Techno-economic assessment of a rice husk biorefinery for bioethanol, precipitated silica, lignin and furfural production

C. Bacquerié, V. Larnaudie, M.D. Ferrari, C. Lareo

Departamento de Ingeniería Bioquímica y Bioprocesos, Instituto de Ingeniería Química, Facultad de Ingeniería, Universidad de la República, Julio Herrera y Reissig 565, 11300 Montevideo, Uruguay

Rice husk is an abundant lignocellulosic residue with significant potential for valorization within the framework of a biorefinery. It contains cellulose, hemicellulose and lignin, as well as a high ash content mainly composed of SiO_2, which can be transformed into biofuels and value-added products. The development of integrated processes for its utilization can contribute to waste reduction and sustainable energy production.

In this work, a rice husk biorefinery was modeled to produce bioethanol and co-products such as silica, lignin, furfural and sodium sulfate. The process includes two main steps: autohydrolysis to recover hemicellulose-derived compounds, and alkaline treatment with NaOH to remove lignin and ash. The remaining cellulose-rich solid is then converted into ethanol through enzymatic hydrolysis and fermentation. The process also includes product recovery, utilities and wastewater treatment.

The process was simulated in Aspen Plus® using the NRTL property method. The model integrates experimental data and literature sources, considering a plant capacity of 16 t/h of dry rice husk. A discounted cash flow analysis was performed to estimate the minimum selling price of ethanol (MESP), defined as the price that results in a net present value (NPV) equal to zero, assuming constant revenues from co-products.

The results show that operating costs, estimated at approximately 52 million USD per year, are dominated by raw materials, particularly NaOH and H_2SO_4, as well as utilities consumption. Capital investment is reaching an estimated total of 300 million USD. Silica and ethanol represent the main sources of revenue. The calculated MESP was 1.53 USD/L, indicating that economic viability remains challenging under the evaluated conditions. Nevertheless, the analysis allowed the identification of improvement scenarios and key process bottlenecks, highlighting opportunities for further experimental work and process optimization.