## About Us

Bioprocess Engineering Laboratory is an integral component of Department of Biotechnology, IIT Kharagpur, a premier research institute of the country. The Principal Investigator (PI), **Prof. Debabrata Das** has been involved in design, fabrication, installation, commissioning of five pilot plants in India and has more than thirty years research experience on the biological gaseous energy recovery systems.

The Bioprocess Engineering Laboratory research activities contribute towards the growing role of advanced technologies for bioenergy recovery from organic wastes to address the nation's energy challenges. The research work of this laboratory is sponsored by several international and national funding agencies viz. National Science Foundation, USA; DAAD, Germany; Norwegian Ministry of Foreign Affairs, Norway; MNRE, BRNS, DST, DBT-Scout, DRDO and ISIRD of Govt. of India. The work-group has collaborative experience with different industries (World Hydrogen Enterprise LLC, New York, USA; IFB Agro Industries, India) and foreign laboratories (University of Miami, USA; Oslo University, University of Bergen, Norway; Ruhr University, Germany; Denmark Technical University, Denmark; Uppsala University, Sweden etc). Our projects mainly focus on (but not restricted to):

- ***Maximization of hydrogen production by dark fermentation*** using both mesophiles and thermophiles
- ***Photofermentation and biophotolysis of water*** using green algae and cyanobacteria
- ***Customized reactor designing; scale up studies***
- ***Microbial fuel cells*** for direct power generation from organic wastes
- ***Butanol production***
- ***Biomethanation***
- ***Biohythane production***
- ***Bioelectrochemical systems and Biosensors***

The lab hitherto has generated as many as **18 PhD** and several M.Tech, B.Tech (graduate, undergraduate) students. It has published more than **130** research papers in the peer-reviewed journals and has published **4** books. Please visit our website: **www.bioh2iitkgp.in** for the information in details.

## Commencement of Biohydrogen Research

***Biohydrogen production*** is acknowledged to be environmentally benign and the most promising renewable energy resource and an ideal alternative to fossil fuels that doesn't contribute to the greenhouse. Biohydrogen production has greater prospect not only for the power generation but also for waste recycling. The ***Bioprocess Engineering Laboratory*** has been actively associated with research in different areas relating to biohydrogen production, its main emphasis being to increase yields of hydrogen from the existing processes and its generation from organic waste. The lab has been working on both the routes, viz. dark and photo fermentative hydrogen production for more than one decade and has also done some substantial research on the isolation of potential $H_2$ producing strains, development of continuous hydrogen production process especially in customized bioreactors. Recently the lab has developed biohythane process for maximization of gaseous energy recovery from organic wastes.

**Road map of major findings in Biohydrogen Research (BPE Laboratory)**

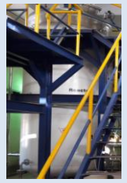
| *Year* | *Research Finding* | *Reference* |
|---|---|---|
| 2000 | Isolation of *Enterobacter* IITBT-08; $H_2$ yield-2.2 mol $H_2$/mol glucose | Kumar & Das, *Process Biochem*. 35: 589-594 |
| 2002 | Simulation and modeling of continuous $H_2$ production process by *Enterobacter cloacae* | Das et al., Enzyme and Microbial Technol, 31: 867-875 |
| 2004 | Molecular Cloning, Characterization and Overexpression of a Novel [Fe]-*hydrogenase* | Mishra J et al., *BBRC*. 324: 679-685 |
| 2006 | Improvement of biohydrogen production under decreased partial pressure of $H_2$ | Mandal et al., *Biotechnol Letts*, 28: 831-835 |
| 2008 | Advances in biological hydrogen production processes | Das and Veziroglu, *IJHE*, 33:6046-6057 |
| 2010 | Development of photobiological processes and photobioreactors for hydrogen production | Dasgupta et al., *IJHE*, 35;10218-10238 |
| 2012 | Improvement of hydrogen production with thermophilic mixed culture | Roy et al., *IJHE* 37:15867-15874 |
| 2014 | Continuous thermophilic biohydrogen production in packed bed reactor | Roy et al., *Applied Energy*, 136: 51-58 |
| 2015 | Gaseous energy recovery from sugarcane bagasse by Dark fermentation and Biomethanation | Kumari and Das, *BRT*, 194: 354-363 |
| 2016 | Biohythane production from organic wastes | Roy et al., *ESPR*, 23: 9391–9410 |
| 2017 | Energy recovery by dark fermentation followed by Biobutanol production | Mitra et al. *IJHE* 42: 4880-4992 |

