Microwave Energy in the Processes of Biomass Treatment

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Summary

The extraction of biomass in microwave field offers advantages such as reduced processing costs, improved stability of products, the possibility to use less toxic solvents and decrease solvent consumption. The submitted contribution presents the results of microwave extraction of wheat straw waste. The sample of waste was characterized by thermal analysis. The content of the fatty acids in extract after microwave leaching of wheat straw in methanol was assayed by gas chromatography.

Keywords: microwave energy, straw, extraction

Introduction

Recently, the role and share of biomass in energy mix at electricity and heat production continually increases in Slovakia and other EU´s member countries. This fact implies from an absence of fossil fuels and also from environmental point of view. The authorities of EU force member countries for an enhancement of renewable sources utilization in energy industry with the aim to reduce dependency on fossil fuels import and greenhouse gases emissions. The biomass for this purpose is mainly represented by quick-growing plants specially cultivated for energy production, by-products and wastes from woodworking and food industry as well as from agriculture. Moreover, the biomass is also source of valuable organic components applicable in the other industrial branches besides power production.

A conversion of biomass to energy is obviously attained by two ways: thermochemical and biochemical ones. Seeing that it is a thermal process an application of microwave heating is possible. The microwave radiation causes a vibrating of atoms and/or molecules, which results in a material heating. Thus, the current research is focused on an application of microwave heating as an innovative technique usable in various industrial branches in order to intensify thermal processes.

The research on microwave energy application in mineral industry has been carried out at the Institute of Geotechnics of SAS since 1993. It was focused on behavior of domestic ores and industrial minerals in microwave field from a viewpoint of their properties changes which enable to improve the winning of utility components from these raw materials [1]. The investigation of microwave-induced extraction of organic compound from coal in different solutions was also performed [2–5]. Microwave extraction in different solutions for obtaining of organic compounds is another possibility of biomass treatment [6, 7].

Materials and methods

The effect of microwaves on the intensification of leaching process has been tested on samples of wheat straw waste (Fig. 1). The samples of waste were subjected to comminution using the grinder MRC model FDV (Fig. 2) and in such way grain size was reduced to –0.5 mm. Methanol as a leaching agent was applied. The weight of the solid compo-

Fig. 1. Straw waste
Rys. 1. Odpady słomy

Fig. 2. Grinder MRC
Rys. 2. Szlifierka MRC

Fig. 3. Laboratory microwave oven Microsynth
Rys. 3. Laboratoryjna kuchenka mikrofalowa Microsynth

nent was 10 g and the volume of the leaching agent was 200 ml.

Thermal analysis (TG, DTG, DSC) was performed at the temperature range from 20°C to 1000°C in argon atmosphere using simultaneous thermal analyzer STA 449 C Jupiter (Netzsch, Germany) under following conditions: sample weight 200 mg, heating rate 5°C/min.

The microwave-assisted leaching was realized in laboratory microwave oven Microsynth (Milestone, Czech Rep.) (Fig. 3) at the power 600 W and frequency 2.45 GHz. The temperature was measured continuously by means of optical fiber. Heated suspension was mixed at the bottom of the oven using magnetic stirrer. The extraction was realized at boiling point of leaching agent for a period 10, 20 and 30 min. After leaching the samples were filtered, weighted and mass yields were calculated. The content of fatty acids in extract was determined by means of the gas chromatograph Shimadzu with column SLB-5ms and FID detector. Nitrogen was used as a carrier gas.

Results and Discussion

The TG curve (Fig. 4) shows the mass loss of sample as the dependence on temperature. The evaporation of water begins at 100°C, which results in a slight mass loss. It is running up to temperature 200°C, which is joined with gradual vaporization of volatile compounds. The highest intensity of decomposition can be observed at 320°C. From DSC curve it

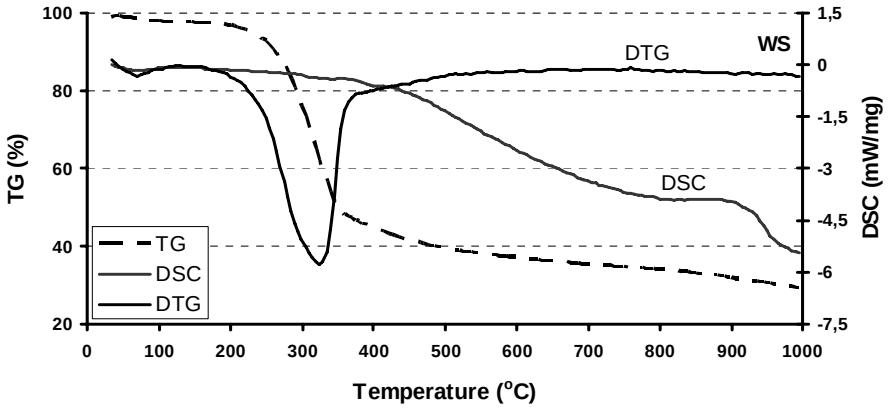

Fig. 4. TG, DTG, DSC curves of wheat straw waste
Rys. 4. Krzywe TG, DTG, DSC odpadów słomy pszenicy

