Concept process design of Low-density polyethylene (LDPE) pyrolysis using Aspen Plus®

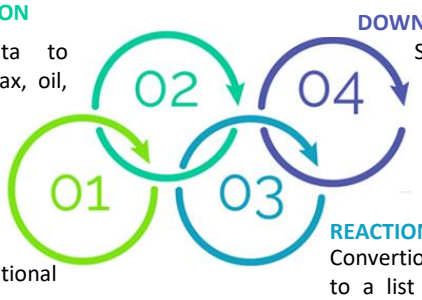
INTRODUCTION

Plastic materials play important role in modern society due to their desirable properties, but they also contribute to solid waste accumulation. Thermochemical conversion of polymers such as pyrolysis is promising to recover energy and generate new products. Pyrolysis is a thermal degradation process in absence of oxygen, obtaining Oil, WAX, Gas, and Char as products. The goal of this project is the concept design of a separation process of the low-density polyethylene (LDPE) pyrolysis products by the fractional cooling system.

METHODOLOGY

MATLAB SIMULATION
Used kinetic data to obtain yields of wax, oil, gas and char.

DOWNSTREAM ASPEN PLUS®
Separation of the phases.



TGA AND Py-GCMS ANALYSIS
Kinetic and compositional data to each phase.

REACTION ASPEN PLUS®
Convertion of MATLAB yields to a list of components to each phase.

Figure 1 – Project flow

Pyrolysis products classification: Char is considered solid carbon, Oil is a mix of 21 componentes C_7-C_{22}, WAX is a mix of 11 componentes C_{22}-C_{41}, and the Gas is a mix of 16 components. The composition of the main components in pyrolysis product is shown in Figure 2.

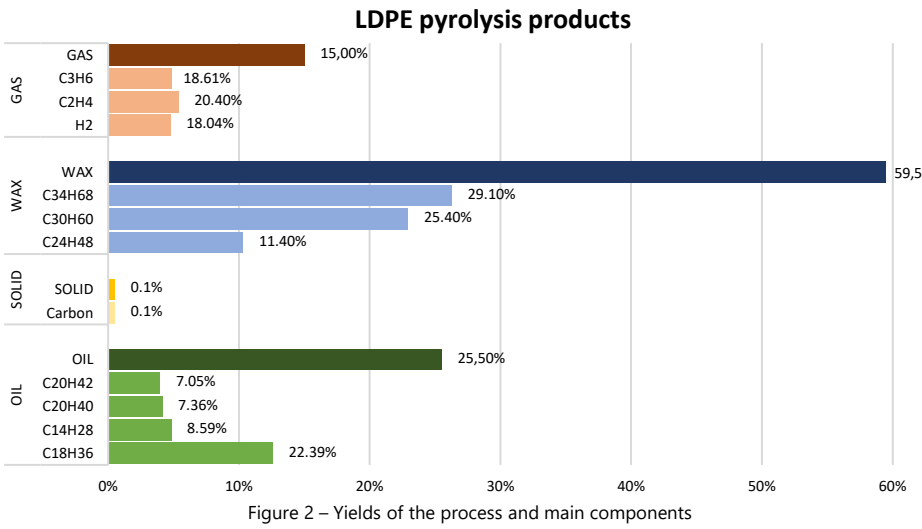


Figure 2 – Yields of the process and main components

Properties: The properties such as HT of formation (DHFORM) and FREE energy of formation (DGFROM) were estimated using Joback or Benson method in Aspen Plus®. UNIFAC was used as the themodynamic method, and CH_4 and H_2 were considered Henry components.

Process: The Process Flow Diagram (PFD) was created using Aspen Plus® (Figure 3) using yield reactors to specify the composition of the components after LDPE pyrolysis at 500 °C and 1 bar for 30 min.

