Recycling of anhydride -cured epoxy resin using polyethylene glycol/ NaOH

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Abstract

The use of polyethylene glycol/NaOH for solubilization of anhydride -cured epoxy resin has been demonstrated. The effects of reaction conditions such as reaction temperature, alkaline species and concentration, as well as PEG molecular weight were evaluated. The structure of the solvolysis products has been characterized by FT-IR, ^{1}H-NMR, ^{13}C-NMR, GPC and ESI-MS, indicating the decomposition of the curing bond through ester hydrolysis accompanied by transetherification as the plausible solvolysis mechanism.

Keywords: Epoxy resin; Polyethylene Glycol/NaOH; Solvolysis; Hydrolysis; Transetherfication

1. Introduction

Nowadays, recycling thermoset composites such as epoxy resins at the end of their life cycle is very difficult because of the cross-linked nature of the resin. Solvolysis, using reactive solvents to break down chemical bonds in thermoset resins, has been regarded as one of the most promising recycling methods. Various solvents have been used [1]. Developing a new process with high efficiency under mild reaction conditions is of considerable importance.

In this paper we have used polyethylene/NaOH to solvolyze anhydride-cured epoxy resin, which is a typical thermosetting resin. High decomposition efficiency has been proved under atmospheric pressure.

2. Materials and Methods

A model methyl tetrahydrophthalic anhydride -cured epoxy resin has been prepared. Typically, NaOH (0.8 g) was dissolved in PEG200 (40 mL), and then mixed with the model epoxy resin (2.0 g). After reacting, the unreacted epoxy resin could be separated by filtration. Then water was added to the liquid products to obtain an aqueous phase and an oil phase. The aqueous phase was distilled to separate water, and then

tetrahydrofuran was added, yielding a white precipitate, characterized as sodium methyl tetrahydrophalate. The oil phase obtained has been dried in a vacuum oven at 60 °C for 24 h, then characterized using FTIR, GPC, ^{1}H-NMR, ^{13}C-NMR and ESI-MS.

3. Results and Discussion

Fig. 1 compares the solubilization efficiency of different catalysts when combining with PEG200. It can be seen that the solubilization degree is as high as 70.0 wt% with NaOH when heated at 180 OC for 30 min, while it is only 9.7% with NaHCO3. When using HCl or without catalyst, almost no change can be observed in the epoxy resin, proving that PEG/NaOH is very efficient in catalyzing the solubilization of epoxy resin.

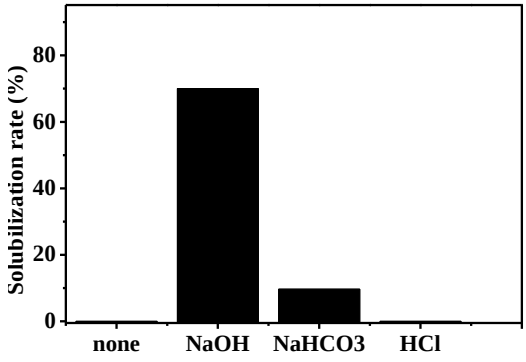
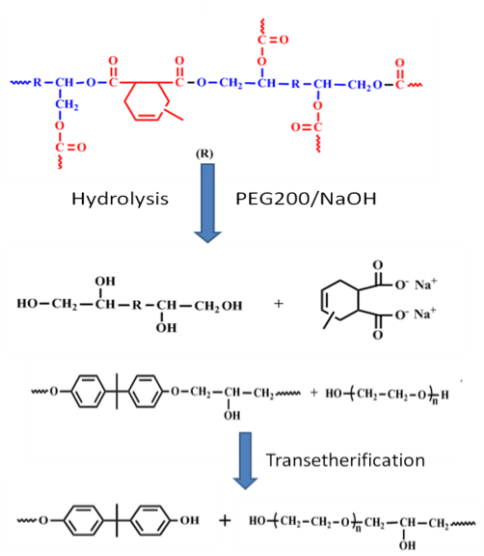


Fig. 1. Comparing the solubilization efficiency of different catalysts

By characterization the degradation products using FTIR, GPC, 1H-NMR, 13C-NMR and ESI-MS, it is found that the main solubilization mechanism is ester hydrolysis accompanied by the transetherification reaction (Scheme 1).



Scheme 1 Plausible reaction mechanism for solubilization of epoxy resin using PEG200/NaOH.

4. Conclusions

Solvolysis of anhydride-cured epoxy resin using PEG/NaOH shows high efficiency under mild reaction conditions. The plausible solubilization mechanism is ester hydrolysis accompanied by the transetherification reaction.

5. Acknowledgments

The authors thank the financial support of the 863 program (Contract No: 2007AA06Z325) and the Program for New Century Excellent Talents in University (NCET-08-0366).

References

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