Table 1. Microwave leaching of wheat straw samples

Tabela 1. Mikrofalowe ługowanie próbek słomy pszenicy

Sample	Leaching agent	Time of heating (min)	Microwave power (W)	Mass yield of substances into solution (%)
1	Methanol	10	600	5.64
2	Methanol	20	600	5.69
3	Methanol	30	600	5.72

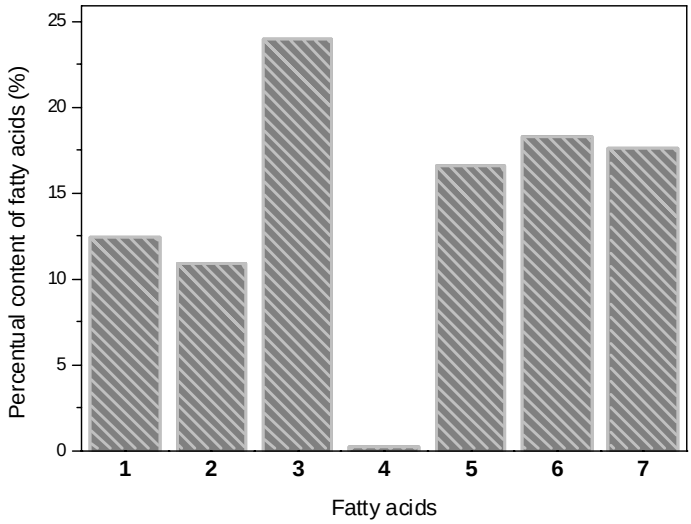

Fig. 5. The content of fatty acids in the wheat straw extract after microwave leaching (1 – Palmitic acid, 2 – Linoleic acid, 3 – Oleic acid, 4 – Stearic acid, 5 – Eicosanoic acid, 6 – Docosanoic acid, 7 – Tetracosanoic acid)

Rys. 5. Zawartość kwasów tłuszczowych w ekstrakcie słomy pszenicy po ługowaniu mikrofalowym (1 – kwas palmitynowy, 2 – kwas linolowy, 3 – kwas oleinowy, 4 – kwas stearynowy, 5 – kwas eikozanowy, 6 – kwas dokozanowy, 7 – kwas tetrakozanowy)

can be concluded, that heat flow is not constant and from temperature about of 400°C significant shift of heat flow is visible.

The conditions of microwave leaching of wheat straw waste and mass yields into the solution are listed in Table 1. The content of fatty acids in extract from solution after microwave leaching determined by gas chromatography is illustrated in Figure 5. The extract contains the following fatty acids: palmitic (12.46%), linoleic (10.88%), oleic (23.99%), stearic (0.26%), eicosanoic (16.55%), docosanoic (18.25%) and tetracosanoic (17.59%).

Conclusion

The microwave-assisted extraction of straw waste was realized at boiling point of leaching agent. The mass yield of organic compounds 5.72% was achieved after extraction in methanol during 30 min. The highest content of oleic acid was obtained (23.99%). It confirmed the significantly higher content fatty acids such as eicosanoic, docosanoic and tetracosanoic.

Acknowledgement

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Energia mikrofalowa w procesach przeróbki biomasy

Wykorzystanie mikrofal w procesie obróbki biomasy daje niewątpliwe korzyści w postaci zmniejszenia kosztów procesu, poprawienia stabilności właściwości produktów oraz możliwości wykorzystania mniej toksycznych rozpuszczalników oraz redukcji ich zużycia. Przedstawiono badania próbek biomasy w postaci odpadów ze słomy pszenicznej. Próbki zostały scharakteryzowane za pomocą analizy termicznej. Zawartość kwasów tłuszczowych po ekstrakcie w metanolu, po ługowaniu w polu mikrofal, zbadano w wykorzystaniem chromatografii gazowej.

Słowa kluczowe: energia mikrofal, słoma, usuwanie