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Data Article

Raw and processed data set for optimization of bio-oil production from microwave co-pyrolysis of food waste and low-density polyethylene with response surface methodology

Shukla Neha, Neelancherry Remya*

Indian Institute of Technology, Bhubaneswar, Odisha 752050, India

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ABSTRACT

This scientific data article is related to the research work entitled "Optimization of bio-oil production from microwave co-pyrolysis of food waste and low-density polyethylene with response surface methodology" published in "Journal of Environmental Management" (10.1016/j.jenvman.2021.113345). In this work, collection of Food Waste (FW) and Low-density polyethylene (LDPE) for 7 consecutive days and its characterization was done. Based on the characterization, the composition of simulated FW was fixed for different experimental runs. Valorization of feedstock (FW and LDPE) with increasing temperature with/without the presence of microwave susceptor was analyzed. Statistical significance of LDPE and microwave susceptor addition on bio-oil yield and Total Acid Number (TAN) was verified with single-factor ANOVA. The outcomes of the present dataset will be helpful for the researchers and engineers working in the field of bio-oil generation from microwave co-pyrolysis of mixed waste.

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* Corresponding author at: Indian Institute of Technology, Bhubaneswar, Odisha 752050, India
E-mail address: remya@iitbbs.ac.in (N. Remya).

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Specifications Table

Subject	Solid Waste Management
Specific subject area	Thermal conversion of waste; bio-oil production
Type of data	Table Figure
How data were acquired	• Food waste (FW) and Low-density polyethylene (LDPE) were subjected to microwave pyrolysis/co-pyrolysis to generate bio-oil. • Granular activated carbon (GAC) was added to improve the heating rate and volatilization of feedstock (FW and LDPE).
Data format	Data raw and processed
Parameters for data collection	• Samples condition: Collection of heterogenous FW was done for 7 consecutive days, and its characterization was done. Based on it, simulated FW has been prepared for the microwave co-pyrolysis/pyrolysis process. Before the pyrolysis, the feedstock (simulated FW and LDPE) was dried (moisture content ~7 wt.%) and shredded (size < 5 mm). • The Thermogravimetric analysis (TGA) was done at the heating rate of 20 °C/min under an inert atmosphere (nitrogen flow rate of 20 mL/min). The changes in mass and temperature of feedstock with time were recorded during the ramping operation to obtain the relevant dataset. • The microwave co-pyrolysis was conducted with grounded and thoroughly mixed feedstock. Before the process, nitrogen gas was purged for 20 min at the rate of 1 L/min to create the inert atmosphere, and during the co-pyrolysis process, the gas flow was maintained at 0.25 L/min. The microwave power was set at 800 W, and the response surface methodology was performed to optimize the operating conditions (400-700 °C of temperature, 3-10 s of residence time at set temperature, and 0-25% of LDPE in feedstock). • The maximum bio-oil yield (42 wt.%) with the low total acid number (TAN, 17 mg KOH/g of bio-oil) was obtained at the optimum operating condition of 550 °C temperature, 7 s residence time, and 13% LDPE in the feedstock.
Description of data collection	• Feedstock characterization: Thermal degradation capability of feedstock was analyzed with proximate, ultimate, and higher heating value (HHV) analysis. • Thermogravimetric analysis (TGA): The changes in mass and temperature of FW, LDPE, and their mixture (13% of LDPE in the feedstock) with time were recorded during the ramping operation to analyze the thermal degradation behaviour. • Heating profile: The temperature profiles of FW, LDPE, and their mixture (13% of LDPE in the feedstock) were analyzed to set the heating time for the microwave co-pyrolysis process. • Statistical analysis: Single-factor ANOVA was performed to analyze the significance of LDPE and GAC addition in the feedstock to increase the bio-oil yield and decrease the TAN. • Phase separation: Storability and stability of bio-oil were observed with phase separation analysis.
Data source location	Institution- School of Infrastructure, IIT Bhubaneswar, Argul, Odisha City- Bhubaneswar Country- India
Data accessibility	Raw dataset for optimization of bio-oil production from microwave co-pyrolysis of food waste and low-density polyethylene, https://doi.org/10.17632/9nprb674b5.3, [9]
Related research article	S. Neha, N. Remya, Optimization of bio-oil production from microwave co-pyrolysis of food waste and low-density polyethylene with response surface methodology, Journal of Environmental Management, 297 (2021) 301–4797. https://doi.org/10.1016/j.jenvman.2021.113345.

