RECYCLING OF PLASTIC WASTE BY CO-PYROLYSIS WITH OLIVE RESIDUE IN AUTOCLAVE REACTOR

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Abstract

Solid wastes compromise biomass and plastics in terms of energy recuperation. Pyrolysis is the promising process in thermochemical conversions. In this study, co-pyrolysis of olive residue and high density polyethylene (HDPE) mixtures (50:50, w/w) was executed in autoclave reactor. Co-pyrolysis runs were performed using pyrolysis temperatures between 400 and 600 °C with heating rates of 2 to 20 °C/min to generate modified bio-oil-. It is interesting to note that the highest bio-oil yield was obtained at 500 °C with a heating rate of 10 °C/min. These bio-oil exhibited higher carbon and hydrogen contents, significantly lower oxygen contents, and lower water contents, acid values and viscosities than olive residue bio-oil.

Keywords: *Bio-oil; Co-pyrolysis; Olive residue; Plastic waste; HDPE*

1. Introduction

Plastics consumption has increased rapidly throughout the world. The rising cost of petroleum is increasing the price of both polymers and fuels, creating a huge opportunity to recycle these plastic wastes or convert them to fuels. Biomass/plastic co-pyrolysis offers one route to liquid fuels. Pyrolysis is a chemical recycling process that breaks organic macromolecules into small molecules at high temperatures in the absence of oxygen via free radical degradation pathways [1,2]. Biomass is a mixture of hemicellulose, cellulose, lignin and minor amounts of other organics which each pyrolyses or degrades at different rates and by various mechanisms and pathways. Lignin decomposes over a wider temperature range compared to cellulose and hemicellulose, which rapidly degrade over narrower temperature ranges, hence the apparent thermal stability of lignin during pyrolysis. The rate and extent of decomposition of each of these components depends on the process parameters such reactor (pyrolysis) temperature, biomass heating rate and pressure [3]. Polyolefins contain higher hydrogen and carbon content than biomass and no oxygen. Therefore, plastic/biomass co-pyrolysis may upgrade the bio-oil properties by increasing the carbon and hydrogen contents while reducing the oxygen present. The elemental content of polyolefin plastics contains more hydrogen (approximately 14% higher) and carbon than biomass. Therefore, plastics produce liquid products with higher hydrogen and carbon content than biomass thermal degradation products [3,4].
The objective of the research was reported here to produce upgraded bio-oil with lower oxygen and higher carbon and hydrogen contents by performing relatively fast, co-pyrolyses of plastics with the olive residue.

2. Materials and Methods

Olive residue was obtained from the solid product of traditional olive oil process (Maasra in Morocco). Air-dried olive residues were ground to obtain a uniform material of an average particle size (0.2 mm). The samples of HDPE were provided by Plador (Marrakech, Morocco). The OR:HDPE (1:1 mass ratio) mixture was blended by tumbling for 30 min in order to achieve homogeneity.
The co-pyrolysis experiments were performed in a 150 ml stainless steel autoclave reactor, with a sweep gas (nitrogen) connection. The autoclave is equipped a pressure release system limiting the pressure to a maximum of 300 bar. The reactor was heated externally by an electric furnace and the initial nitrogen gas pressure is 6 bar

3. Results and Discussion

3.1. Influence of the heating rate

Table 1 shows the yield of oil, gases and conversion from the pyrolysis of the olive residue, HDPE and their mixture (1:1) in relation to heating rate from 2 to 20 °C min^{-1} to a final pyrolysis temperature of 500 °C in the autoclave reactor. It can be seen that there was an increase in oil from 2-10 °C min-1 after which the yield of oil decreased as the heating rate was increased to 20 °C min^{-1}. The yield of the conversion and gases increased progressively throughout as the heating rate increased from 2 to 20 °C min^{-1}, while there was a corresponding progressive decrease in char.

Table 2: Effect of heating rate on product yields at temperature of 500 °C.

Heating rate (°C/min)		2	5	10	15	20
Olive residue	Conversion	64.3	65.5	66.4	67.5	68.6
	Oil	42.9	43.8	45.6	45	43.8
	Gas	21.4	21.7	21.9	22.5	24.8
HDPE	Conversion	97.3	98.4	99.3	99.4	99.6
	Oil	88.6	88.5	88.3	87.8	87.4
	Gas	8,7	9,9	11	11,6	12,2
Olive residue -HDPE	Conversion	85,8	86,95	87,85	88,45	89,1
	Oil	72,75	73,15	73,95	73,4	72,6
	Gas	10,35	11,1	11,2	12,35	13,8

3.2. Influence of the pyrolysis temperature

In the second group of experiments performed in the autoclave, for pyrolysis temperature between 400 and 600 °C at a heating rate of 10 °C min^{-1}, the product yields of pyrolysis of the sugarcane bagasse in relation to the temperature are given in Table 2.

At the lowest pyrolysis temperature examined of 400 °C, the oil yield was low, this data reflecting incomplete pyrolysis. As the temperature was increased the oil yield increased until it reached a maximum at 500 °C, after which there was a decrease in oil yield at 600 °C. There was a progressive increase in conversion and gas yield and conversion degree from 400 °C to 600 °C, while the char decrease as the temperature of pyrolysis increased.

Table 2: Effect of temperature on product yields at heating rate of 10 °C/min.

Temperature (°C)		400	450	500	525	550	600
Olive residue	Conversion	61,2	64,4	66,4	67,1	67,4	67,7
	Oil	41,4	43,8	45,6	45,3	45	43,8
	Gas	20,9	21,7	21,9	22,9	23,5	24,9
HDPE	Conversion	93,9	95	99,3	99,6	99,7	99,7
	Oil	85	85,6	88,3	86,1	84,2	82,1
	Gas	8,9	9,4	11	11,7	13,4	16
Olive residue -HDPE	Conversion	84,15	84,75	87,95	88,85	89,45	91,55
	Oil	71,45	71,85	73,95	74,85	70,55	70,45
	Gas	9,9	10,1	11,2	11,2	16,1	18,3

4. Conclusions

At a reactor bed temperature of 500°C with a heating rate of to 10 °C/min, an oil yield of 73,95wt% of dry feed was obtained for the mixture of olive residue and HDPE. The pyrolysis process temperature was found to have influenced on the product yields. The results show that co-pyrolysis of olive residue and HDPE is a good option for producing bio-oils to be used as alternative to petroleum fuels and valuable chemical feedstocks.

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