RECOVERY OF USEFUL RESOURCES FROM WEEE BY USING RECYCLABLE SOLVENT

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Abstract

Development of technology for recovering useful materials from waste of electric and electronic equipments (WEEE) is very important for securing long stable supply of indispensable resources to high technology industries. Fiber reinforced epoxy board was decomposed at 600 - 900 ˚C for 60 min to produce solvent for liquefaction of the circuit board. Yield of the liquid product was higher than 75% at these temperatures. Many kinds of cresol derivatives were observed in the liquid product. Tar solvent was prepared from the liquid product by removing light fraction. Epoxy board was liquefied almost completely in the tar solvent at 250 °C for 120 min under atmospheric pressure. Finally, relatively much amount liquid product was recovered from thermal decomposition of the once liquefied epoxy board at 600 - 900°C. These experimental results indicate that the liquid product can be used as a solvent repeatedly.

Keywords: *WEEE, E-waste, Recycle, thermosetting resin, Metal recovery*

1. Introduction

Precious metal and rare-earth elements are indispensable resources to high technology industries. Long stable supply of these resources is serious concern, because remarkable expansion of demand for them is expected by spread of IT devices. The waste of electric and electronic equipments (WEEE) is valuable domestic resources for Japan, and recovery technology of these metals from WEEE is very important.

Printed circuit board cannot be decomposed by conventional pyrolysis, because thermosetting resin such as epoxy resin or phenol resin have three dimensional network structure. Liquefaction of printed circuit board in supercritical solvents or in specific solvents [1], [2] have been proposed. However, commercial viability of them was difficult due to using an expensive high pressure vessel or organic solvent. Recently we showed that epoxy circuit board can be dissolved in biomass derived tar solvent at 250 - 300 ˚C under atmospheric pressure, and copper or glass fiber could be recovered easily (Fig.1) [3]. Cresol derivatives that were derived from degradation of lignin contained in biomass were effective to liquefaction of epoxy board. Liquid product derived from thermal decomposition of epoxy board is expected to contain a lot of cresol derivatives, as well as biomass derived liquid product.

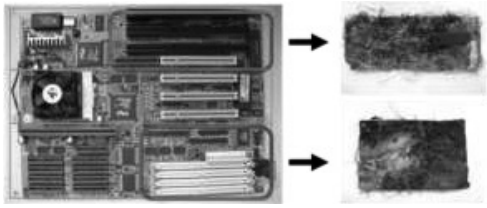

Fig.1 Liquefied circuit board in biomass derived tar solvent.

In this work, epoxy board was dissolved in liquid product derived from epoxy board in the first step, and the once liquefied epoxy board was decomposed to recover recyclable solvent in the next step.

2. Materials and Methods

Experimental procedure was shown in Fig.2. Glass fiber reinforced epoxy board (Hitachi Chemical Co. Ltd.) was charged in a fused quartz reactor (D=30 mm, L=300 mm) and the sample was decomposed at 600 - 900 ˚C for 60 min. Distillate liquid product was collected into a iced flask through a glass tube. Gaseous product was collected in an aluminium laminated gas bag, and it was analyzed by an automatic GC (GL Sciences).

Liquefaction of epoxy board was carried out at 250 ˚C for 120 min with addition of trace amount of sulfuric acid in the tar solvent which was prepared from the liquid product by removing light fraction. In the most of experiments, the liquefied epoxy baord was heated up again, and was decomposed at 600 – 900 ˚C for 60 min. In some experiments, the liquefied epoxy sample was extracted by tetrahydrofuran for at least 10 hours. Liquefaction rate was calculated by using equation (1).