Value of the Data

- The manuscript presented the raw data obtained during the microwave co-pyrolysis of heterogenous FW. The data consisted of the composition of simulated FW used in the experiments and its comparison with the FW collected from a residential area for 7-days.
- The dataset would provide insight into selecting the heating time and temperature range to generate a high bio-oil yield from the microwave pyrolysis/co-pyrolysis process.
- The dataset is useful to represent the effect of LDPE and GAC addition in the feedstock to achieve high bio-oil yield and low TAN via single-factor ANOVA. This statistical model is valid under the following operating conditions range: LDPE percentage in feedstock- 0 to 25%, residence time- 3 to 10 s, and temperature- 300 to 700 °C with 4.8-8.1% of the error range.
- The applicability of the dataset can be projected to commercialize the microwave co-pyrolysis plant to generate higher efficiency of waste to bio-oil conversion at optimum operating conditions.

1. Data Description

The feedstock used in the dataset comprised FW (primarily composed of rice and vegetables) and LDPE. For 7 consecutive days, FW and LDPE were collected from a residential area of the Indian Institute of Technology Bhubaneswar, India. Plastic bags used for the collection of FW was used as LDPE representative. The FW was collected for 7- days and analyzed for proximate, ultimate, and higher heating value characteristics (Table 1). It was observed that the FW has variation in its composition; hence, to maintain the uniformity, simulated FW was used in this dataset [1–3]. The properties of simulated FW were comparable to that of the average of the collected FW (Table 1).

As LDPE is transparent to microwave and FW is a poor microwave absorber with a low loss tangent (tan δ, 0.0001- 0.22) [4], GAC (6 wt.%) was added as a microwave absorber to enhance the microwave absorbance of the feedstock and to increase the heating rate in order to generate maximum volatiles in the form of bio-oil. Thermal degradation behaviour of FW and LDPE and their combination with optimum ratio (87:13) is presented with thermogravimetric analysis (TGA) (Fig. 1). Fig. 2 represented the change in the weight of FW, LDPE, and their mixture (13% of LDPE in the feedstock) as a function of temperature. Fig. 3 showed the temperature profile of FW, FW and LDPE with/without microwave susceptor with pyrolysis time during microwave irradiation. The data of the single-factor ANOVA test is presented in Table 2. Fig. 3 showed the phase separation in bio-oil due to repolymerization and condensation of volatiles.

Table 1
Properties of collected and simulated FW.

Parameter	Collected FW (7-days average)	Simulated FW
Moisture content (wt.%)	63.5±10.0	70.0±5.0
Volatile matter content (wt.%)	85.0±5.0	86.5±2.5
Ash content (wt.%)	1.7±0.7	2.3±0.2
Fixed carbon (wt.%)	10.0±2.3	11.2±0.1
Carbon (wt.%)	43.0±5.1	41.1±3.2
Hydrogen (wt.%)	5.15±0.22	6.24±0.15
Nitrogen (wt.%)	1.84±0.08	2.68±0.05
Sulfur (wt.%)	0.35±0.05	0.48±0.02
Oxygen (wt.%)	45.5±5.2	49.5±2.3
HHV (kJ/kg)	12862±50	13167±42

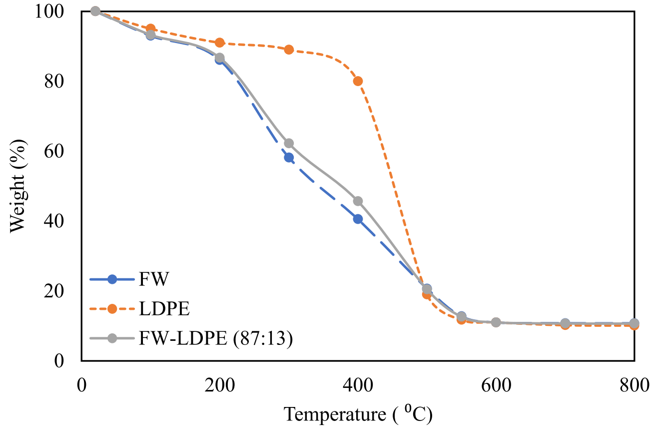

Fig. 1. TGA of FW, LDPE, and their mixture.

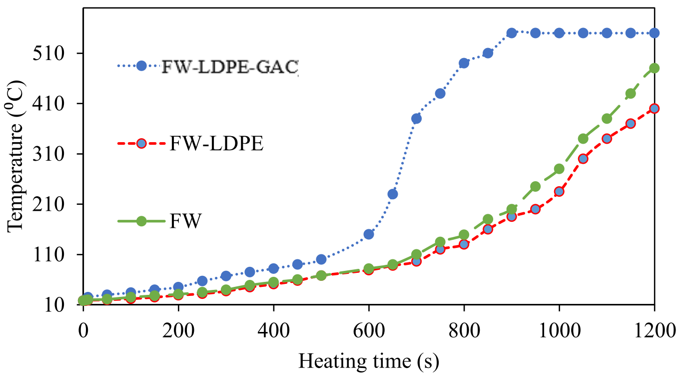

Fig. 2. Temperature profile of feedstock at different conditions.

