INFLUENCE ON RAPID HYDROPYROLYSIS OF POLYETHYLENE BY COEXISTENCE OF COAL

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Abstract

Hydrogasification is a process to produce methane which substitutes natural gas from coal. It has been considered to diversify feedstock of hydrogasification other than coal. Waste plastics mixed with coal were seems to be suitable materials as a means of feedstock. Hydrogasification of polyethylene singly and a mixture of the coal and polyethylene (50:50) were carried out. Synergistic effect was observed when polyethylene was mixed with coal for raw materials, increasing in yield of methane. From the change in the temperature monitored inside the reactor, heat of reaction seemed to be dominant for the synergistic effect. Heat of exothermic hydrogenation of polyethylene may supplement the heat of endothermic pyrolysis of coal to enhance the overall reaction. In this study, the ratio of polyethylene and coal mixture was varied to clarify the mixing effect. The amounts of products were analyzed and reaction enhancement affected by mixing was discussed from the methane yield. As a result, synergistic effect was observed when the ratio of polyethylene and coal mixture was varied.

Keywords: *Rapid hydropyrolysis, Hydrogasification, Polyethylene, Coal, Mixture*

1. Introduction

Coal hydrogasification is a process to produce methane which substitutes natural gas. It has been considered to diversify feedstock of hydrogasification other than coal. Waste plastics mixed with coal were seems to be suitable materials as a means of feedstock. In a previous study, hydrogasification of polyethylene singly were carried out. As a result, a large quantity of methane and benzene were produced from polyethylene singly used. It was understood that polyethylene could be used as a raw material of hydrogasification. Hydrogasification of a mixture of the coal and polyethylene (50:50) were carried out. As a result, a large quantity of methane was produced. Therefore, it can be expected to produce methane in high efficiency when waste plastic and coal mixture is used as a feedstock for hydrogasification(1). From the change in the temperature monitored inside the reactor, heat of reaction seemed to be dominant for the synergistic effect. In this study, the ratio of polyethylene and coal mixture was varied to clarify the mixing effect. The change in polyethylene reaction by mixing with coal was discussed.

2. Materials and Methods

Japanese Taiheiyo coal (C 75.93, H 6.46, N 1.31, O+S 16.27 wt%(daf)), polyethylene, and those mixture were used for the samples. The amount of samples for coal singly (100:0) was 0.67g, polyethylene singly (0:100) was 0.61g, mixture (25:75) was mixed coal 0.17g and polyethylene 0.52g. Reaction experiment was carried out at 1073K under 7Mpa of hydrogen pressure. The reaction time was set at 1 second to 80 seconds.

In this study, a unique batch reactor was used for rapid hydrogenation(2). The reactor consist of threea main components, sample feeder, reaction chamber and gas reservoir. Prior to reaction, the sample was loaded in the sample tube and was kept at room temperature. The reaction chamber filled with gas for reaction atmosphere under the condition where the reaction pressure was preheated to the reaction temperature and the sample tube was driven into preheated chamber just before the reaction started. From the sample tube, the sample was blown into the reaction chamber and started the reaction. The reaction was started with blowing sample to reaction chamber after the sample tube was let down by air-cylinder. After a set time, the product gas was moved immediately to the gas reservoir. The gas production in the reservoir was determined and obtained a part of product gas by the syringe. The compositions of the product were analyzed with GC-TCD, GC-FID and GC-MS.

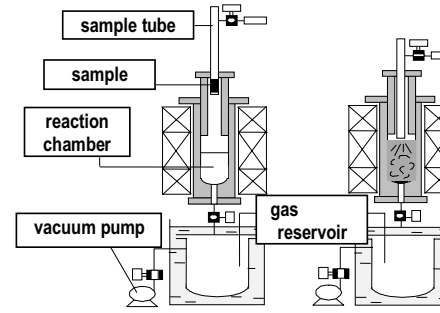

Fig. 1 Outline of apparatus

3. Results and Discussion

1.)Product distribution

Major products from coal and polyethylene mixture(25:75) by rapid hydropyrolysis experiment were methane, benzene, C_2H_X and C_3H_X. Product distribution as carbon conversion of major hydrogasification products from mixture (25:75) is shown in Fig. 2. Carbon conversion was calculated by dividing amount of carbon in each product by amount of carbon in the mixture(25:75). Methane increased linearly with reaction time. Benzene increased from 1 second to 20 seconds, following by decreasing to 80 second with convex upward. Their tendency is similar to those tendency with using coal singly or a mixture (50:50) as the samples[1].

