖ Electrochemical devices that convert electrical and thermal energy from water into chemical energy in the form of Green hydrogen.

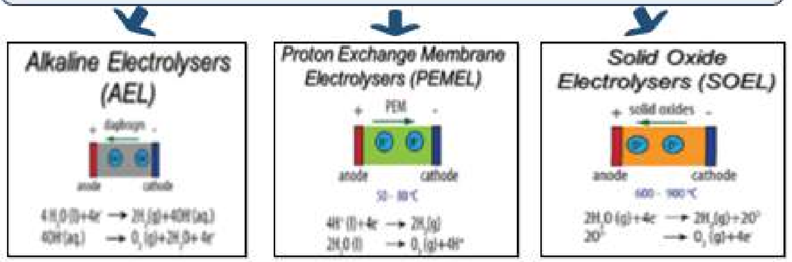


Fig 1. Electrolyzer systems for Green hydrogen generation

Integration with Fuel Cells

- ❖ Proton exchange membrane electrolyzer (PEMEL) and its integration with a PEM Fuel cell (PEMFC) into a regenerative fuel cell (RFC) as an energy system.
- ❖ Advantageous in many aspects, one of the most effective ways of energy storage.
- ❖ RFCs can be designed to have two different systems: a traditional system consisting of a discrete coupled stack and a unitized RFC (URFC).

Typical RFC systems

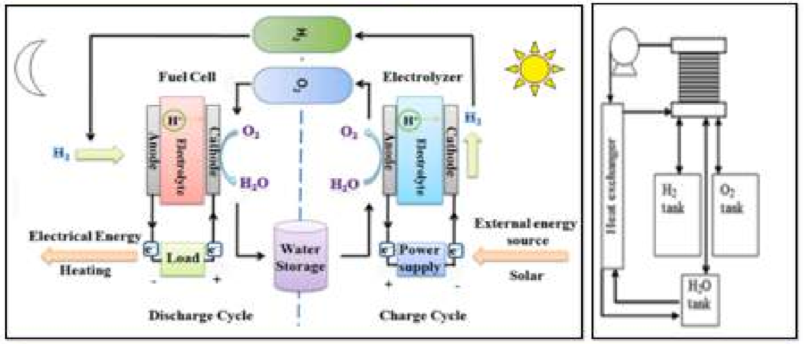


Fig 2A. RFC system powered by PV energy systems. Fig 2B. Unitized RFC (URFC)

Applications

- ✓ Renewable energy systems
- ✓ Automobile and transportation
- ✓ Aviation and aerospace industry

Challenges

- Facilities for hydrogen storage
- Uninterrupted power supply
- Cell stack design and assembly
- Utility costs

Conclusion

With more research and technological advancements, hydrogen will own a large share of the energy infrastructure and portfolio.

References

1. M. Yu, K. Wang, and H. Vredenburg, Int. J. Hydrogen Energy, **46**, (2021).
2. K. Zeng and D. Zhang, Prog. Energy Combust. Sci., **36**, (2010).
3. A. Ursúa, L. M. Gandía, and P. Sanchis, Proc. IEEE, **100**, (2012).

ALTERNATIVES TO CONVENTIONAL PLATINUM-BASED CATALYSTS IN POLYMER ELECTROLYTE MEMBRANE FUEL CELLS

Iqra Arabia Ali Khan[1*], Ujwal Shreenag Meda[1,2*]

[1]Department of Chemical Engineering, RV College of Engineering, Bengaluru, India

[2]Centre for Hydrogen and Green Technology Research, RV College of Engineering, Bengaluru, India

ABSTRACT

- ✓ Pt catalyst accounts to 40% of the total cost of the fuel cell and hence there is a need to find solutions to these issues.
- ✓ Fe-N-C catalysts have recently been identified as suitable replacements to PGM catalysts

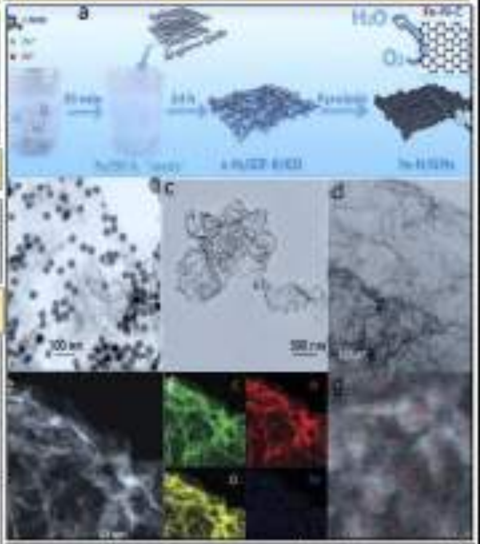
OBJECTIVE

To evaluate the effectiveness and performance of new Fe-N-C catalyst in comparison to the conventional platinum based catalyst

INTRODUCTION

- ✓ The relatively slow ORR in the cathode necessitates Pt catalysts with larger surface area and optimised structure.
- ✓ They are also readily prone to carbon monoxide (CO) poisoning .This can be prevented by alloying Pt with low-cost metals (Co, Fe, etc.). The discovery of high performance non PGM is the key alternative, however in comparison to Pt based catalyst the activity and stability are still inferior to Platinum metal based catalyst.

