Biohydrogen production from waste plant biomass via dark fermentation

mgr inż. Weronika Cieciura Włoch

Supervisor: dr hab. inż. Sebastian Borowski

Abstract

Hydrogen applicability in the power, chemical and petrochemical industries is constantly growing. Efficient methods of hydrogen generation from renewable sources such as lignocellulose biomass, including waste products, are currently being developed, even though hydrogen is mainly produced through steam reforming or thermal cracking of natural gas or petroleum fractions. Hydrogen can be obtained on microbiological path via dark fermentation. The efficiency of hydrogen production by microbiological techniques is strongly dependent on the conditions used i.e. the pH range, temperature, composition of fermentation medium or even the presence of substances with potentially inhibitory effects on the microbiological culture.

The research concerned differences in hydrogen productivity depending on the type of substrates and supplementation compounds used, and allowed for the evaluation of the effectiveness of the process in relation to the above-mentioned factors. The research included the determination of the influence of the compounds: $(NH_4)_3PO_4$, NH_4Cl and K_3PO_4 on the productivity of hydrogen from a substrate poor in nitrogen and phosphorus. Moreover, the influence of iron-containing compounds: Fe_2O_3, $FeSO_4$, $FeCl_3$ on microorganisms producing hydrogen and the efficiency of the dark fermentation process were assessed.

It was found that among the tested supplements there are compounds that positively affect the production of hydrogen and significantly increase the efficiency of the process, and thus allow the use of substrates poor in micro- and macroelements, but rich in sugar. The strongest stimulation of the process was noted in the case of the use of potassium phosphate and iron (III) oxide, for which the hydrogen yield was twice or almost four times higher compared to the control series without supplementation. The dosing of the missing elements into the fermentation medium enables the hydrogen-producing microorganisms to function properly. This makes the dark fermentation process more stable and more efficient.

Semi-continuous dark fermentation is a relatively long process and adaptation of methanogenic archaea to unfavorable environmental conditions was observed for the beet pulp hydrolyzate during the process. At the same time, the amount of hydrogen in the emitted biogas decreased from 40% to 20%, while the methane content increased from 0% to 10%.