STUDY ON THE RECYCLING TECHNOLOGY OF A SYNTHETIC POLYMER

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Abstract: The pyrolysis of waste polycarbonate resin using various solvents was studied. In the simple pyrolysis of resin of waste polycarbonate, the liquid product yield was 62wt%. However, in the pyrolysis using sodium hydroxide as a catalyst and propylene glycol as a solvent, the liquid product yield was 82wt%. Furthermore, in the pyrolysis using p-cresol and propylene glycol as solvents, the liquid product yield was 82wt% and was obtained in the lower temperature zone.

1. Introduction

Polycarbonate resin (PC) is an industrial plastic characteristic for its mechanical characteristics, weatherability and transparency and approximately 2,200,000t is used per year in the world [1]. Although it is thermoplastic resin, it is hard to decompose in a simple pyrolysis since it has carbonic ester combination in the main chain. It is difficult to recycle it since it generates many residual substances. Reinforcement materials and additives are mixed in according to purposes, recycling is difficult and it usually ends up in reclamation or incineration disposal.

With reference to researches to disassemble PC, studies to convert PC into monomers are under progress [1,2]. However, it there are problems of safety and cost performance since it requires high pressure and solvent in large quantities. This research aims to establish a recycling method by pyrolysis oil recovery under mild conditions from PC waste. Since PC has a nature to swell or dissolve in aromatic hydrocarbon, ester and ketone, decomposition by adding aromatic hydrocarbon, cresol contained in the wood tar which is reported to be effective in solubilization of the epoxy resin, whose structure of the organic solvent is similar, was considered [3].

2. Experiment

The sample is the waste of PC (SPC) 30% combined with reinforced glass filler which is actually in use. The experimental flow is shown in Fig.1. First, a reactor was filled with the sample and was heated in an electric tubular furnace after nitrogen substitution. Temperature was conditioned to hold the heating rate of 5 °C/min and the outside temperature of the reactor was increased up to 500 °C and was maintained for 10 minutes. The gas emitted by heating was cooled in the cooling tube. The liquid product was accumulated in the separating funnel, and a gasbag collected the gas product. Then the liquid product and gas product were analyzed using GC and GC/MS. The weight of the residue and liquid product was deducted from the weight of the sample, and it was considered as gas and other yields. The following experiment was conducted using 50g of sample, 50g of solvent, 0.2g of sodium hydroxide (NaOH). Also, mixed solvents were made using 25g of solvents respectively.

A pyrolysis experiment was conducted to check each solvent independently and the product yield rate of SPC was estimated from the product yield rate. Further, glass filler 30wt% was considered as residue, and the pyrolysis product yield rate of the PC among SPC which was the object of oilification.