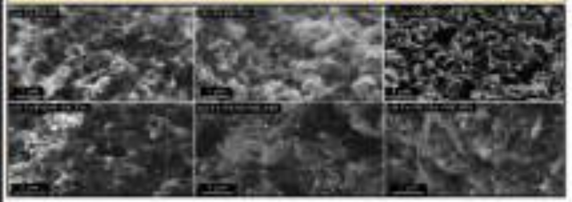
SYNTHETIC STRATEGIES



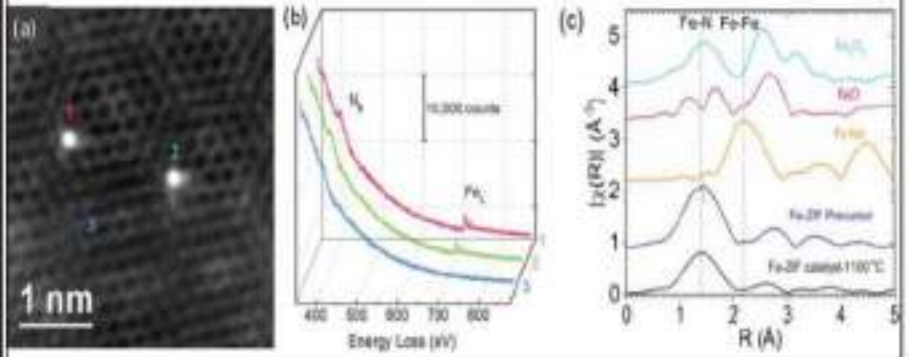
Current strategies for improving the efficiency and durability of PGM based (left) and PGM-free (right) ORR catalysts for PEMFCs

COMPARISON BETWEEN PGM AND PGM FREE CATALYSTS

CHALLENGES OF PGM FREE CATALYST



- ✓ The currently investigated Fe-N-C catalysts shows a diverse morphology and heterogenous carbon matrix including amorphous carbon and graphitized nanocarbon (onion-like carbon, carbon nano shells, graphene-like carbon or carbon tubes).



As micropores are likely to host many active sites, their flooding may severely affect fuel cell performance. It is also a major cause of poor durability.

CONCLUSION AND FUTURE DEVELOPMENTS

A significant effort is still needed to achieve full understanding of the causes of PGM-free catalyst instability and to derive much needed correlations between stability and intrinsic materials properties and cell operation conditions

REFERENCES

1) Yuyan Shao, Jean-Pol Dodelet, Gang Wu, and Piotr Zelenay : PGM-Free Cathode Catalysts for PEM Fuel Cells: A Mini-Review on Stability Challenge – Advanced Materials

2) Lina Wanga , Xin Wana , Shuangyu Liub , Li Xub, , Jianglan Shui : Fe-N-C catalysts for PEMFC: Progress towards the commercial application under DOE reference – Journal of Energy Chemistry

Activities under Green Technology

Sl.No	Activities	Remarks
1	Geo-polymer composites and NOx reduction	1 funded project
2	A Method and System to Enhance the Properties of Cementitous Products	1 patent published
3	Nox reduction using nano coatings	2 conference proceedings | 6 student projects

Inter-Disciplinary Funded Project

Project Title: Development of geopolymer composites for enhanced mechanical properties and to subside air pollution by the addition of nano particles with emphasis on achieving content uniformity

Sponsoring Agency: DST – Nano Mission

Sanction Order: SR/NM/NT-1025/2017

Total Cost: **Rs. 70,04,306**

Investigators: Dr. Radhakrishna, Professor and Head, Civil Engineering and Dr. Ujwal Shreenag M, Assistant Professor, Chemical Engineering

Labs created: Nanomaterial synthesis lab (8 nano powders including thin films for sensors)

Bulk solids blending lab (Nauta Mixer – to uniformly mix 0.1% nano powder with rest of the cementitious materials)

Nauta Mixer

Fume hood for Nanomaterial Synthesis

Photocatalytic cementitious materials to reduce air pollution: Review

Pavan Kumar R[a], Sachin K c[a], Radhakrishna[a], Ujwal Shreenag Meda[b]
[a] Department of Civil Engineering, [b] Department of Chemical Engineering

