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Fast Pyrolysis oil from plastics waste as a Fuel for Gas Turbine Power Plants

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ABSTRACT: *Plastic production and usage increase every year due to its low cost, practicality, and flexibility. Despite the advantages of plastics as a raw material, it represents a serious environmental problem when it becomes waste. Most of the plastic is produced from petrol. Its chemical composition provides the opportunity to be transformed into a fuel via a pyrolysis process, with or without a catalyst. The pyrolysis process yields solid, liquid and gas fractions. The liquid fraction has properties similar to those of conventional fuels and can be used in internal combustion engines. However, although fast pyrolysis is cheaper, it produces lower quality products (longer carbon chains) not suitable for these types of engines. In the present paper, main properties of oils from fast pyrolysis are analysed and compared to those of Heavy Fuel Oils (HFO) to demonstrate that they represent a feasible alternative to decrease the impact of plastics in the environment and to obtain an alternative fuel to feed a power plant.*

Materials and methods

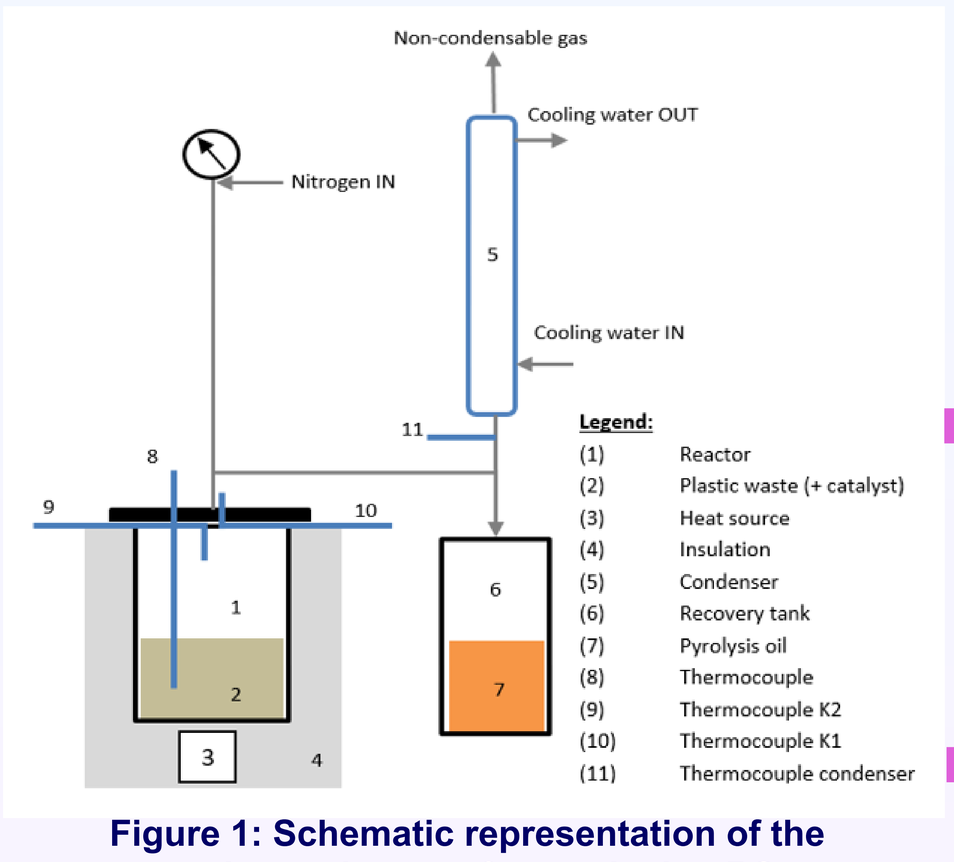

Figure 1: Schematic representation of the experimental set-up for producing POs.

Solid plastic waste → Elemental composition: 0.23% N, 87.23% C, 13.67% H, and 0.03% S
HHV: 46.14 MJ/kg.

Sample preparation → Cut 100 g of solid HDPE plastic into smaller pieces of approximately 2 cm^2.

HDPE
(thermal pyrolysis set at 430°C ± 15°C)

HDPE + Z
(catalytic pyrolysis set at 400°C ± 15°C)

Characteristics of zeolite used	
SiO_2/Al_2O_3 [mol/mol]	13
BET surface area [m^2/g]	540
Na_2O [wt %]	0.13
Average particle size D50 [μm]	2.25
Pore volume [cm^3/g]	0.1
Pore width [nm]	4.4

Results

	YIELD (wt %)		
	Liquid	Gas	Char
HDPE	74,89	15,11	10
HDPE+Z	54,80	35,20	10

	HFO [1] % by mass		HDPE % by mass		HDPE+Z % by mass	
ELEMENTAL COMPOSITION	%C	85.1	%C	85.5	%C	79.4
	%H	10.9	%H	13.1	%H	12.4
	%S	4.0	%S	0.09	%S	0.11
	%N	0.0	%N	0.22	%N	0.26
Density (kg/m^3)	970		770.4		778.7	
HHV (MJ/kg)	41.83		46.35		45.15	

The GC-MS results from POs obtained, with and without a catalyst, have been analysed and classified into the categories illustrated in Figure 2.

