Thermal characterisation of seaweed during pyrolysis and combustion

Nerijus Striūgas[1] and Justas Eimontas[1]

[1]Laboratory of Combustion processes, Lithuanian energy institute, Kaunas, LT-44403, Lithuania

1. Introduction

In order to reduce the ecological problems, caused by eutrophication in water pools and seas, one of the preventive methods is collecting micro and macro algae. Bioenergetics is one of the most promising uses of collected algae. Seaweed is a potential raw material (biomass) for the production of biogas and biomethane. At the end of biogas production process the digestate is formed in the bioreactor, which can be used as a fertilizer in agriculture, closing the product life cycle and contributing to the circular economy. However, the natural water biomass at growing process absorbs not only nutrients, but also pollutant in the deposits, such as heavy metals. If heavy metals concentrations are too high, alternative ways of digestate uses must be found.

2. Methodology

Seaweed was placed in thermogravimetric analyser, to determine how it behaves in pyrolysis and combustion processes. The main experimental parameters: heating rate – 35 °C/min, maximum pyrolysis temperature – 900 °C, maximum combustion temperature – 800 °C.

Thermogravimetric analyser is combined with Fourier – transform infrared spectrometer, which can determine the functional groups of volatile matter. After identification of functional groups, depending on our feedstock, it is possible to predict, what kind of derivatives it is.

Table 1. Proximate analysis results

Proximate analysis	
	Seaweed
Moisture (%)	0,55
Volatile matter (%)	58,65
Fixed carbon (%)	32,08
Ash (%)	8,87

Table 2. Ultimate analysis results

Ultimate analysis	
	Seaweed
C (%)	46,93
H (%)	4,73
N (%)	4,13
O (%)	30,22
S (%)	5,13

Table 3. Heavy metals analysis

Element	Value	Unit of measurement
As	<0,24*	µg/kg
Cd	<0,01	µg/kg
Co	<0,07	µg/kg
Cr	14,18	µg/kg
Cu	14,71	µg/kg
Mn	78,11	µg/kg
Ni	<0,12	µg/kg
Pb	<0,26	µg/kg
Sb	<0,20	µg/kg
V	<0,02	µg/kg
Zn	<0,03	µg/kg

*- values with sign (<) express that element concentration are lower than instrument detection limit.

The ultimate analysis shows most representative parameters, such as percentages of C, H, N, S and O. Also, proximate analysis performed to expose composition of the feedstock in terms of gross components, such as moisture, volatile matter, fixed carbon and ash.

3. Results and Discussion

The study shows that seaweed residual mass is about 8.87 wt.% (Figure.1). The highest rate of volatile matter releases shows Gram Schmitd curve, which has peak points at different temperatures. These temperatures are 300.3 °C and 737.3 °C, and are related mainly to devolatilization of material and combustion of pyrolysis residues, respectively.

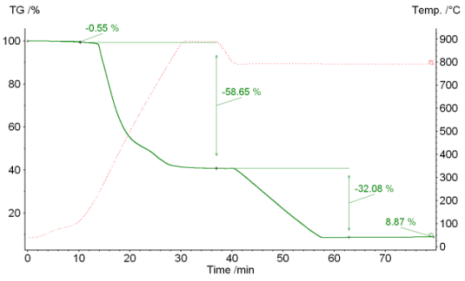

Figure 1. TGA curves of Wood, Straw and RDF samples

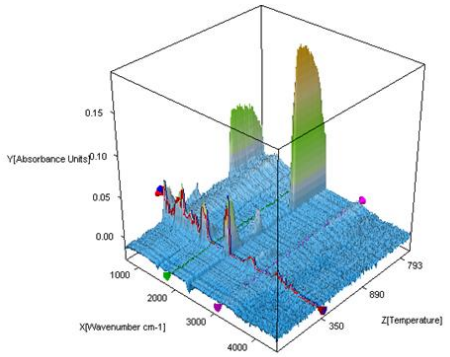

Figure 2. Seaweed spectra cube at different temperatures

Figure 2 shows FTIR spectrum and their intensities depending on the reaction temperature. To analyse and identify possible decomposition products spectra lines at the mentioned peak temperatures were taken from the spectra cube. Extracted spectra lines are shown in Figure 3.

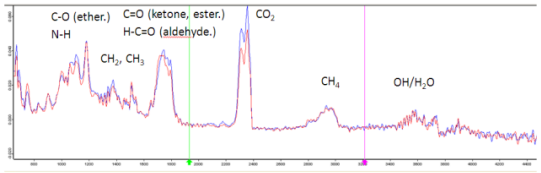

Figure 3. Identified functional groups of seaweed feedstock

According to FTIR spectra, it is able to identify the functional groups, which is in volatile matter. In micro and macro algae could be identified some alcohols, methane, CH_3 and CH_2 groups, carbon dioxide, carbon monoxide, aldehydes, ketones and ethers.

4. Conclusions

Based on the observations in this study, it is clear, that highest thermal degradation rates are determined at two different temperatures – 300.3 °C and 737.3 °C. Residual mass is 8.87 wt.%. According to FTIR impressions, could be identified some functional groups, which belong to various derivatives. Ultimate and proximate analysis shows most representative parameters, like main elements percentages and feedstock gross components. Heavy metal analysis shows, that main metals in obtain seaweed are chrome, copper and manganese.

5. Acknowledgment

The research is funded by the Interreg South Baltic Programme 2014-2020 under the COASTAL Biogas project No. STHB.02.02.00-DE-0129/17.

Interreg South Baltic

EUROPEAN UNION

European Regional Development Fund