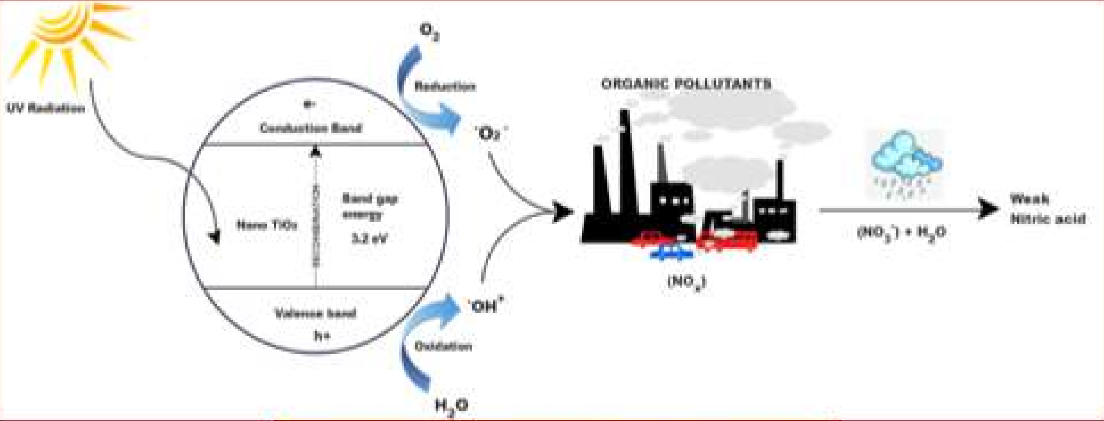
Introduction

Environmental pollution → Need innovations and environmental friendly technology
Climate change and accelerated resource degradation → Need for Sustainable development

- Air pollution – Industrial & Road traffic -Urban environments → Health hazards.
  - Oxides of nitrogen (NO_X) - Nitric oxide (NO) & Nitrogen dioxide (NO_2)
    - NO_X accumulation = Formation of tropospheric ozone, urban smog, acid rain etc.,.

Solution = Heterogeneous photo-catalysis→ photo-catalysts such as titanium dioxide (TiO2).

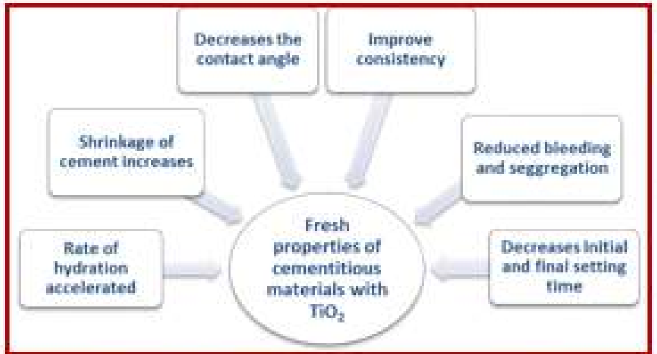
- TiO2 can adsorb and oxidize organic and inorganic particles (NO_X and VOCs)in the air
  - Presence of ultraviolet light (sunlight) + Run-off water = Dilute Nitric acid



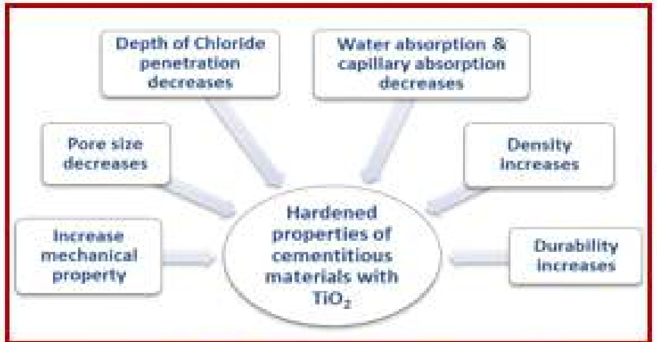
Mechanism of Photocatalytic Degradation

Photo-catalysis

- **Photo catalysis** -semiconducting oxides of metal- activated under **UV radiation** of sunlight
- Photo-excitation; Reduction and Oxidation
- Promising technology - **highly congested areas & high ground-level pollutant** concentrations



Impact of TiO_2 on Fresh properties



Impact of TiO_2 on Hardened properties

Conclusion

Photocatalytic cementitious materials will reduce air pollution by converting oxides of nitrogen into dilute nitric acid in the presence sun light and water. It also enhance the fresh, hardened properties and durability of the cementitious composites. This make the composite sustainable

TiO_2 Coating

Surface	Observation
Concrete	Service life of TiO_2 coating = 6 to 11 months
Asphalt	The service life of TiO_2 coating = 10 and 16 months
Concrete Road	Purifying rate of NO is higher than NO_2
Concrete	Increased crystalline $Ca(OH)_2$ amount at the early age of hydration
Cementitious surface	Concentration of NH_3, N_2O, CO_2, and CH_4 was reduced.

