Slovak Society of Chemical Engineering
Institute of Chemical and Environmental Engineering
Slovak University of Technology in Bratislava

PROCEEDINGS

52nd International Conference of the Slovak Society of Chemical Engineering SSCHE 2026

Hotel SOREA TRIGAN
Štrbské Pleso, Slovakia
May 26 - 29, 2026

Editors: Assoc. prof. Mário Mihaľ

ISBN: 978-80-8208-177-3, EAN: 9788082081773

Published by the Faculty of Chemical and Food Technology, Slovak University of Technology in Bratislava in Slovak Chemistry Library for the Institute of Chemical and Environmental Engineering; Radlinského 9, 812 37 Bratislava, 2026

Nowicka, A., Dudek, M.: Analysis of the Efficiency of Acid Thermohydrolysis of Lignocellulosic Biomass (Willow Chips) Using Conventional and Microwave Heating in the Biogas Production Process, Editors: Mihaľ, M., In *52nd International Conference of the Slovak Society of Chemical Engineering SSCHE 2026*, Štrbské Pleso, Slovakia, 2026.

Analysis of the Efficiency of Acid Thermohydrolysis of Lignocellulosic Biomass (Willow Chips) Using Conventional and Microwave Heating in the Biogas Production Process

Anna Nowicka[1], Magda Dudek[1],

[1]*Department of Environmental Engineering, University of Warmia and Mazury in Olsztyn, ul. Warszawska 117a, 10-720 Olsztyn, Poland*

e-mail: anna.grala@uwm.edu.pl

Key words: acid thermohydrolysis, lignocellulosic biomass, anaerobic digestion, methane yield, microwave heating

Biogas is considered one of the most stable renewable energy sources; however, the efficient utilization of lignocellulosic biomass remains limited due to its complex structure and low biodegradability. Willow chips, characterized by high lignin content, represent a promising but recalcitrant substrate requiring effective pretreatment to enhance methane production.

The aim of this study was to evaluate the effect of acid thermohydrolysis on the efficiency of biogas production from willow biomass and to compare two heating methods: conventional and microwave-assisted heating. Pretreatment was carried out using hydrochloric acid (HCl) at temperatures of 110°C, 120°C, and 130°C, with a residence time of 20 minutes.

The application of acid thermohydrolysis significantly increased the solubilization of organic compounds. Chemical oxygen demand (COD) increased from 10.2 g/L in the control sample to 14.7 g/L for the microwave-assisted variant at 120°C, indicating enhanced availability of biodegradable matter. A substantial increase in soluble sugars was also observed, with glucose rising from 14 mg/L to 124 mg/L and xylose from 194 mg/L to 412 mg/L, confirming effective hemicellulose hydrolysis.

At the same time, the formation of inhibitory compounds was detected. The concentration of hydroxymethylfurfural (HMF) increased with temperature, reaching 24.78 mg/L for conventional heating at 130°C, indicating thermal degradation of sugars. In contrast, the concentration of phenolic compounds decreased with increasing temperature, suggesting partial lignin breakdown.

Biogas production was significantly improved after pretreatment. The highest yield was obtained for microwave-assisted thermohydrolysis at 120°C (800.0 Nml/g VS), corresponding to an increase of approximately 45% compared to the control (550.6 Nml/g VS). Conventional heating also enhanced performance, with the highest yield of 773.2 Nml/g VS at 120°C. At 130°C, a

decrease in biogas production was observed, likely due to the formation of inhibitory by-products.
The methane content in biogas remained relatively stable across all experimental variants, ranging from 59.8% to 60.6% CH_4, indicating that pretreatment mainly affected the quantity rather than the quality of biogas.
In conclusion, acid thermohydrolysis is an effective method for improving the biodegradability of lignocellulosic biomass. Microwave-assisted heating enhances process efficiency compared to conventional methods; however, excessive process severity leads to inhibitor formation. The optimal conditions were identified at 120°C, where the most favorable balance between substrate solubilization and inhibitor generation was achieved.

The research was funded as part of the project "Development of pretreatment technologies for lignocellulosic substrates prior to conversion into second-generation biofuels" under the LIDER XIII programme, funded by the National Centre for Research and Development, grant no. LIDER 13/0050/2022. Amount of funding: PLN 1,410,000.00