## Major Outcomes

| *Microorganism* | *Feedstock* | *Nutrient Supplement* | *Mode of operation* | *Reactor volume (L)* | *Cumulative $H_2$ production (L/L)* |
|---|---|---|---|---|---|
| ***Klebsiella pneumoniae*** | Cane molasses | Yeast extract | Batch | 2 | 1.9 |
| | | GDOC | | 2 | 2.8 |
| | | DDGS | | 2 | 2.5 |
| | Distillery effluent | Yeast extract | | 2 | 1.8 |
| | | GDOC | | 2 | 2.1 |
| | | DDGS | | 2 | 1.7 |
| **Acidogenic mixed culture** | **Distillery effluent** | **Yeast extract** | **Batch** | **2** | **1.6** |
| | | **GDOC** | | **2** | **2.2** |
| | | **DDGS** | | **2** | **2.0** |
| ***Klebsiella pneumoniae*** | **Cane molasses** | **GDOC** | **Batch** | **50** | **2.9** |
| ***Klebsiella pneumoniae*** | **Cane molasses** | **Yeast extract** | **Continuous** | **20** | **3.35 (L $L^{-1}$ $h^{-1}$)** |
| **Thermophillic mixed culture** | **Cane molasses** | **Yeast extract & Tryptone** | **Batch** | **20** | **4.8** |
| **Thermophillic mixed culture** | **Distillery effluent** | **Yeast extract & Tryptone** | **Batch** | **20** | **2.9** |
| **Acidogenic mixed culture** | **Distillery effluent** | **DDGS** | **Continuous** | **0.5** | **0.38 (L $L^{-1}h^{-1}$)** |
| **Thermophillic mixed culture** | **Cane molasses** | **Yeast extract & Tryptone** | **Continuous** | **0.5** | **1.6 (L $L^{-1}$ $h^{-1}$)** |
| **Thermophillic mixed culture** | **Starchy wastewater** | **Yeast extract & Tryptone** | **Batch** | **0.5** | **3.9** |

GDOC: Groundnut de-oiled cake, DDGS: Distilled dried grain solids

## Facilities of Biohydrogen Pilot Plant



10 $m^3$ Reactor


Gas collection & online monitoring system

pH dosing system

Control system

Steam generator

Water Bath

Air compressor

Chiller

## Performance of Biohydrogen Pilot Plant

### Experimental Conditions

| | | | |
|---|---|---|---|
| *Feedstock* | Cane Molasses: 1% (w/v) Groundnut de-oiled cake: 1.5% (w/v) | *Working condition* | Unsterile |
| | | *Initial pH* | 6.5 |
| *Total volume* | 12 $m^3$ | *Temperature* | 34 - 37°C |
| *Working volume* | 10 $m^3$ | *Time of fermentation* | 30 h |
| *Microorganism* | *Klebsiella pnemoniae* | *Mixing* | Recirculation |

### Outcome

| | Run - 1 | Run - 2 |
|---|---|---|
| *Total gas ($m^3$)* | 161.01 | 158.9 |
| *$H_2$ content (% v/v)* | 50 | 48 |
| *Total $H_2$ production ($m^3$)* | 80 | 76.2 |
| *Carbohydrate conversion (%)* | 92 | 78.8 |
| *COD removal efficiency (%)* | 55.6 | 57.27 |
| *Total VFA (Kg)* | 34.31 | 35.92 |

## Sponsors

- Ministry of New and Renewable Energy (MNRE)
- Department of Biotechnology (DBT)
- Department of Science and Technology (DST)
- Defense Research and Development Organization (DRDO)
- Norwegian Ministry of Foreign affairs (MFA), Norway

## Research Contributors

| *Name* | *Designation* | *Name* | *Designation* |
|---|---|---|---|
| **Prof. Debabrata Das** | Principal Investigator | Balachandar G | Research Scholar |
| Dr. Narendra Kumar | Research Scholar | Preeti Mishra | Research Scholar |
| Dr. Jayashree Mishra | Research Scholar | Sinu Kumari | Research Scholar |
| Dr. Kaushik Nath | Research Scholar | Amrit Lal | Research Scholar |
| Dr. Kaustabha Mohanty | Research Scholar | V Ramya | Research Scholar |
| Dr. Tumpa Dutta | Research Scholar | Jhansi L V | Research Scholar |
| Dr. Shireen Meher K | Research Scholar | Srijoni Banerjee | Research Scholar |
| Dr. Mohan Yama | Research Scholar | Harshita Singh | Research Scholar |
| Dr. Namita Khanna | Research Scholar | Vaishali Singh | Research Scholar |
| Dr. Kanhaiya Kumar | Research Scholar | Chandan Mahata | Research Scholar |
| Dr. Jose Gilbert | Research Scholar | Basudeb Mondal | Project Assistant |
| Dr. Soumya Pandit | Research Scholar | Raghupati Samanta | Project Assistant |
| Dr. Nitai Basak | Research Scholar | Tapas Mohanty | Project Assistant |
| Dr. Shantonu Roy | Research Scholar | | |
| Dr. Supratim Ghosh | Research Scholar | | |
| Dr.Bikram Kumar N | Research Scholar | | |

## Contact us

**Professor Debabrata Das**
**Department of Biotechnology**
**Indian Institute of Technology, Kharagpur**
**Kharagpur 721302,**
**Dist. West Midnapore, West Bengal, India**
**Tel: +91 9434717424**
**e-mail: ddas.iitkgp@gmail.com**
**website: www.bioh2iitkgp.in**

# BIOHYDROGEN PILOT PLANT

*From* Lab scale...

...*To* Pilot scale

**DEPARTMENT OF BIOTECHNOLOGY**
**INDIAN INSTITUTE OF TECHNOLOGY**
**KHARAGPUR, INDIA**