Applications of TiO_2

- Self cleansing & Air cleaning
- Water purification
- Super hydrophilic & Self sterilizing
- Paints, inks, Food colouring, etc.,.

Patent - Granted

Method and system to develop a polymer - hydrogel - metal oxide composite based sensor to detect and quantify hydrogen gas

Inventors: Ujwal Shreenag M, Lourdu Antony Raj, Shripathi ramakrishnan, Maitri Uppaluri, A R Phani

Filing Date: 11.04.2018

Patent Published: 18.10.2019

Granted on: 05.06.2020

Patent Number: 338004

INTELLECTUAL PROPERTY INDIA
PATENTS | DESIGNS | TRADE MARKS
GEOGRAPHICAL INDICATIONS

क्रमांक : 044119634
SL No :

भारत सरकार
GOVERNMENT OF INDIA
पेटेंट कार्यालय
THE PATENT OFFICE
पेटेंट प्रमाणपत्र
PATENT CERTIFICATE
(Rule 74 Of The Patents Rules)

पेटेंट सं. / Patent No.	:	338004
आवेदन सं. / Application No.	:	201841013768
फाइल करने की तारीख / Date of Filing	:	11/04/2018
पेटेंटी / Patentee	:	R.V. College of Engineering

प्रमाणित किया जाता है कि पेटेंटी को उपरोक्त आवेदन में यथाप्रकटित METHOD AND SYSTEM TO DEVELOP A POLYMER-HYDROGEL-METAL OXIDE COMPOSITE BASED SENSOR TO DETECT AND QUANTIFY HYDROGEN GAS नामक आविष्कार के लिए, पेटेंट अधिनियम, १९७० के उपबंधों के अनुसार आज तारीख 11th day of April 2018 से बीस वर्ष की अवधि के लिए पेटेंट अनुदत्त किया गया है।

It is hereby certified that a patent has been granted to the patentee for an invention entitled METHOD AND SYSTEM TO DEVELOP A POLYMER-HYDROGEL-METAL OXIDE COMPOSITE BASED SENSOR TO DETECT AND QUANTIFY HYDROGEN GAS as disclosed in the above mentioned application for the term of 20 years from the 11th day of April 2018 in accordance with the provisions of the Patents Act,1970.

Patent - Published

(12) PATENT APPLICATION PUBLICATION

(21) Application No.201641012578 A

(19) INDIA

(22) Date of filing of Application :11/04/2016

(43) Publication Date : 13/10/2017

(54) Title of the invention : METHOD AND SYSTEM FOR DEVELOPING A SENSOR TO DETECT HYDROGEN GAS AT AMBIENT CONDITIONS

(51) International classification	:G01M
(31) Priority Document No	:NA
(32) Priority Date	:NA
(33) Name of priority country	:NA
(86) International Application No	:NA
Filing Date	:NA
(87) International Publication No	: NA
(61) Patent of Addition to Application Number	:NA
Filing Date	:NA
(62) Divisional to Application Number	:NA
Filing Date	:NA

(71)**Name of Applicant :**

1)R.V. College of Engineering

Address of Applicant :Mysore Road, R. V. Vidyaniketan Post, Bengaluru 560059, Karnataka, India. Karnataka India

