

## CHEMICAL REACTION OF PHENOL RESIN FOAM POWDER AND PREPOLYMER IN HIGH — TEMPERATURE FLUIDS

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### Abstract

In this study waste plastics such as phenol resin foam powder were decomposed into their monomer and oligomer compounds in sub- and supercritical fluids. Solvents play important roles as stable physical medium at high temperature and reactive chemical reagents to accelerate decomposition reaction of the thermosetting resin. In the decomposition reaction at relatively high temperature, methylene bonds of plastics were cleaved selectively via the ionic reaction by solvents. The solvent participating mechanism of decomposition was confirmed to make clear the decomposition products of phenol resin foam. The methylated reaction also occurred in the reaction in methanol, and cresol and dimethylphenol were found as main components.

**Keywords:** High Temperature Water, High Temperature Methanol, Phenol Resin, Thermosetting Resin, Chemical Recycling

### 1. Introduction

The chemical recycling of waste plastics has been gaining greater attention in recent years as a means of obtaining valuable products from wastes. Thermal cracking of thermosetting resin is a well-known technique and fluidized-bed pyrolysis technology has been under development. It is well known that water under supercritical conditions is much less polar and can homogenize substantial amounts of non-polar organic compounds. Furthermore, it is pointed out that the supercritical water is emerging as a medium, which could provide the optimum conditions for a variety of chemical reactions, among them the destruction of hazardous waste. We have already confirmed that waste plastics such as phenol resin decompose into their monomeric compounds in sub- and supercritical water (Fig.1) [1], [2].

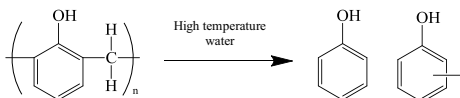


Fig.1. Decomposition reaction of foamed phenol resin.

### 2. Materials and Methods

Foamed phenol resin was reacted after pulverizing. A 10 mL tubing bomb reactor and 2L autoclave reactor were used as the reactor. The typical reaction was carried out for 0.1g of foamed phenol resin in 1 mL water with  $\text{Na}_2\text{CO}_3$  or methanol. After the reaction, products were extracted by ether and measured by GC/MS and GC

(Fig.2). In the thermal analysis the temperature increasing rate was  $10^\circ\text{C}/\text{min}$ .

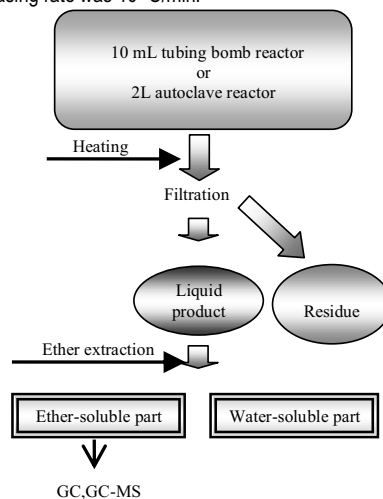


Fig.2. Experiment method.

### 3. Results and Discussion

#### 3.1 Decomposition reaction in high temperature water.

Foamed phenol resin was decomposed into their monomers by reactions at  $350^\circ\text{C}$  under an Ar atmosphere in high temperature water with  $\text{Na}_2\text{CO}_3$  for 2h. According to GC/MS analysis, phenol and cresol were found as main components in the liquid phase (Fig.3). The decomposition was accelerated by the quantity of  $\text{Na}_2\text{CO}_3$  addition increasing. In addition, the

yield of their monomers was higher at longer reaction time and higher temperature (Fig.4). However, carbonization reaction occurred at the high reaction temperature.

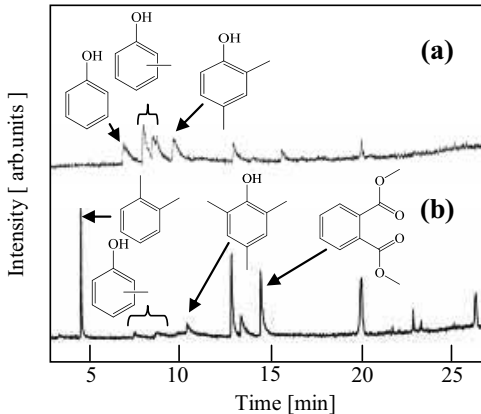


Fig.3. GC/MS chromatogram of the products in the reaction of foamed phenol resin (a) in water 400mL with  $\text{Na}_2\text{CO}_3$  at 350 °C for 1h and (b) in methanol 400mL at 280 °C for 1h by using 2L reactor.

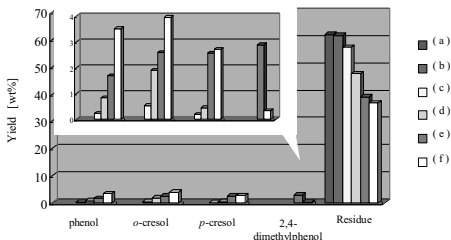


Fig.4. Decomposition reaction of foamed phenol resin in water 1.0 mL with  $\text{Na}_2\text{CO}_3$  for 2h (a) at 280 °C ,(b) at 300 °C ,(c) at 320 °C ,(d) at 350 °C ,(e) at 400 °C ,(f) at 430 °C.

3.2 Decomposition reaction in high temperature methanol. Foamed phenol resin was decomposed by reactions at 280°C in high temperature methanol without the addition of additive. Foamed phenol resin decomposed mainly into dimethylphenol and xylene in high temperature methanol shown in Fig.3. It is considered that xylene was produced from the plasticizer.

#### 4. Conclusions

Decomposition reaction of phenol resin foam could be carried out using methanol at around 300°C. Indicating that the decomposition reaction proceeded at lower temperature when methanol was used as the solvent. The reaction products depended on the solvent used.

#### References

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- [2] T. Sugeno and H. Tagaya. Treatment of phenol resin foam powder and prepolymer in high-temperature fluids. *PACIFICHEM 2010*, Honolulu, (2011); Abstract 587.