THE TECHNOCRACY
STUDENTS' TECHNICAL COMMITTEE, NIT RAIPUR

AAVARTAN'25-26

VIGYAAN

DEPARTMENT OF CHEMICAL ENGINEERING

PROBLEM STATEMENTS

CHEM01: Bioprocess Model for Converting Rice Straw to Bioplastic

Develop a sustainable bioprocess to convert rice straw into biodegradable PHA bioplastic by integrating simple pretreatment, hydrolysis and microbial fermentation steps. The solution should be feasible using commonly available biochemical lab equipment, demonstrate clear environmental benefits and low energy demand and include estimation of PHA yield along with a low-cost strategy for product recovery.

CHEM02: Zero Liquid Discharge Model for RO Brine

Develop a compact, energy-efficient zero-liquid-discharge system for treating RO brine by concentrating dissolved solids and recovering reusable water and salt fractions. The solution should be simple and modular enough for pilot-scale demonstration while operating under realistic energy and process constraints suitable for small-scale deployment.

CHEM03: PET Waste Chemical Recycling System

Develop a continuous chemical recycling process that converts PET waste into BHET via glycolysis under low catalyst loading, moderate operating temperatures and controllable reaction conditions. The solution should be suitable for bench-scale implementation, deliver predictable BHET purity and demonstrate a clear environmental advantage over purely mechanical recycling through an estimated material balance and indicative product quality assessment.

CHEM04: CO_2 Capture for Cement Plant Exhaust Streams

Develop a practical, energy-efficient post-combustion CO_2 capture system for cement plant exhaust that can be retrofitted with minimal disruption to existing operations. The solution should use amine-based absorption and regeneration to treat realistic flue gas conditions while achieving meaningful capture efficiency under feasible energy demands.

CHEM05: Biomass Gasification Route for Green Hydrogen

Develop a small-scale biomass gasification system capable of producing hydrogen-rich syngas from agricultural residues, suitable for decentralized or rural deployment. The solution should ensure reliable field operation with simple, maintainable components for syngas generation and hydrogen recovery. The design must also include tar formation analysis and incorporate practical gas-cleanup measures such as cyclones, scrubbers or filters as these factors critically influence hydrogen yield, equipment longevity and the overall efficiency of the gasification process.

CHEM06: CO_2 Mineralization in Cement-Based Materials

Develop a controlled CO_2 curing process for cement-based materials that enhances mechanical strength, reduces porosity, and permanently stores carbon within the matrix. The solution should be demonstrable using accessible curing setups and supported by measurable improvements in properties such as compressive strength, density and CO_2 uptake when compared to conventionally cured samples.

CHEM07: Nanostructured Protective Coatings for Corrosion Resistance

Develop a corrosion-resistant coating for steel that incorporates nanostructured or polymer-based additives to improve durability under industrial exposure conditions. The solution should be synthesizable using basic laboratory infrastructure and demonstrate clearly measurable performance gains through standardized corrosion testing, along with acceptable adhesion and environmental durability.

CHEM08: Biofilter System for Methane Mitigation in Landfills

Develop a biofilter system that uses methanotrophic microorganisms supported in a porous medium to oxidize methane from simulated landfill gas. The solution should be simple to construct and operate, demonstrate clearly measurable methane reduction and maintain stable performance under varying moisture and temperature conditions.

CHEM09: Digital Twin for Continuous Reactor Optimization

Develop a lightweight digital twin for a continuous reactor that combines fundamental reactor modelling with data-driven algorithms to predict performance, detect deviations and recommend operating adjustments in real time. The solution should be easy to simulate on a lab or desktop scale and demonstrate meaningful optimization or early fault detection using a representative case study.

CHEM10: Solar Photocatalytic Water Purifier

Develop a compact, solar-driven photocatalytic water purification system that uses TiO_2-based surfaces to degrade contaminants under natural sunlight. The solution should prioritize portability, low maintenance, and reliable treatment performance suitable for use in resource-limited or rural settings.