(72)**Name of Inventor :**

1)Ujwal Shreenag Meda

2)Akshay Kulkarni

3)Abhinav Bajaj

4)Aditya Kulal

5)Karthik SS

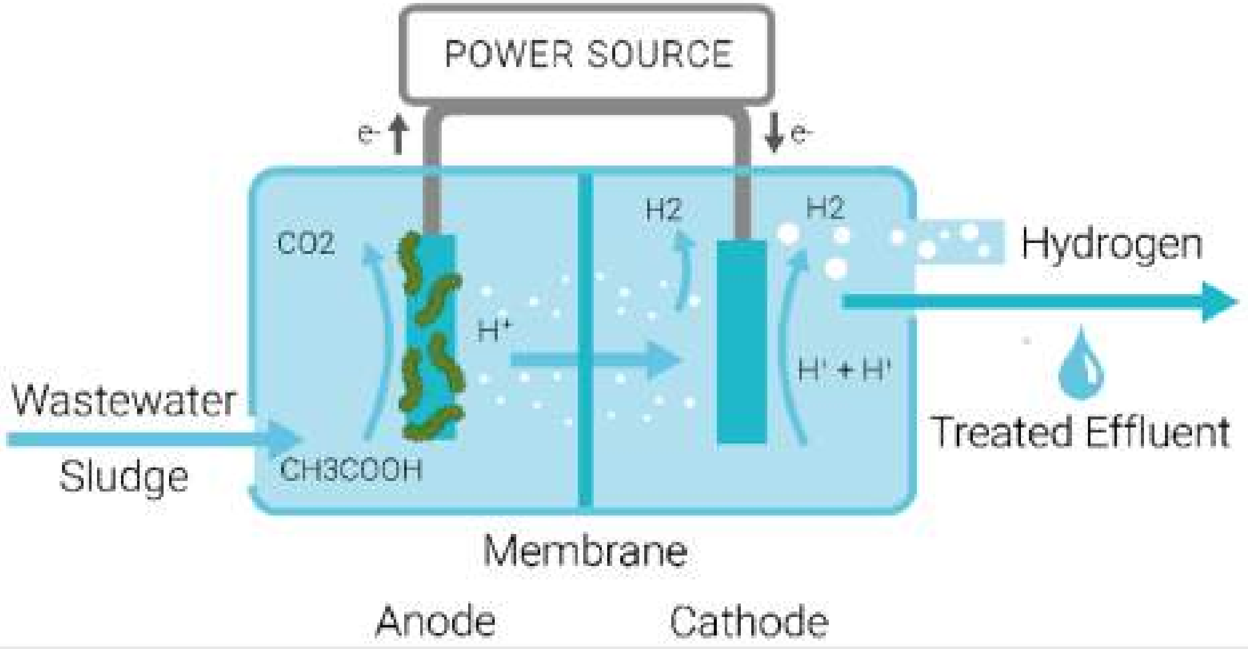
Patent - Published

Patent Title: A Method to Enhance the Performance of a Microbial Fuel Cell

Application number: 202141015075

Inventors: Ujwal Shreenag Meda, Pradeep G A

Filing Date: 31.03.2021



Recent Publications – SCI Journals

ELSEVIER

Journal of Energy Storage

Available online 18 November 2021, 103564

In Press, Corrected Proof

Solid Electrolyte Interphase (SEI), a boon or a bane for lithium batteries: A review on the recent advances

Ujwal Shreenag Meda [a, b, c], Libin Lal [a], Sushantha M [a], Paridhi Garg [a]

[a] Department of Chemical Engineering, RV College of Engineering, Bengaluru, India

[b] Centre for Hydrogen and Green Technology Research, RV College of Engineering, Bengaluru, India

[c] Centre of Excellence in e-Mobility, RV College of Engineering, Bengaluru, India

Received 24 June 2021, Revised 21 October 2021, Accepted 2 November 2021, Available online 18 November 2021.

Q1 Electrical and Electronic Engineering best quartile

SJR 2020 1.09

powered by scimagojr.com

CiteScore 6.0

Impact Factor 6.583

Acceptance rate 31%

List price APC: OA $2,370

Embargo period: $ 24 months

Top readership countries: CN, US, IN

ELSEVIER

Process Safety and Environmental Protection

Available online 24 March 2022

In Press, Journal Pre-proof

Titanium Dioxide based Heterogeneous and Heterojunction Photocatalysts for Pollution Control Applications in the Construction Industry

Process Safety and Environmental Protection

Publication of the Institution of Chemical Engineers

Official Journal of the European Federation of Chemical Engineering: Part B

ISSN: 0957-5820

Publishing options: OA Open Access $ Subscription

Process Safety and Environmental Protection

Q1 Chemical Engineering (miscellaneous) best quartile

SJR 2020 1.17

powered by scimagojr.com

CiteScore 8.9

Impact Factor 6.158

The Impact Factor of this journal is 6.158, ranking it 22 out of 143 in *Engineering, Chemical*

With this journal indexed in 10 international databases, your published article can be read and cited by researchers worldwide

Recent Publications – SCI Journals

Q-1 ; IF = 3.73

Surfaces and Interfaces 18 (2020) 100445

ELSEVIER

Contents lists available at ScienceDirect

Surfaces and Interfaces

journal homepage: www.elsevier.com/locate/surfin

Rational design and synthesis of hetero-nanostructured electrospun PU@PANI@FeS_2: A surface tailored hybrid catalyst for H_2 production via electrochemical splitting of water

C. Manjunatha[a,*], Rahul S Patil[b], M. Sudeep[c], N. Srinivasa[d], R. Chandra Kumar[b], M.P. Sham Aan[a], S. Ashoka[d,*]