RESULTS AND DISCUSSION

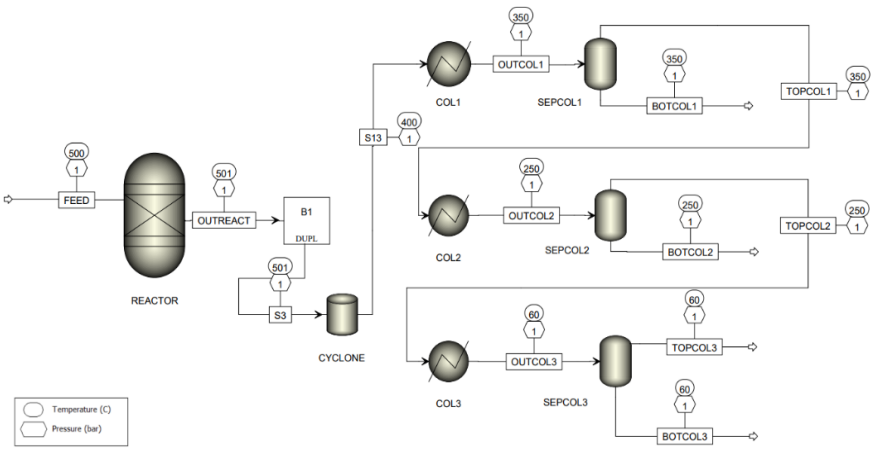


Figure 3 – PFD of the LDPE pyrolysis

Table 1 shows the composition of the key streams. Oil with 76.35% purity is obtained in the bottom stream flow of Cooler 3 in which 85% of the wax present are light wax components (C_{22} < WAX_{light} < C_{25}).

Table 1 – Stream results

	%OIL	%WAX	%CHAR	%GAS
COOLER 1 - TOP	41.68	33.01	0.0245	25.31
COOLER 1 - BOT	2.07	97.83	0	0.07
COOLER 2 - TOP	53.83	10.75	0	35.87
COOLER 2 - BOT	13.83	85.99	0	0.18
COOLER 3 - TOP	20.25	0.03	0	79.72
COOLER 3 - BOT	76.35	18.19	0	5.47

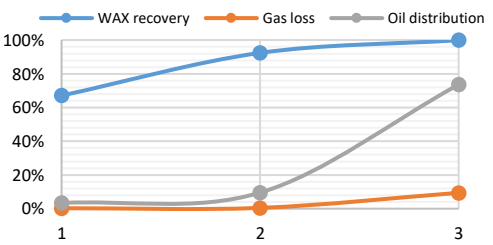


Figure 4 – Stream analysis

Figure 4 presents the recovery of wax of almost 100% and 9.37% of the gas is lost during the cooler process as liquid. The oil distribution shows that 3.32% and 9.49% of the oil is lost as bottom stream flow.

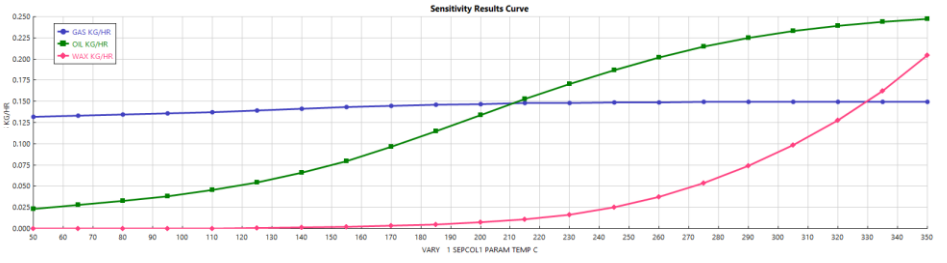


Figure 5 – Top stream flow using just one Cooler

CONCLUSION AND RECOMMENDATIONS

The system is eficient to recover oil (83.3%) and WAX (99.9%). Gas phase could be improved. The simulation can be optimized for a desirable phase or to recover a specific component by changing process conditions or exploring another operational process/equipment.

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