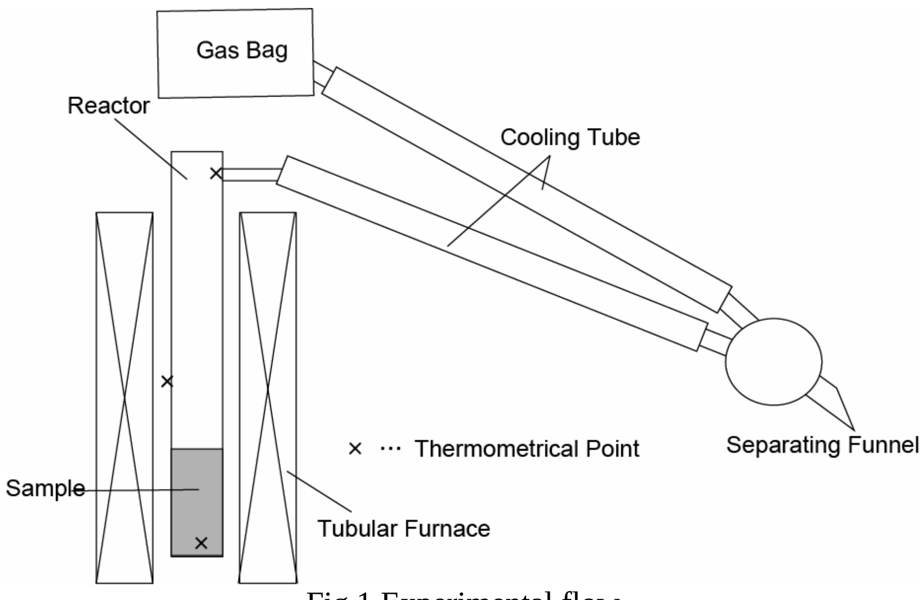

Fig.1 Experimental flow

3. Result and discussion

3.1 Pyrolysis using various solvents

The product yield of pyrolysis using various solvents is shown in Fig.2. Ethylene glycol (EG) had the highest liquid product yield and the low residual substance yield. They were approx. 74 wt% and approx. 8 wt% respectively. Next, the amount of accumulated recovery of the liquid product in accordance with the temperature change is shown in Fig.3. P-cresol (p-Cre) had the lowest temperature of 280°C when its accumulated liquid product amounted to 50g. Benzyl alcohol and Ethylene glycol had the amount of recovery increased at the temperature range of 350 to 400°C.

This result suggests that [guaiacol, p-cresol and xylenol] which are contained in wood tar, and [benzyl alcohol and ethylene glycol] have different decomposition mechanisms. The former relates to the low temperature of PC pyrolysis temperature region of SPC, and the latter has an influence over promotion of decomposition.

In the following paragraph, another experiment is described using glycol series as solvents because the solvent that most influenced the product yield was ethylene glycol. The aim is to clarify the decomposition mechanism. Also, p-cresol and the glycol series solvent that lowered the temperature of the pyrolysis temperature range of PC part were mixed and pyrolysis was performed.

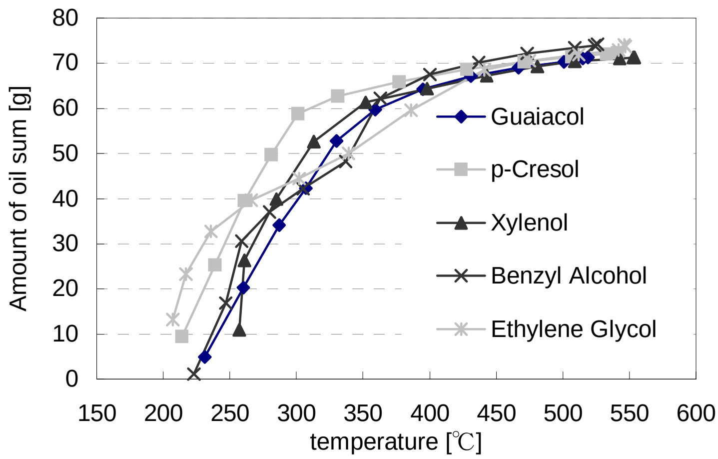

Fig.2 The product yield of pyrolysis using various

3.2 Pyrolysis using a glycol series solvent and a mixed solvent

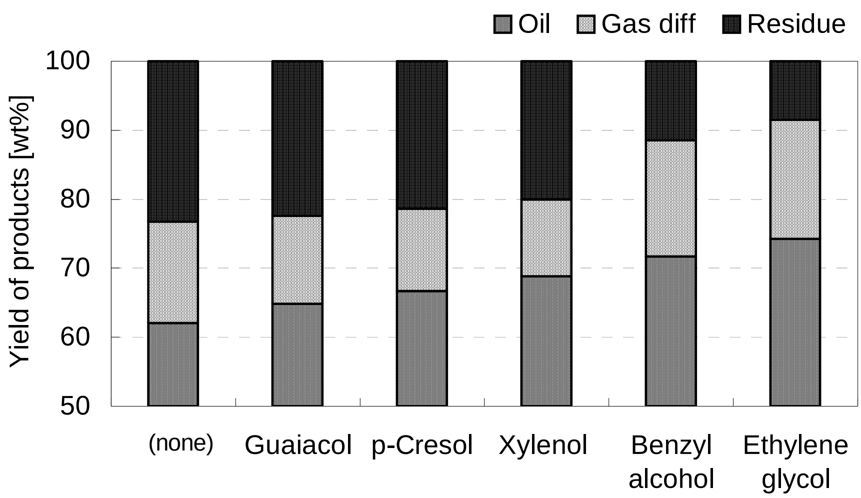

Fig.3 The amount of accumulation recoveries of the liquid product of pyrolysis using various solvents