Q-1 ; IF = 5.6

Materials Today Energy 18 (2020) 100414

ELSEVIER

Contents lists available at ScienceDirect

Materials Today Energy

journal homepage: www.journals.elsevier.com/materials-today-energy/

Controlled synthesis of nickel sulfide polymorphs: studies on the effect of morphology and crystal structure on OER performance

C. Manjunatha[a,f,*], N. Srinivasa[b], S.K. Chaitra[c], M. Sudeep[d], R. Chandra Kumar[c],

"Surfaces and Interfaces"

Indexed in Scopus, Web of Science, Q-1 Ranking, Impact factor= 3.724

NTNU

Norwegian University of Science and Technology

ELSEVIER

Contents lists available at ScienceDirect

Surfaces and Interfaces

journal homepage: www.elsevier.com/locate/surfin

https://doi.org/10.1016/j.surfin.2021.101161

Development of non-stoichiometric hybrid $Co_3S_4/Co_{0.85}Se$ nanocomposites for an evaluation of synergistic effect on the OER performance

C Manjunatha[a,*], S Lakshmikant[b], L Shreenivasa[c], N Srinivasa[c], S Ashoka[c,*], BW Shivraj[b], Manickam Selvaraj[d], Ujwal Shreenag Meda[e], G Satheesh Babu[f], Bruno G Pollet[g]

[a] Department of Chemistry, RV College of Engineering, Bengaluru, 560059, India
[b] Department of Mechanical Engineering, RV College of Engineering, Bengaluru, 560059, India
[c] Department of Chemistry, Dayananda Sagar University, Bengaluru, 560068, India
[d] Department of Chemistry, King Khalid University, Faculty of Science, P.O. Box 9004, Abha 61413, Saudi Arabia
[e] Department of Chemical Engineering, RV College of Engineering, Bengaluru, 560059, India
[f] Interdisciplinary Research Center, RV college of Engineering, Bengaluru, 560059, India
[g] Department of Energy and Process Engineering, Faculty of Engineering, Norwegian University of Science and Technology (NTNU), NO 7491 Trondheim, Norway

Recent Publications – SCI Journals

IF= 3.119 Q-1 h-index =148

RSC Advances

ROYAL SOCIETY OF CHEMISTRY

PAPER

View Article Online
View Journal | View Issue

Check for updates

Cite this: RSC Adv., 2021, 11, 14654

Facile synthesis of Ni/NiO nanocomposites: the effect of Ni content in NiO upon the oxygen evolution reaction within alkaline media†

Srinivasa N.,[a] Jack P. Hughes,[bc] Prashanth S. Adarakatti,[cd] Manjunatha C.,[e] Samuel J. Rowley-Neale,[bc] Ashoka S.[*a] and Craig E. Banks[*bc]

Q-2; IF = 1.7

Chemical Papers
https://doi.org/10.1007/s11696-020-01113-5

ORIGINAL PAPER

Engineering the $M_xZn_{1-x}O$ ($M = Al^{3+}$, Fe^{3+}, Cr^{3+}) nanoparticles for visible light-assisted catalytic mineralization of methylene blue dye using Taguchi design

