CHARACTERIZATION OF CFRP USING RECOVERED CARBON FIBERS FROM WASTE CFRP

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1. Introduction

CFRP (Carbon Fiber Reinforced Plastics) is widely used in sporting goods such as golf club, tennis racket and fishing rod, and in aerospace and industrial field because of its high tensile strength, high elastic modulus and high dimensional stability. But due to its superior properties, it is difficult to recycle. Consequently the amount of waste CFRP is increasing and the recycling technology is required.

We have developed the depolymerization of thermosets under ordinary pressure. We use potassium phosphate tribasic (K_3PO_4) as a catalyst and benzyl alcohol (BZA) as a solvent to depolymerize cured epoxy resin (EP) and unsaturated polyester resin (UP). FRP made of EP or UP can be dissolved in solvent and be separated into depolymerized resin and reinforcement. We have already reported that the result of application of our method to GFRP (Glass Fiber Reinforced Plastics) is useful for recycling of GFRP in Fiber Recycling 2007.

We applied our method to CFRP based EP and investigated possibility of recycling of CFRP.

2. Experimental

2.1 Depolymerization of Cured Epoxy Resin

Epoxy resin cured with acid anhydride is mainly used for a matrix of CFRP. This is applied to golf club, tennis racket and aerospace parts, but is difficult to recycle. We estimate that cured epoxy resin can be depolymerized by transesterification with mono alcohols, and then be dissolved in solvent (Fig.1).

2.2 Depolymerization of CFRP

Various CFRP products could be dissolved by the depolymerization under ordinary pressure. For example, a tennis racket was dissolved in 8 hours (Fig. 2), and an aircraft part was dissolved in 2 hours (Fig. 3). Recovered CF (Carbon Fiber) was prepared nonwoven fabric by a carding machine (Fig. 4).

