AIR GASIFICATION OF MIXED PLASTIC WASTES USING A TWO-STAGE GASIFIER FOR THE PRODUCTION OF A PRODUCER GAS WITH LOW TAR AND A HIGH CALORIC VALUE

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Abstract

Air gasification was conducted with a fraction of mixed plastic wastes in a newly developed two-stage gasifier. In this work, the influence of equivalence ratio on the producer gas composition and tar removal were investigated. In addition, the effects of activated carbon and dolomite were also examined. At an equivalence ratio of 0.21, a very clean producer gas was obtained with a LHV of 13.44MJ/Nm^3. Activated carbon showed a better tar removal efficiency than dolomite. The amount of additive had significant effects on the tar removal efficiency and hydrogen production. When 640 g of activated carbon was applied, the total tar production was about 2.5 times less and H_2 production 2 times higher than without activated carbon.

Keywords: *Air Gasification; Mixed plastic wastes; Tar; Two-stage gasifier; Activated carbon*

1. Introduction

The traditional ways of plastic wastes disposal have been to either bury or burn them in landfills and incinerators, respectively. Landfills and incineration, however, are associated with serious environmental problems.[1]. Plastics recycling can be divided into three methods: mechanical recycling, feedstock (or chemical) recycling and energy recovery [2]. Feedstock recycling, which converts plastic materials into useful basic chemicals, has been recognized as an advanced technology process. Gasification is one example of these feedstock recycling technologies, which converts carbonaceous materials into a combustible gas, referred to as producer gas. Producer gas can be applied for heating and power generation. One main obstacle that needs to overcome with gasification is the problem associated with the production of tar. In particular, plastic gasification generates a huge amount of tar [3], which can cause environmental and operational problems. Fundamentally, there are two methods for the removal of tar: primary methods, where measurements are taken from the gasifier itself, and secondary methods, where measurements are taken downstream [4]. In the present study, a fraction of post-consumed mixed plastic wastes was gasified in a newly developed two-stage gasification process. This study aimed to create a producer gas with low tar and high LHV by applying additives in a newly developed two-stage gasifier.

2. Materials and Methods

Material. A recycling center in Korea provided a fraction of pellet-type post-consumed mixed plastic wastes. The feed material was firstly ground and successively sieved to obtain materials with diameters between 0.85-2 μm and 2-3.35 μm, respectively. In each experiment, 300 g of the feed material was applied.

Gasfier and experimental procedure Fig. 1 shows the gasification plant.

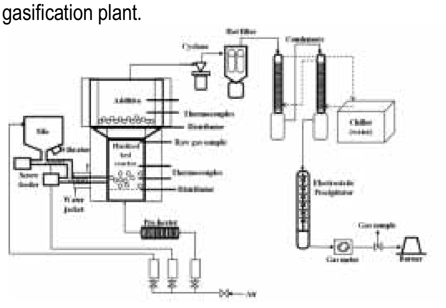


Figure 1. Schematic diagram of the two-stage gasification plant

The gasifier is divided into two parts; namely, the bottom reactor and the upper reactor, which are heated separately using electricity furnaces. The bottom reactor is filled with silica sand, which serves as a fluidized bed material. The upper reactor is filled with activated carbon or dolomite, which is used for tar cracking. The two reactors

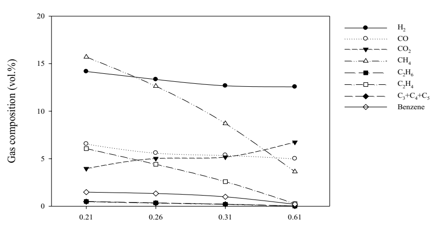
Reaction conditions. Table 1 shows the reaction parameters. Experimental Runs 1–4 were performed to investigate the effect of the ER. The results of Runs 1 and 5-9 were conducted to observe the effects of the amount of activated carbon or dolomite on the producer gas composition and tar removal. The results of Runs 8 and 9 were compared with Runs 1 and 6, respectively, to compare the effects of activated carbon or dolomite on the producer gas properties.

Table 1. Reaction conditions

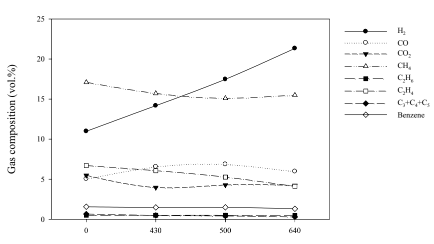
Parameter	Run1	Run2	Run3	Run4	Run5
Upper reactor (˚C)	806	800	803	804	797
Bottom reactor (˚C)	798	824	825	827	795
Feed rate (g/min)	7.14	5.77	4.84	2.4	7.31
ER	**0.21**	**0.26**	**0.31**	**0.62**	0.21
Additive(g)	**430**[a]	430[a]	430[a]	430[a]	**500**[a]
Parameter	Run6	Run7	Run8	Run9	
Upper reactor (˚C)	802	798	800	794	
Bottom reactor (˚C)	804	819	819	817	
Feed rate (g/min)	7.5	7.31	7.31	7.31	
ER	0.2	0.21	0.21	0.21	
Additive(g)	**640**[a]	**0**	**430**[d]	**640**[d]	

[a]: activated carbon [d]:dolomite

3. Results and Discussion



a)



b)

Fig. 2. Effects of (a) ER and (b) the amount of activated carbon on the producer gas composition.

In Fig. 2(a), with increasing ER, the variation in the H_2 concentration is not significant. The CO concentration decreases from 6.56 to 5.01 vol.% and that of CH_4 decreases steeply from 15.7 to 3.64 vol.%. In Fig. 2 (b), the most notable result is the increased H_2 production. The tar-cracking reactions produce hydrogen, and tar cracking can be enhanced by the presence of activated carbon.

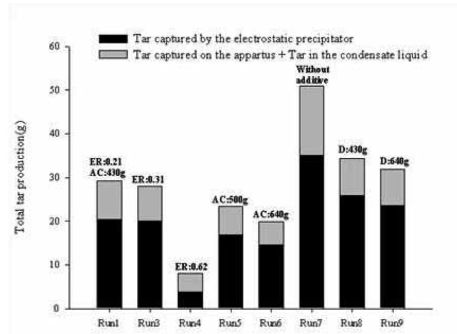


Fig. 3. Total tar yield at various ERs and with activated carbon (AC) and dolomite (D).

In Fig. 3, the following facts can be observed: 1) the total amount of tar rapidly decreases at higher ERs, especially at an ER of 0.62 (Run4), due to the strengthened oxidization reactions. 2) When the amount of activated carbon increases, the total amount of tar decreases steeply from 50.99 g (Run7) to 19.95 g (Run6), due to the strengthened tar adsorption followed by tar cracking. 3) The total amount of tar generated, when activated carbon is applied (Runs 1 and 6), is smaller than when dolomite is applied (Runs 8 and 9). Therefore, activated carbon seems to be more effective for tar removal than dolomite.

4. Conclusions

Air gasification of a fraction of mixed plastic wastes was conducted to yield a clean and high caloric producer gas. The maximum LHV of the producer gas was about 14.5 MJ/Nm^3. At higher ERs, an increase in the CO_2 concentration, and decreases in the concentrations of H_2, CO, CH_4 and hydrocarbons were observed. It was revealed that activated carbon was superior to dolomite for tar removal. The amount of additive was also an important factor for efficient tar removal. In addition to the reduction of tar, the use of activated carbon realized a high production of H_2.

References

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