The product yield of pyrolysis using a glycol series solvent and a mixed solvent is shown in Fig.4. Similar to ethylene glycol, diethylene glycol and propylene glycol (PG), compared with other solvents, had the effect f increasing the liquid product yield and reducing the residual substance yield. The mixed solvents increased the liquid product yield and decreased the residual substance yield compared with the solvent of a simple substance. Next, the accumulation recovery rate of the liquid product in a temperature change is shown in Fig.5. Although Ethylene glycol and diethylene glycol have the different the boiling points, they were similar in the recovery of liquid product. Also in a mixed solvent, there was an effect to lower the temperature of the pyrolysis temperature region of PC part of p-cresol.

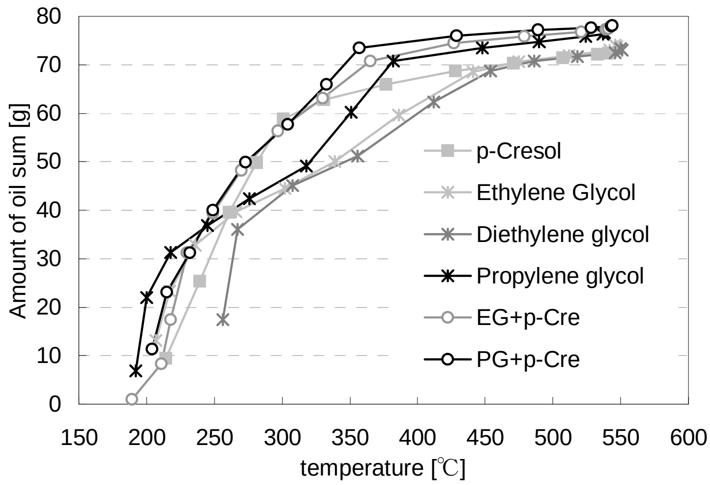

Fig.4 The product yield of pyrolysis using a glycol series solvent and mixed solvents

This result suggests that the glycol series solvent as well as EG has an effect of promoting the decomposition of PC part. Further, in the mixed solvent, it has the effects of [lowering the temperature of a pyrolysis temperature region] of PC part of p-cresol and [pyrolysis promotion] of PC part of a glycol series solvent. The influence on the decomposition is considered to be independent even though it is a mixed solvent.

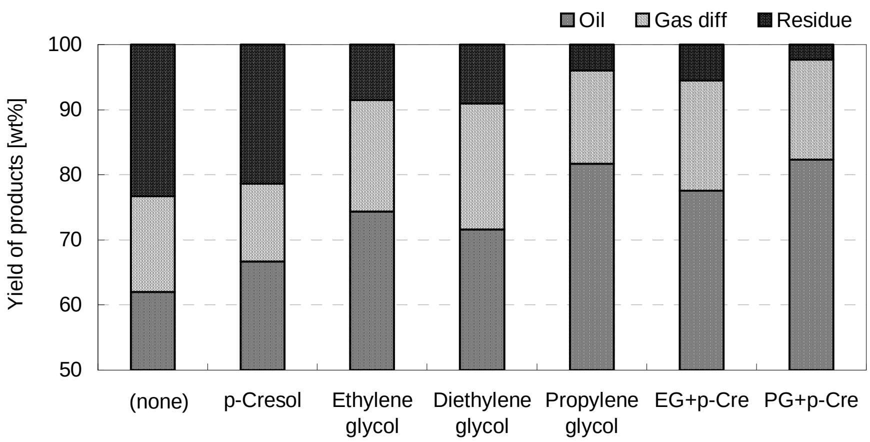

Fig.5 Amount of accumulated recovery of pyrolysis using glycol series solvent and mixed solvents

4. Conclusion

In this research, pyrolysis was performed using various solvents. Glycol series solvents has an effect of promoting the decomposition of PC and solvents such as p-cresol which is contained in wood tar had an effect of lowering the temperature at which PC was decomposed. Also the mixed solvent had both those effects and also achieved an improvement in a liquid product yield greater than the glycol series solvent alone.

References

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