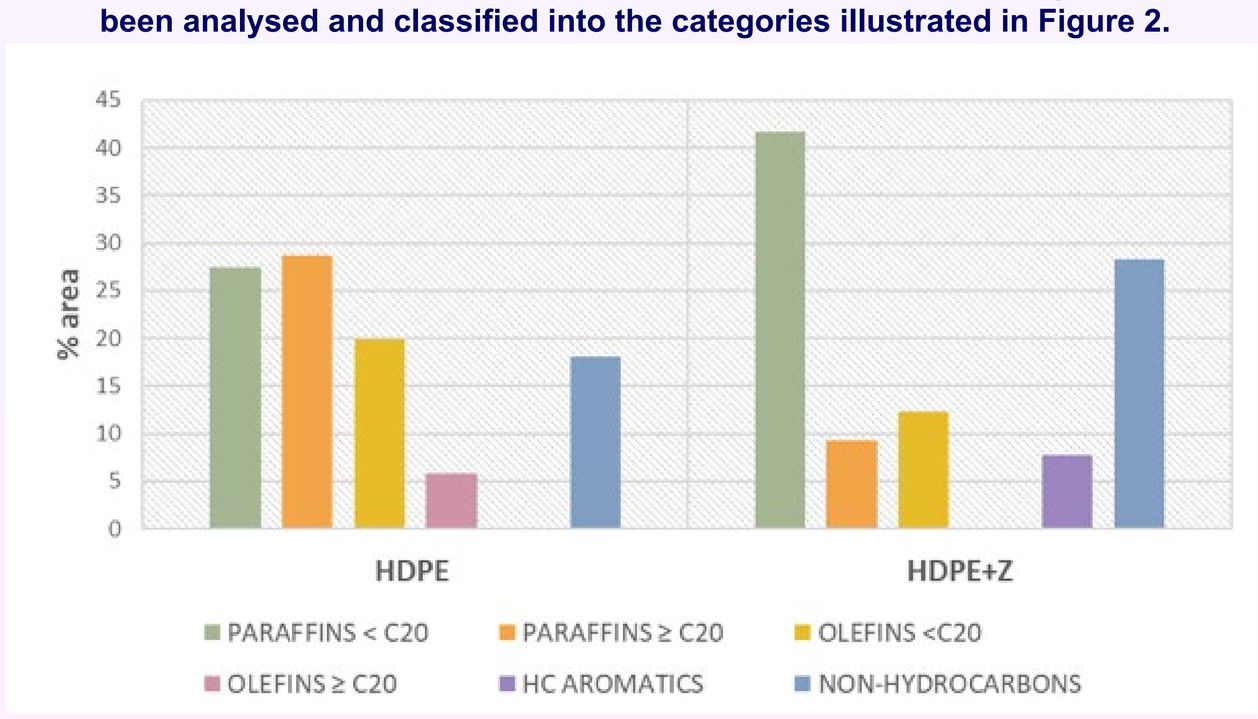

Figure 2.

CONCLUSIONS:

HDPE

- It does not contain aromatic hydrocarbons and, therefore, neither polycyclic aromatics, which are harmful to human health.
- Fast thermal pyrolysis yields a significantly greater amount of liquid product but with poorer quality (higher content of double and triple bonds and carbon chains C ≥ 20, wax at room temperature). However, the properties of this product are closer to those of HFO.
- It does not contain heavy metals that damage the appropriate turbine operation. Altogether, non-hydrocarbons different from oxygenates account for less than 1%, and they contain N2, F, and Si.
- Chlorinated components are not found.
- Elemental composition is more similar to HFO compared to the HDPE+Z sample.

HDPE + Z

- The presence of heavy metals is detected. Non-hydrocarbons different from oxygenates account for more than 19%, and they contain N, Cl, Si, S, and Br.
- There are 2.72% of polycyclic aromatic hydrocarbons.
- The cracking of carbon chains is better (higher % of olefins and paraffins < C20), which emerges from the use of the catalyst.
- The %C of its elemental composition is significantly less than in HFO.

[1] Faisal, S. H., Naeem, N. K., & Jassim, A. A. (2021, February). Energy and exergy study of Shatt Al-Basra gas turbine power plant. In Journal of Physics: Conference Series (Vol. 1773, No. 1, p. 012020). IOP Publishing.