THE EFFECT OF STOICHIOMETRIC RATIO OF CURING AGENT ON THE MECHANICAL PROPERTIES OF EPOXY RESINS

Peng Wang, Gang Sui and Xiaoping Yang.

State Key Laboratory of Organic-Inorganic Composites, Beijing University of Chemical Technology, Beijing 100029, China

Introduction

The use of carbon fiber-reinforced plastic (CFRP) composites as high performance materials is increasing in the aerospace, military, automobile, and sports industries. The performance of CFRP is dependent on fiber and matrix characteristics. Carbon fiber (CF), having a high elastic modulus, is an excellent material selection to sustain the static and long-term cyclic loadings imposed on such structural components. The epoxy matrix in the composite provides bulk and enables transfer of loads between fibers. However, an epoxy matrix is relatively brittle and has little tensile strength. On the basis of different mechanical analysis model, the theory of deformation layer regard the intermediate layer as ductile layer that has good deformability to take effect in stress relaxation. On the other hand, the theory of restrain layer consider that matrix neighbouring the fiber piles up more compact and has higher modulus than matrix itself as a result of the preference adsorption of carbon fiber. [1] The interface layer whose modulus is between the matrix and fiber can distribute stress well. According to a model of double interface/interphase [2], the analysis reveal the modulus of the matrix plays an important role in the mechanical properties of CF/Epoxy composite. The damage pattern varies greatly on the modulus of matrix and the modulus of fibers. In this paper, we studied the effect of ratio of lively hydrogen equivalent weight in curing agent and epoxy equivalent weight on the mechanical properties of epoxy resins.

Experimental

Materials

TDE-85 (epoxy equivalent weight 118,viscosity 1.6~2.0 Pa•s (25℃))was obtained from Jin dong chemical plant. Diethyltoluenediamine（DETDA）(lively hydrogen equivalent 45) was obtained from Lonza company,Sweden. Diamino diphenyl sulfone（DDS）(lively hydrogen equivalent 62) was obtained from Yinsheng chemical Ltd,Suzhou. Amine-grafted multiwalled carbon nanotubes (MWCNTs) was obtained from advanced composite center. Carbon fiber (T800H) was obtained from Toray® company, Japan.

Specimen preparation and testing

The epoxy resin (TDE-85) and three different types of curing agent, DETDA and DDS were used to confect resin matrix, respectively. In each resin system we use the same type but different amounts of curing agent to manufacture epoxy matrices. According to a calculation of curing agent, in each resin system, we set several ratio (r=0.5,0.75,1,1.25) of lively hydrogen equivalent weight and epoxy equivalent weight. The different types of chemical bonds and the degree of crosslinking that will occur[3].In turn, different curing agent and differernt amount curing will be formed and affect the mechanical property of the cured resin. To manufacture resin cast, we add specified quantity of curing agent into the epoxy. The resin was heated at a specified temperature to dissolve the curing agent. Then the resin mixture solution was casted into the mould after it’s degassed.

Analysis and characterization

The tensile test of the resin cast was carried out at room temperature. The crosshead speed was 2 mm/min. The short-beam-shear test of the unidirectional composites was carried out on an Instron-1196 universal testing machine at a span-to-depth ratio of 6/1. More than six composite specimens with dimensions of 20 mm × 6 mm × 2 mm were selected for each ILSS test. The dynamic mechanical analysis (DMA) was performed with Rheometrics Scientific DMTA V, Temperature scans at 1Hz frequency were carried out with a heating rate of 5℃/min. The fracture morphology of the epoxy and composites were observed with Cambridge Stereoscan 250MK3 scanning electron microscope (SEM).

Results and Discussion

Each system using the same type but different amounts of curing agent undergoes the same curing procedure. According to the tensile test, the Young's modulus of the cured resin with different amount of curing agent altered. At the stoichiometric ratio, which means the ratio of lively hydrogen equivalent weight and epoxy equivalent weight (r) is 1, the lowest tensile modulus of resin was revealed. Both of the TDE-85/DETDA system and the TDE-85/DDS system obeyed the same rule. And TDE-85/DDS system show higher tensile modulus than TDE-85/DETDA system at the same equivalence ratio, as shown in Table 1.

Table 1.Tensile modulus of epoxy resin with different amount of curing agent

ratio	Tensile Modulus of TDE-85/DDS system (MPa)	Tensile Modulus of TDE-85/DETDA system (MPa)
0.5	3043.0	2863.3
0.75	2794.0	2585.0
1	2637.3	2573.4
1.25	2707.3	2661.2

The glass transition temperature (Tg) of TDE-85/DDS epoxy system obtained from the dynamic mechanical analyses is shown in Fig.1. When the ratio of lively hydrogen equivalent weight and epoxy equivalent weight is 0.75, the Tg of cured resin is the highest.

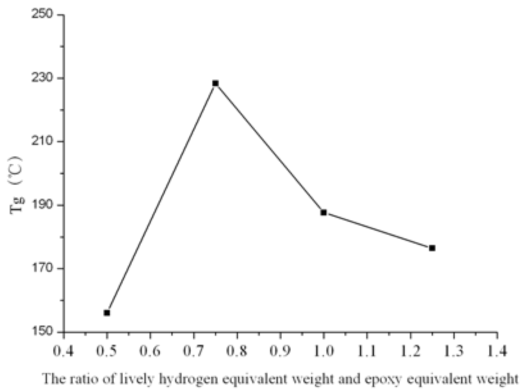

Fig.3. The Tg of TDE-85/DDS epoxy system

Conclusion

The consequence reveal that the epoxy resin can't obtain its ultimate mechanical property when the amount of curing agent is at the stoichiometric ratio. And both the types of chemical bonds and degree of crosslinking play an important role in the mechanical property of the resin matrix.

References

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