Microbial Biohydrogen Production Training – Fermentation, MEC & Scale-Up Expertise

Microbial Biohydrogen Production Training at NTHRYS provides deep, process-oriented expertise for renewable energy biotechnology. This program equips participants to isolate and engineer high-yield hydrogenogenic microbes, optimize metabolic pathways, design dark/photo-fermentation and microbial electrolysis systems, and implement scalable, cost-effective, and sustainable hydrogen production processes. Training also addresses advanced downstream recovery, quality control, regulatory frameworks, and commercial deployment in the growing hydrogen economy.

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Microbial Biohydrogen Production: Industrial Training Program

Intro Module - Biohydrogen Basics & Market Landscape (Theory)

Fees: Rs 5000/-

1. Hydrogen as a clean energy vector: combustion & fuel cell utility.
2. Microbial pathways for H_2 generation: dark fermentation, photo-fermentation, MEC.
3. Key microbial groups: *Clostridium*, *Enterobacter*, purple non-sulfur bacteria.
4. Global hydrogen economy: green hydrogen and microbial niche.
5. Energy balance and carbon neutrality advantages.

Academic Module - Bio Hydrogen Production from Algal Source or Bacterial Source

Fees: Rs 35000/-

Duration: 45 Days

Deliverables

1. Certificate of Completion issued by NTHRYS.
2. Hands-on training manuals covering protocols and workflows.
3. Datasets generated during experiments (raw and processed).
4. Standard Operating Procedures (SOPs) for reproducibility.
5. Access to lab instrumentation during training period.
6. Networking opportunities with industry and academia.

Detailed Academic Module

1. **Isolation of Hydrogenogenic Microbes**: Collection of samples from anaerobic digesters, sediments, and wastewater, followed by selective culturing of *Clostridium*, *Enterobacter*, and purple non-sulfur bacteria.
2. **Enrichment & Screening**: Use of anaerobic culturing and hydrogen evolution assays to identify high-yield strains with stable performance.
3. **Strain Characterization**: Morphological, biochemical, and molecular identification (16S rRNA sequencing) of isolates with confirmation of hydrogenase gene clusters.
4. **Metabolic Pathway Analysis**: Evaluation of [FeFe] and [NiFe] hydrogenases, substrate utilization pathways, and regulatory mechanisms for hydrogen production.
5. **Feedstock Optimization**: Testing of carbohydrate-rich substrates (molasses, lignocellulosic hydrolysates, agro-industrial waste (select any one) with pretreatment strategies for maximum fermentability.
6. **Bioreactor Setup**: Standardization of dark fermentation, photo-fermentation, and microbial electrolysis systems under controlled pH, temperature, and anaerobic conditions.
7. **Process Monitoring & Gas Analysis**: Measurement of H_2 evolution rate (HER) using gas chromatography(2 batches), pressure sensors, and online monitoring systems (SCADA).
8. **Product Recovery & Purification**: Hydrogen purification through pressure swing adsorption (PSA) (1 batch), membrane separation (1 batch), and CO_2 scrubbing for industrial grade purity.
9. **Scale-Up & Sustainability Evaluation (Theory - SCADA Exposure)**: Pilot-scale trials, techno-economic analysis, life cycle assessment (LCA), and integration into renewable hydrogen economy frameworks.

Microbial Bio-Hydrogen Production Industrial Modules

Duration: Each module spans 45 days to 3 months, depending on the level and depth of training.

These industrial modules in Microbial Bio-Hydrogen Production cover strain isolation to large-

scale bioreactor optimization, integrating advanced fermentation, purification, and process scale-up strategies tailored for clean energy industries.

Module 1 – Strain Selection, Engineering & Characterization

Fees: Rs 550000/-

1. Isolation from anaerobic digesters, sediments, waste streams.
2. Activity assays for hydrogen yield and gas chromatography analysis.
3. Genetic engineering: [FeFe] and [NiFe] hydrogenase pathway optimization.
4. Adaptive evolution for tolerance to pH, temperature, inhibitors.
5. Strain banking, cryopreservation, and inoculum quality metrics.

Module 2 – Fermentation Strategies & Bioprocess Design

Fees: Rs 300000/-

1. Dark fermentation process parameters (substrate, C/N ratio, pH control).
2. Photo-fermentation design: light intensity, wavelength, reactor geometry.
3. Microbial electrolysis cells (MECs): electrodes, mediators, voltage optimization.
4. Continuous vs batch system tradeoffs; PAT integration.
5. Scale-up criteria: mixing, mass transfer, k_La for gas evolution.

Module 3 – Feedstock Management & Pretreatment

Fees: Rs 700000/-

1. Utilization of industrial/municipal/agricultural waste streams.
2. Pretreatment techniques: thermal, enzymatic, acid/alkali hydrolysis.
3. Lignocellulosic biomass deconstruction for fermentable sugars.
4. Coproduct management (VFAs, solvents, organic acids).
5. Cost reduction via integrated biorefinery approaches.

Module 4 – Hydrogen Recovery, Purification & Storage

Fees: Rs 800000/-

1. Gas separation techniques: PSA, membrane filtration, cryogenic methods.
2. CO_2 and CH_4 removal strategies.
3. Storage solutions: compressed H_2, metal hydrides, LOHCs.
4. Safety protocols for hydrogen handling.
5. Integration into existing fuel infrastructure.

Module 5 – Quality Control & Analytics

Fees: Rs 300000/-

1. Gas composition analysis using GC and MS.
2. Yield and productivity calculations; H_2 evolution rate (HER).
3. Hydrogen purity specifications for industrial vs fuel cell use.
4. Stability studies for microbial cultures and process robustness.
5. Standard reporting for certification and audits.

Module 6 – Industrial Applications & Integration

Fees: Rs 900000/-

1. Fuel cells for transport and stationary power.
2. Industrial hydrogen use: metallurgy, chemical synthesis, refining.
3. Hybrid biohydrogen + biomethane systems for energy diversification.
4. Coupling biohydrogen plants with wastewater treatment.
5. Demonstration case studies: pilot to industrial scale.

Module 7 – Regulatory, Environmental & Safety Frameworks

Fees: Rs 210000/-

1. Hydrogen purity and safety standards (ISO, SAE, FSSAI energy approvals).
2. Process safety management (PSM) and HAZOP reviews.
3. Environmental impact and carbon footprint analyses.
4. Life cycle assessment (LCA) for green hydrogen certification.
5. Compliance documentation for funding and deployment.

Module 8 – Scale-Up, Economics & Commercialization

Fees: Rs 820000/-

1. Pilot to production scale bioreactors and gas collection systems.
2. Techno-economic analysis: CAPEX/OPEX, energy yields, payback periods.
3. Cost reduction strategies: co-product valorization, waste integration.
4. Business models: decentralized biohydrogen hubs vs central plants.
5. Funding, IP, and partnership strategies for commercialization.

Deliverables & Outcomes

1. Complete SOPs for microbial biohydrogen production and recovery.
2. Validated protocols for strain engineering and optimization.

3. Process design templates for dark, photo, and electro-fermentation systems.
4. Safety and compliance manuals for industrial deployment.
5. Commercialization roadmap and TEA reports.

Optional Add-Ons

1. Hands-on MEC reactor build and testing workshop.
2. DoE-based metabolic optimization projects.
3. Waste-to-hydrogen integrated feasibility analysis.
4. Carbon credit and sustainability certification support.
5. Industrial site deployment mentorship.