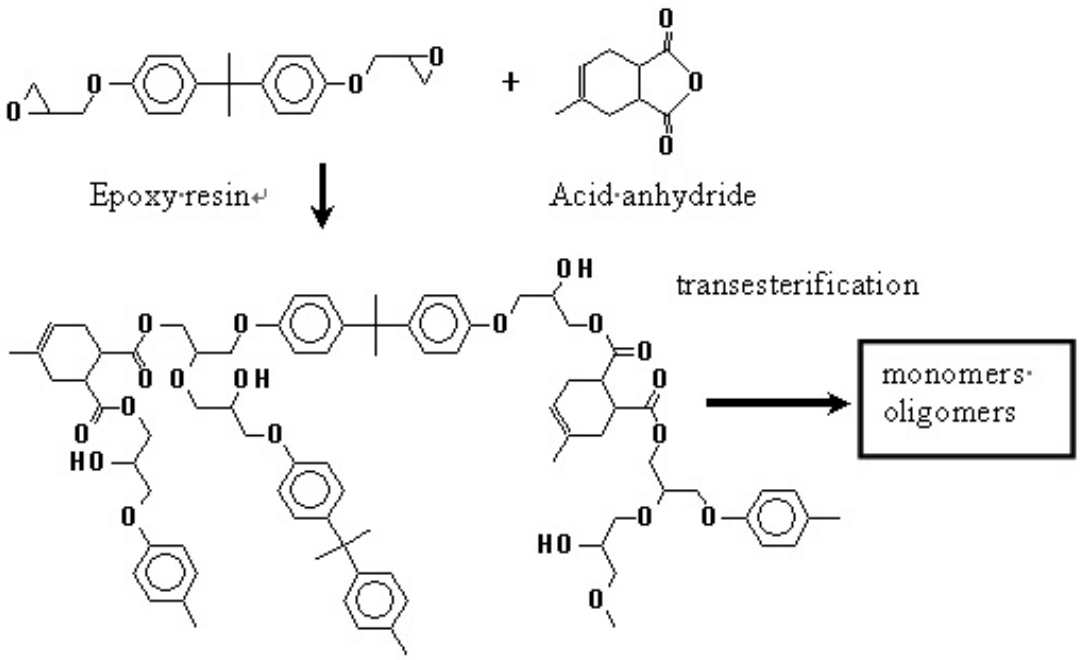

Fig. 1 Depolymerization of epoxy resin cured with acid anhydride

Fig. 2 Dissolve of a tennis racket

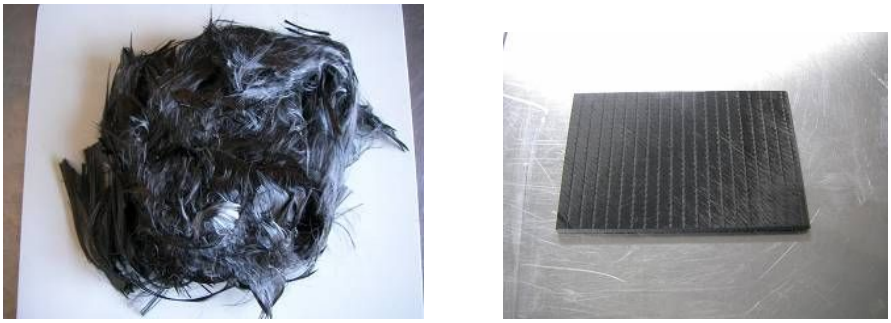

Fig. 3 Dissolve of aircraft parts

Fig. 4 Nonwoven fabric used recovered CF

2.3 Mechanical Properties of “Recycle CFRP”

We prepared “recycle CFRP” used nonwoven fabric made from recovered CF (Tab.1). Tensile properties compared to mass production GFRP, strength of recycle CFRP is 1.4 times higher, modulus is equality and elongation is 1.1 times higher than GFRP (Fig.5). We expect that “recycle CFRP” can be used as well as GFRP.

Tab. 1 Mechanical properties of “recycle CFRP”

Item	Unit	Mass production GFRP	Recycle CFRP
Fiber form		Glass chopped strand mat	Nonwoven fabric
Matrix resin		UP	
Fiber length	mm	25	
Fiber content	vol%	16	
Specific gravity	-	1.7	1.6
Tensile strength	MPa	63.8	89.7
Tensile modulus	GPa	5.7	5.5
Tensile elongation	%	3.7	4.0

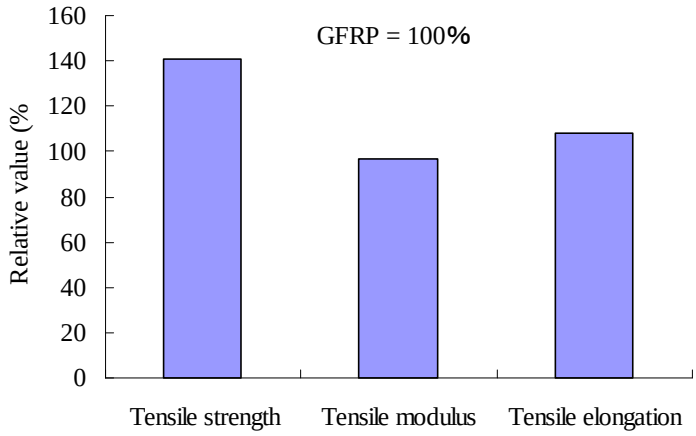

Fig. 5 Mechanical properties of CFRP used recovered CF

2.4 Recyclate Application – Formula Car Parts

We offered Toyohashi University of Technology (TUT) nonwoven fabric using recovered CF from tennis rackets. TUT prepared driver's seat using this fabric by hand-lay-up method (Fig.6). They installed the seat on the formula car, and competed at Student Formula SAE Competition of JAPAN 2008.

Fig. 6 A driver's seat on the formula car used nonwoven fabric made from recovered CF

3. Conclusion

Recovered CF was obtained from CFRP using the depolymerization of thermosets under ordinary pressure, and "recycle CFRP" could be prepared using nonwoven fabric made from recovered CF. Tensile properties compared to mass production GFRP, strength of recycle CFRP is 1.4 times higher, modulus is equality and elongation is 1.1 times higher than GFRP. "Recycle CFRP" can be used enough as FRP. We are developing applications of nonwoven fabric of CF.