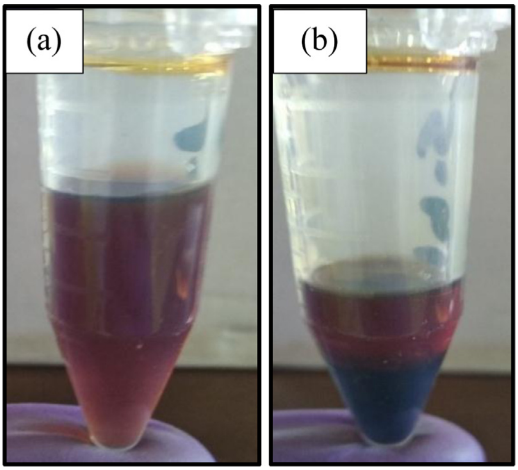

Fig. 3. Phase separation in bio-oil with time (a) 0 day (b) 15 days.

Table 2
Single-factor ANOVA for bio-oil yield and TAN with/without LDPE and microwave susceptor.

	Bio-oil yield				TAN			
Feedstock	Average yield (wt.%)	Variance	Mean square	p-value	Average value (mg KOH/g of bio-oil)	Variance	Mean square	p-value
FW-LDPE	31.2	0.125	25	0.024	45.39	0.30	156.37	0.0016
FW-LDPE-GAC	42.3	0.245	123.21	0.001	17.52	0.55	776.45	0.0005

The assumed system boundary included drying, grinding, pyrolysis, and quenching (cooling) of the end products with the following assumptions.

- The collected FW for 7 days did not contain any household inert materials.
- The simulated FW represented the average composition of collected FW.
- Microwave caused the rapid and uniform heating of feedstock.
- A minimum error was assumed during the bio-oil collection and TAN calculation.

2. Experimental Design, Materials and Methods

2.1. Materials

The feedstock used in this dataset comprised FW and LDPE. The FW was collected from a residential area, whereas the plastic bag used for FW collection was used as LDPE. GAC, isopropanol, and KOH used in this dataset was of analytical grade and procured from Sigma Aldrich, India.

2.2. Methods

1. The characterization of FW and LDPE (Proximate analysis by APHA, 2012; ultimate analysis by Elemental analyzer, Euro Vector EA3000, Germany; HHV analysis by Bomb calorimeter, Rajdhani Co. Lim, Model RSB-5, India) and microwave co-pyrolysis reactor (Ragatech, India) description and experimental procedure was done following the previously published procedures [5,6].
2. Before the microwave co-pyrolysis process, nitrogen gas was purged for 20 min at the rate of 1 L/min to create the inert atmosphere. Later, during the co-pyrolysis process, it was maintained at 0.25 L/min.
3. 50 g of the feedstock with different FW-LDPE ratios and GAC was taken in the quartz vessel inside the microwave chamber and pyrolyzed at 400- 700 °C of temperature. After reaching the desired temperature, the residence time of 3- 10 s was provided based on the previous literature, showing maximum bio-oil yield within 0.5– 10 s [7,8].
4. Subsequently, bio-oil and biochar were weighed and expressed as weight percentages to that of feedstock, whereas pygas was calculated using the mass balance method.
5. 20 mg of FW with/without LDPE (13% in the feedstock) and microwave susceptor was placed inside thermogravimetric analyzer, Q50 V20.13 Build 39, USA under a nitrogen atmosphere for TGA.
6. To analyze the heating rate of feedstock at different conditions, the temperature profile of feedstock was recorded with the help of a non-contact IR thermocouple (Sensotronic System, India) during the microwave pyrolysis/ co-pyrolysis process.
7. Subsequently, the bio-oil yield and TAN dataset were obtained under different experimental conditions, which were statistically analyzed through single-factor ANOVA using MS-excel.
8. The bio-oil was stored at room temperature for 15 days and phase separation was visually observed and reported.

Ethics Statement

This article does not contain any dataset involving animals or human participants performed by any of the authors.

CRediT Author Statement

Shukla Neha: Draft preparation, Data analysis, and interpretation, writing; Methodology, Data collection, and Investigation, Writing – original draft preparation; **Neelancherry Remya:** Conceptualization, Writing – review & editing, Funding acquisition, Supervision.

Declaration of Competing Interest

Not Applicable.

Data Availability

Raw dataset for optimization of bio-oil production from microwave co-pyrolysis of food waste and low-density polyethylene (Original data) (Mendeley Data).

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Supplementary Materials

Not Applicable.

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