Optimal conditions determination for plastic wastes valorization using pyrolysis in a semi batch reactor

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Abstract

This study makes a global summary of our recent findings in the pyrolysis of different plastic waste using pyrolysis in a semi batch reactor. A set of operating conditions have been defined in order to train a neural network and finally determine optimal conditions of degradations.

Introduction

The production of plastic has grown promptly from 1.5 million tons in 1950–368 million tons in 2019, Plastics - the Facts(2020). The European plastic production was up to 57.9 million tons in 2019, and almost half of the produced plastic became waste Karayılan *et al.* (2021). Pyrolysis is considered a promising alternative to landfill disposal of waste plastic, which can simultaneously produce liquid oil similar to commercial fuels (gasoline and diesel) according to Al-Salem *et al.* (2021), Dai *et al.* (2021), Mazloum *et al.* (2021) and Wen *et al.* (2021).

Recently, we have studied severaltype of plasctic waste using a pyrolytic procees in semi batch reactor. A general summary of our studies is reported in this abstract.

Material and Methods

Semi Batch Reactor

The semi-batch reactor is favoured for plastic pyrolysis due to its convenience of operation. Thus, the plastic waste pyrolysis tests were carried out in a 200 mL lab-scale reactor. The initial weight of the samples were ~ 5 g in all test. Nitrogen (under the flow rate of 100 mL/min) purged the reactor for 30 min to exhaust oxygen before the start of each test. The heating rate and pressure were maintained at 6 °C/min and 0.1 MPa, respectively.

Artificial Neural Network (ANN) and Genetic Algorithm (GA)

A hybrid artificial neural network model coupled with a genetic algorithm (ANN-GA) was adopted to predict and optimize the plastic wastes pyrolysis product yields, oil components, and fractions. A general overview of the procedure is given in Figure 1.

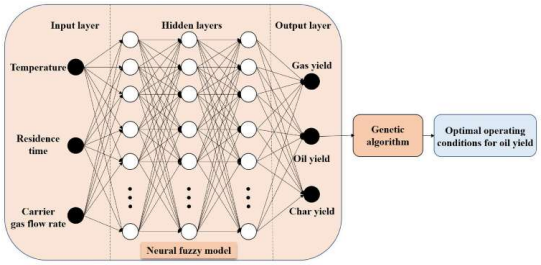

Figure 1 : The schematic representation of neural fuzzy model coupled with genetic algorithm

Results and Discussion

Optimal conditions for different plastic wastes and mixtures of plastics.

According to our previous studies [7-12], we have investigated plastic wastes pyrolysis with different operating conditions, such as temperature, residence time, carrier gas flow rate for instance. A general summary is given in Table 1. We use WPE, WPP, WPS and AC to represent respectively Waste PolyEthylene, Waste PolyPropylene, Waste PolyStyrene and Activated Carbon .

Table 1. plastic waste valorization with variable operating conditions

waste	Residence time	Carrier gas flow rate	temperature	reference
WPE	x	x	x	Pan *et al.* (2021-a)
WPP	x	x	x	Pan *et al.* (2022-a)

WPE/WPS	x	x	x	Pan *et al.(*2022-b)
WPE/AC		x	x	Pan *et al.* (2022-c)

Optimal conditions determination

Training the ANN and coupling it with an optimization procedure, we have determined for all of the preceding plastic wastes optimal conditions. Those are reported in Table 2 with the optimal experimental conditions.

Table 2. Optimal conditions for oil yield production depending on the plastic wastes and experimental parameters.

	Oil yield (% mass)	T (°C)	Q (ml/min)	t(min)	%PS	AC/WPE mass ratio
WPE/WPS	82,33	525	0	-	10	
WPE/AC	69,63	479	10	-		1
WPE	83,5	488	20	20		
WPP	68,4	456	50	20		

According to the operating conditions we clearly exhibit the good conversion of WPE in oil depending of the temperature T and carrier gas flow rate Q. effects of both the mixing of WPE and WPS in order to produce higher oil yield. Mixing WPE with WPS will lead to similar oil yield for 10% in mass of WPS. The main difference will be in the oil composition. Adding activated carbon will lead to a reduction in oil yield but this could result to a better selectivity index depending on the operating conditions. For WPP, the oil yield is the lower one reported here with a low sensitivity for the main functional groups on the operating conditions.

Conclusions

We have studied the degradation of different plastic wastes recently. Using a semi batch reactor, and varying the operating conditions, we have exhibited the dependence of the oil yield to Temperature, carrier gas flow rate and residence time.

In the full paper a comparison with oil composition will be also summarized depending on the plastic wastes, and operating conditions.

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