C. Manjunatha[1,3] · B. Abhishek[2] · B. W. Shivaraj[2] · S. Ashoka[5] · M. Shashank[4,6] · G. Nagaraju[4]

Received: 29 November 2019 / Accepted: 18 February 2020

Q-1 , IF =2.73

Solid State Sciences 106 (2020) 106314

Contents lists available at ScienceDirect

Solid State Sciences

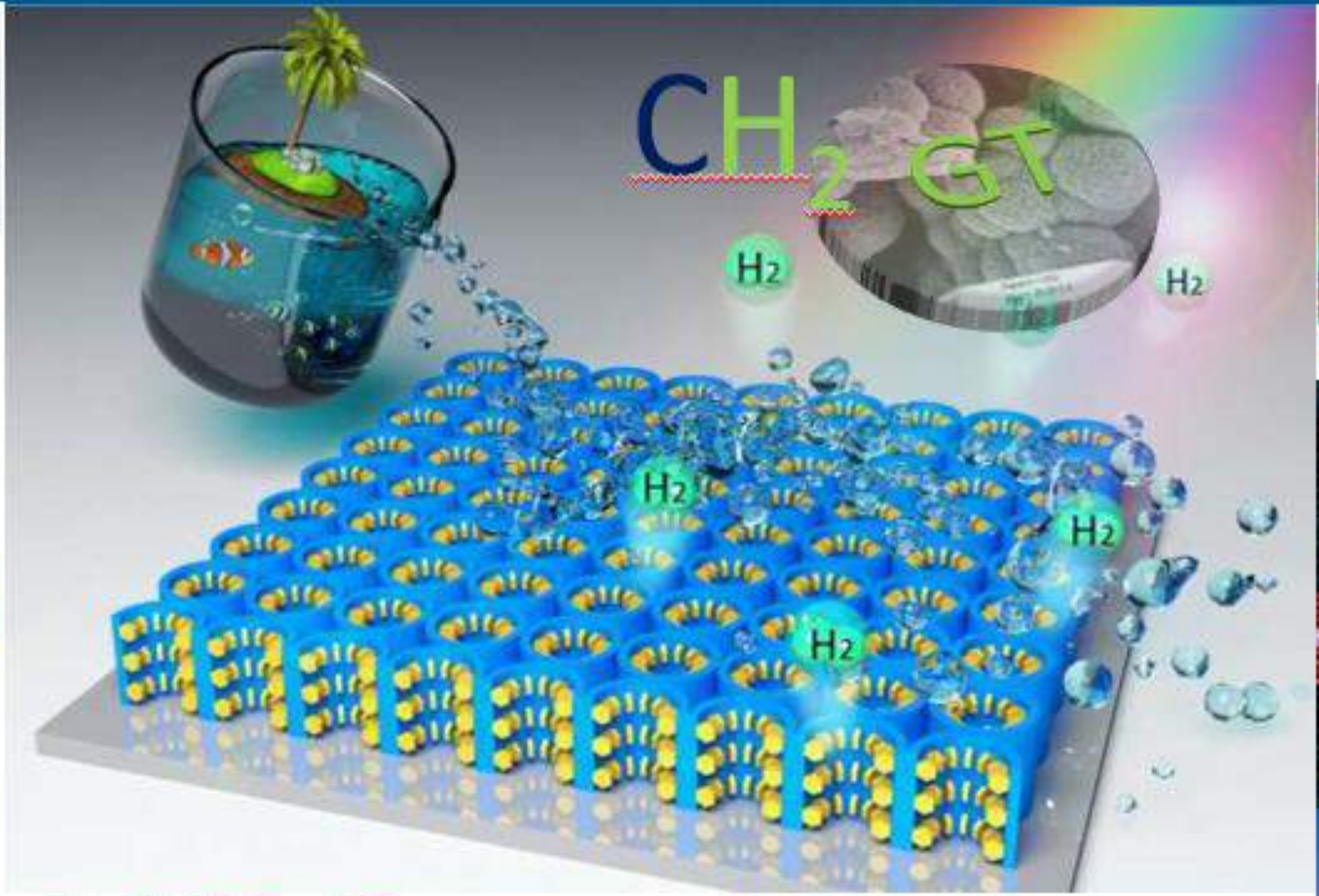
journal homepage: http://www.elsevier.com/locate/ssscie

ELSEVIER

Studies on anion-induced structural transformations of iron(III) (Hydr) oxide micro-nanostructures and their oxygen evolution reaction performance

C. Manjunatha[a,d,*], N. Srinivasa[b], S. Samriddhi[c], C. Vidya[c], S. Ashoka[b,**]

KING KHALID UNIVERSITY



DAYANANDA SAGAR UNIVERSITY
ESTD. 2014 BANGALORE INDIA

IIITDM

SIDDAGANGA INSTITUTE OF TECHNOLOGY TUMKUR

VIT-AP UNIVERSITY

มหาวิทยาลัยสงขลานครินทร์
Prince of Songkla University

NTNU
Norwegian University of Science and Technology

2/17/2023

International Collaborators

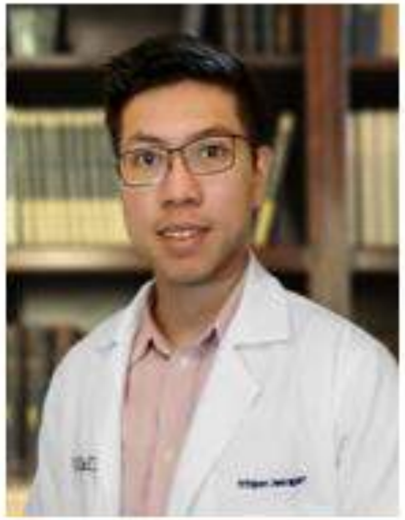
1. Prof. Dr. Bruno G Pollet, AFIChemE, FRSC
President of the Green Hydrogen Division of the International Association for Hydrogen Energy,
Full Professor of Renewable Energy,
Norwegian University of Science and Technology (NTNU)
(h-index = 45, i10-index= 127, publications > 200, Citations=9000) .