2.)Synergistic effect on methane production

Comparison between experiment value of methan yield (○)and a predicted value are shown in Fig. 3. Dashed-dotted line "(0)" indicates values calculated on the assumption that synergistic effect isn't observed. Comparing experiment value with a predicted value, experiment value exceeds a predicted value in a whole time. This tendency is similar to a mixture (50:50). Therefore, synergistic effect was observed when the ratio of polyethylene and coal mixture was varied.

From the change in the temperature monitored inside the reactor, heat of reaction seemed to be dominant for the synergistic effect. Heat of exothermic hydrogenation of polyethylene may supplement the heat of endothermic pyrolysis of coal to enhance the overall reaction. Then, it was validated that the reaction of polyethlene is enhanced by mixing with coal. Another values ware calculated based on a hypothesis that only the reaction of coal is enhanced, the reaction of polyethylene isn't enhanced. Each dash line in Fig. 3 shows synergistic effect rate of the coal 0.4-1.0 are based on above hypothesis. "0.4" means 40% more methane produced from coal than "(0)". In the case of "1.0" as a same manner of calculation, all carbon in coal will convert to methane.

As a result, experiment value in 1 second indicated a value close to synergistic effect rate of the coal 0.9. Experiment value in 2 seconds indicated a value close to "0.8". Experiment value in 5 seconds indicated a value close to "0.6". Experiment value in 20 seconds indicated a value close to "1.0". But experiment value in 80 seconds exceeds a predicted value of synergistic effect rate of the coal 1.0. Synergistic effect rate of the coal 1.0 indicate a value calculated on the assumption that coal completely carbon conversion to methane. Therefore, it seems that the experiment value cannot be reproduced by above hypothesis. Not only coal reaction but also polyethylene reaction was suggested to be enhanced. Therefore, it could be understood that the reaction of polyethylene enhanced by mixing coal.

4. Conclusions

In this study, the ratio of polyethylene and coal mixture was varied to clarify the mixing effect. The amounts of products were analyzed and reaction enhancement affected by mixing was discussed from the methane yield. As a result, synergistic effect was observed when the ratio of polyethylene and coal mixture was varied.

Experiment values and predicted values baed on a hypothesis were compared. As a result, an experiment value exceeds a predicted value. It was suggest that not only coal reaction but also polyethylene reaction seemed to be enhanced.

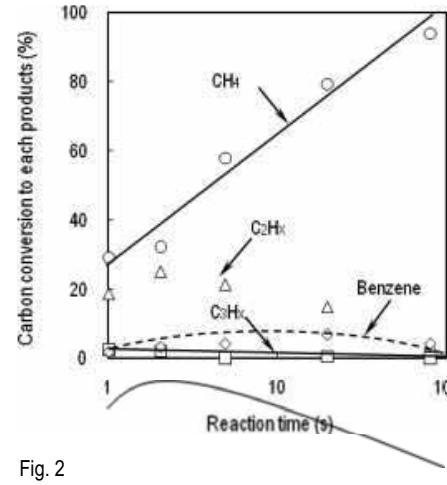

Fig. 2
Carbon conversion to major hydrogasification products from coal and polyethylene mixture[25:75].

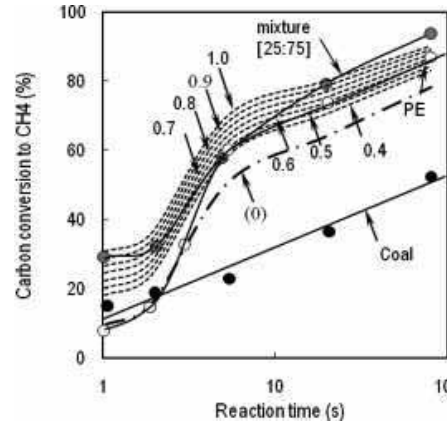

Fig. 3 Comparison between experiment value and predicted values synergistic effect rate of the coal 0.4-1.0.

References

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