Abstract

The aim of this doctoral thesis was to develop and evaluate a biological hydrogen production technology based on dark fermentation of tannery waste, with particular emphasis on chromium-containing leather shavings. The research was conducted under real conditions using a laboratory-scale setup located in an industrial facility Bader Polska Sp.z o.o. in Bolesławiec. Various substrate configurations, process parameters and fermentation-enhancing methods were tested.

The study examined the effects of substrate type and composition (including leather shavigs waste, straw, glucose, buckwheat husks), as well as different pretreatment methods (thermal, chemical), substrate particle size and mixing intensity on hydrogen production efficiency. The modified Gompertz model was applied to describe fermentation kinetisc and compare the performance of tested configurations.

Parallel to the experimental work, CFD (Computational Fluid Dynamics) simulations were performer to analyze mixing dynamics within the fermenters. The models enabled exaluation of flow patterns, mixing uniformity and identification of the most efficient impeller geometries and rotation speeds.

The results indicate the chromium-containing leather waste, especially when co-fermented with lignocellulosic materials, can be effectively used for hydrogen production. The proces not only achieves high hydrogen yields but also reduces tannery waste management costs by converting industrial residues into valuable Energy carriers. Economic analysis demonstrated that dark fermentation using raw industrial waste may be feasible and scalable.

The developed technology constributes to circular economy goals by minimizing environmental impact and supporting the transition toward renewable energy systems.