Entrained Flow Gasification Characteristics of Plastic Waste Pyrolysis Oil

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Plastic is convenient to manufacture and use, and its demand is steadily increasing. As plastic production increased from 234 million tons in 2000 to 460 million tons in 2019, plastic wastes also increased 126% over the same period from 156 million tons to 353 million tons globally (Lee, 2022).

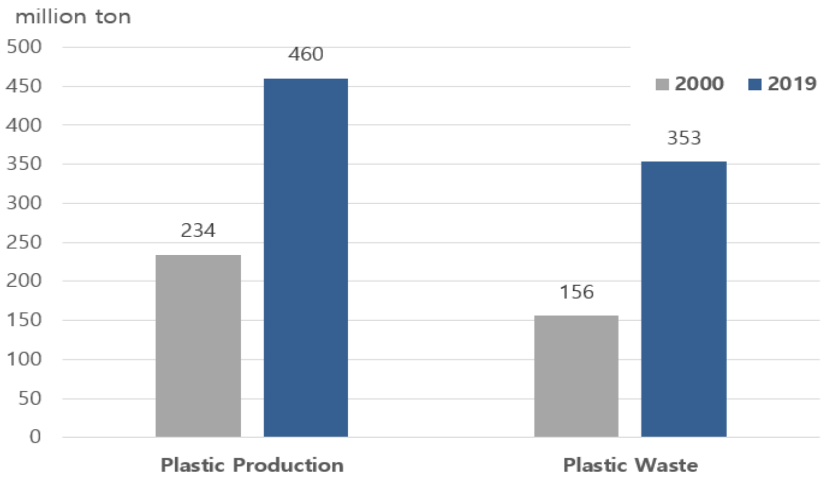

Figure 1. Global plastic production and waste generation

Pyrolysis is widely used as a way to effectively dispose of plastic waste. However, the conventional pyrolysis process for waste plastics produces a large amount of impurities such as chlorine or sulfur, which requires additional processes such as dechlorination and desulfurization to reform the pyrolysis oil for the NCC (Naphtha Cracking Center) to produce regenerated plastics. In order to know the composition of plastic waste pyrolysis oil, it is necessary to know the composition of plastic waste as a raw material.
Table 1 shows the concentration of metal and halogen contaminant according to the type of plastic waste (Roosen et al., 2020). In case of multilayer films containing PVC, high amount of CI was detected.

Table 1. Concentration of metal and halogen contaminant

	PET bottle [ppm]	**PET trays [ppm]**	**PE bottles [ppm]**	**PP bottles [ppm]**	**PP trays [ppm]**	**PS trays [ppm]**	**Monolayer films [ppm]**	**Multilayer films [ppm]**
Co	1.1	0.9	<LOD	0.1	0.2	0.1	0.1	0.1
Cr	0.3	0.4	0.3	0.1	1.3	0.4	0.7	1.0
Mn	0.3	1.2	0.7	0.7	1.0	1.0	2.8	1.3
Li	.1	1.1	1.6	2.0	1.5	2.6	1.1	.3
Sr	1.3	6.1	3.4	11.3	1.7	9.1	3.9	5.6
Sb	39.9	96.0	<LOD	0.7	0.2	2.0	0.3	7.8
Cu	7.7	3.3	8.8	3.2	82.7	7.8	21.4	40.4
Ti	3.5	4.8	8.1	31.0	46.6	21.2	35.4	39.3
Mg	9.4	34.3	31.7	46.5	186	75.6	32.4	51.4
Fe	11.9	29.5	13.6	15.4	270	24.3	37.5	27.5
Zn	3.0	11.1	7.7	5.1	39.2	45.6	28.1	33.4
Na	42.7	61.7	145	130	29.3	152	90.7	108
Al	81.1	205	228	247	145	117	236	455
Ca	334	2131	1127	1642	1348	1471	678	2770
F	0.6	<LOD	20.2	0.6	<LOD	<LOD	45.8	36.8
Cl	302	383	132	214	229	269	466	2904

This problem can be solved by injecting pyrolysis oil into the entrained bed gasification system. Entrained flow gasification enables effective removal of impurities in the gas phase through gas refining with simple removal processes. In this study, an entrained flow gasification system was constructed on a lab-scale (1kg/h) to investigate the gasification characteristics of plastic waste pyrolysis oil as shown in Figure 2.

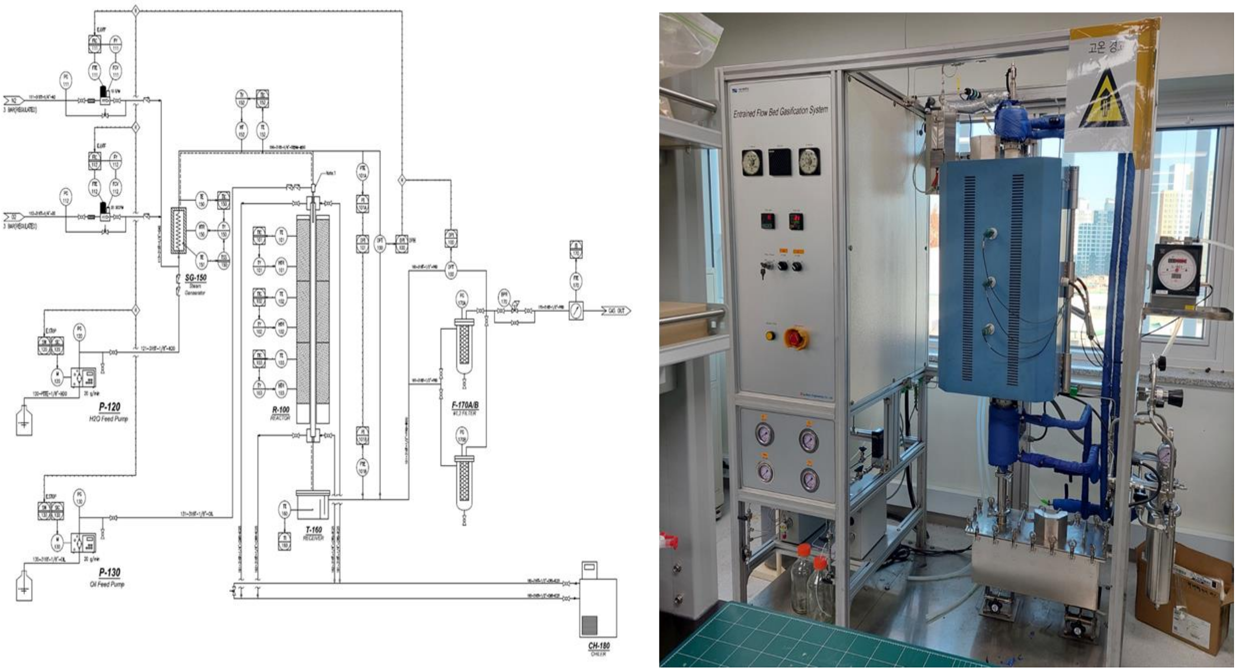

Figure 2. P&ID (left) and picture (right) of entrained flow gasifier

The plastic waste pyrolysis oil contains 0.115 wt% of water and 0.02 wt% of Cl. The LHV of plastic waste pyrolysis oil is 10,150 kcal/kg. The operating variables are the O_2/fuel ratio varied in the range of 1.1 to 1.3, steam/fuel ratio of 0.4 and the temperature of 600 - 1000 ^{o}C. The carbon conversion increased with O_2/fuel ratio. As the gasification temperature increased, the carbon conversion and the cold gas efficiency were found to increase.

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