NTNU
Norwegian University of Science and Technology

360 QS WORLD UNIVERSITY RANKINGS

มหาวิทยาลัยสงขลานครินทร์
Prince of Songkla University

3. Dr. Itthipon Jeerapan
Division of Physical Science, Faculty of Science,
Prince of Songkla University,
Hat Yai, Songkhla, 90112, Thailand,
itthipon.j@psu.ac.th



2. Prof. Dr. M. Selvaraj,
Professor of Materials Chemistry and Catalysis
King Khalid University, Abha,
Kingdom of Saudi Arabia
(h-index=31, i10 index= 67, citations =2500

QS WORLD UNIVERSITY RANKINGS 448

KING KHALID UNIVERSITY

4. Prof. Dr. Mika Sillanpää.

Journal Editorial Board member
Elsevier (Inorganic Chemistry Communications),
Springer (Environmental Chemistry Letters)
Visiting Scientist,
Abu Dhabi University, UAE

International Collaborators

Prof. Dr.-Ing. Stephan Sommer
Labor für Qualitätsmanagement,
Fertigungsmess- und Wälzlagertechnik
Hochschule Würzburg-Schweinfurt
Ignaz-Schön-Straße 11
D-97421 Schweinfurt

Dr. Mohtada Sadrzadeh, PhD, PEng
Associate Professor, Faculty of Engineering
Mechanical Engineering Dept
The University of Alberta, , Canada
Email : sadrzade@ualberta.ca

Prof. Ajit Khosla, Ph.D
School of Mechanical Systems Engineering,
Faculty of Engineering, Yamagata University,
4-3-16 Jonan, Yonezawa, Japan. 992-8510
E-mail: khosla@yz.yamagata-u.ac.jp
Editor: The Electrochemical Society Journals (JES and JSS)
Microsystem Technologies (Springer), IEEE / IET Nanobiotechnology

Industrial Collaborations

Anvita Electronics

Rashtreeya Sikshana Samithi Trust RV INSTITUTIONS®

CH_2GTR

ipgi

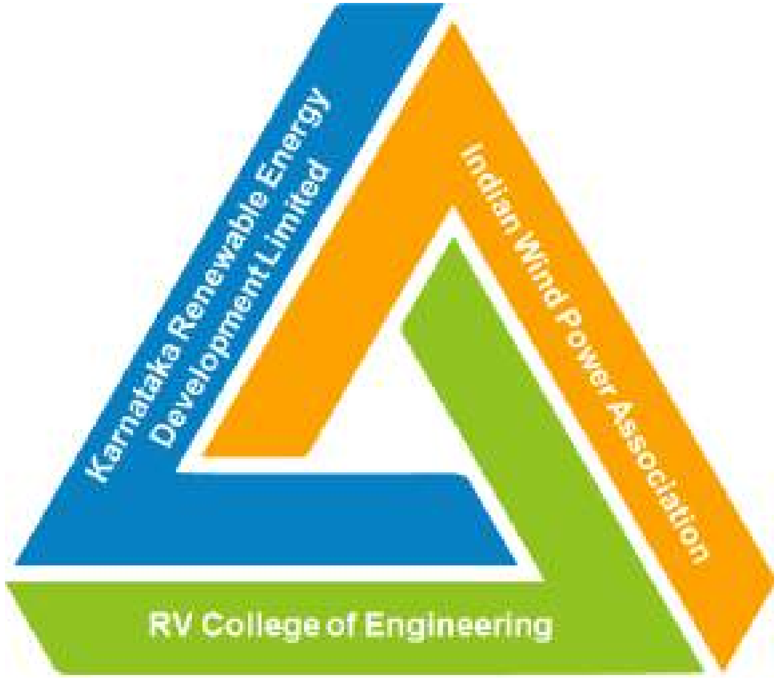
Nichrome Testing Laboratory & Research Pvt. Ltd.

NTLR

CONSULTING / TESTING / TRAINING / ENGINEERING

MoU with KREDL & IWPA

Greening Young Minds



Greening Young Minds – Student Internship

- Internships for UG students
- Consists of 8 modules spread across four years
- To train the students in the RE sector
- Open to all engineering disciplines
- First batch of fifteen students started today

Module	Title
1	Introduction to Renewable Energy, Indian Power Sector and Asset Management
2	Wind measurement, analysis & Mico-sitting
3	Evacuation planning of RE projects using load flow studies
4	Wind Turbine Technology
5	Heavy materials handling and foundations in Wind and Solar forms
6	SCADA Remote monitoring and appliction of power electronics in RE projects
7	RE Hybrid Projects and Hydrogen Technology
8	Operation and Maintanance of RE projects

Greening Young Minds – Student Internship





Open Day at CH_2GT