$$\text{Liquefaction rate}(\%) = 100 - (c-b)/(a-b)\times 100 \quad (1)$$

a : weight of epoxy board

b : weight of glass fiber in the sample

c : weight of carbon residue

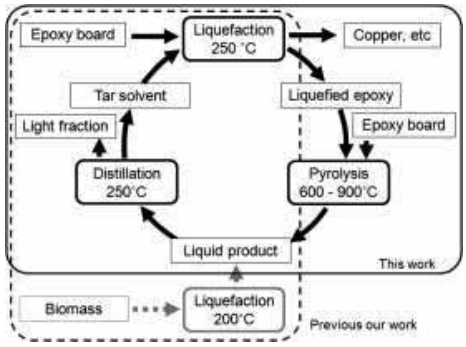

Fig. 2. Experimental procedure

3. Results and Discussion

Product distribution of thermal decomposition of epoxy board at 600 – 900 °C was shown in Fig.3. Yields of product were calculated from weight of only epoxy resin excluding glass fiber. Yields of gas, liquid, solid products were 6.5%, 75.1%, and 20.6% at 600 °C, respectively. Liquid yield increased with temperature slightly, it indicates that residue was converted to liquid product at higher temperature. A lot of cresol derivatives such as alkyl phenol were observed in the liquid product.

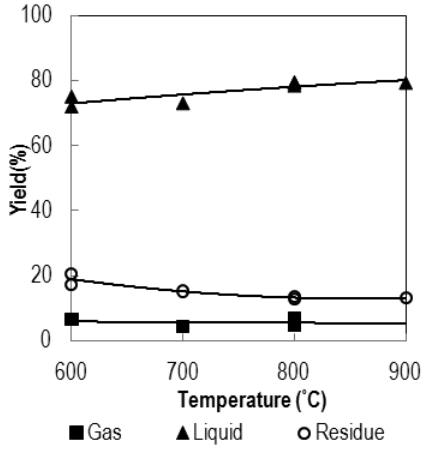

Fig.3. Distribution of products from thermal decomposition of epoxy board.

Epoxy board was dissolved almost completely at 250 °C for 120 min in the tar solvent which was prepared from liquefaction product of thermal decomposition of the epoxy board itself by removing light fraction. Particularly, tar solvent prepared at high temperature was effective, even if epoxy board was added more than 20% of the tar solvent weight, the epoxy board was dissolved almost completely.

Distributions of products derived from thermal decomposition at 700 °C of the once liquefied epoxy board were shown in Fig.4. If tar solvent or epoxy board was decomposed independently, yield of liquid or residue is expected to be on the calculated dashed straight lines, respectively. However, yield of liquid product decreased with increasing of initial weight ratio of epoxy board, and much more residue was produced from thermal decomposition of the once liquefied epoxy board.

When weight ratio of epoxy board in tar solvent was less than 10%, relatively much amount solvent was recovered from thermal decomposition of the once liquefied epoxy board, even if residue was produced by condensation. We expect that liquid product formed from the once liquefied epoxy circuit board can be used as solvent repeatedly and shortage of solvent is replenished by liquid product derived from biomass.

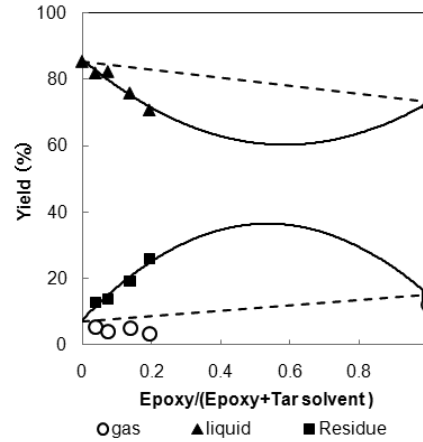

Fig. 4. Distributions of products derived from thermal decomposition of the liquefied epoxy board. (700 °C)

4. Conclusions

Many kinds of cresol derivatives were observed in the liquid product derived from thermal decomposition of epoxy board. Epoxy board was liquefied almost completely in the tar solvent that was derived from thermal decomposition of epoxy board. Relatively much amount liquid product was recovered from the once liquefied epoxy circuit board. The liquid product can be used as recyclable solvent repeatedly.

References

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