DOI: 10.2478/adms-2013-0014

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DYNAMIC MECHANICAL BEHAVIOUR OF GFRP COMPOSITES WITH SiO_2 NANO PARTICLES REINFORCED EPOXY MATRIX

ABSTRACT

Dynamic mechanic (DMA) tests were performed to compare the mechanical behaviour of glass fibre reinforced epoxy laminate composites with SiO_2 nanoparticle reinforced matrix. The selection of the most promising nanoparticle concentrations was considered in terms of elastic modulus and glass transition temperature. The reference specimens (0% nanoparticles) did not contain diluent accordingly the results do not allow the exact comparison with unreinforced composite, nevertheless the ranking of the nanocomposites was made. In terms of stiffness requirements 20% nanoparticles composites offer the best behaviour, 25% higher elastic modulus than 5% nanoparticles. For nano composites the glass transition temperature T_G is the highest: 80°C, 77°C for 3%, 5% nanoparticles respectively and the lowest 75°C, 72°C , 71°C for 15%, 10% and 20% nanoparticles is respectively .

Key words: *Polymer composites, nano composite, DMA, glass transition temperature*

INTRODUCTION

Recently, significant research efforts were invested in improving the toughness of epoxy resin matrices for fibre reinforced composites. As described in ref. [1] various strategies were followed with variable success. According to the recent review, modification of epoxy resin with nano filler - organo-silicates (clay) is known as effective for enhancement of mechanical performance like modulus and strength [2]. As fracture toughness [3,4,] however in some cases no improvement or even a reduction was observed. Some researchers found such modifications of the resin to be effective for increasing the performance of the laminates as well. Specifically bending strength and modulus [5,6] could be enhanced by up to 15 and 30% respectively.

In addition to clay minerals hard nanoparticles such as SiO_2, SiC i Al_2O_3 are used as fillers of epoxy resins. The optimum amount of nanoparticles for the best improvement of fracture toughness, as reported by Su Zhao is 10-15% nano Al_2O_3. The effect of nanoparticles on other properties is not well known. Accordingly it is essential to accumulate the experimental data obtained on various materials in different laboratories and conditions.
The aim of this preliminary study was to compare the effect of nanoparticle modifiers of epoxy resin matrix in GFRP laminates in terms of the mechanical performance and glass transition temperature.

MATERIALS AND EXPERIMENTS

Glass fibre-reinforced-epoxy (GFRP) laminates were investigated in this study. Epoxy matrix resin Hexion 285 cured with L285 hardener was modified with SiO_2 nano-particles 3wt%, 5wt%, 10wt%, 15wt% 20%. In order to reduce resin viscosity and thus facilitate impregnation of the fibres the nanoparticle modified epoxy resin mixture was diluted by using 5wt% diluent, a (mixture of ethyl benzene and isobutene). Glass fibres were woven fabric: 2 layers 110 g/m^2 and 5 layers 80 g/m^2 (Krosno). The same fibres and resin (without nanoparticles or diluent) were used to produce a laminate plate needed for comparison with nanoparticle composites. All laminates were fabricated using hand lay-up method.
Dynamic mechanic (DMA) tests were performed using MetraVib+150 (ACOEM, Limonest, France). Three specimens of each materials were tested so as to consider the selection of the most promising nanoparticle concentrations .

RESULTS AND DISCUSSION

Figs. 1, 2 illustrate Young modulus and loss angle respectively as a function of temperature for glass fibre reinforced laminates with 5 nano-particle reinforced epoxy matrices. Significant (ca. 25%) enhancement of Young modulus is observed for 20% nanparticles composites compared with 5%N. 15% nanoparticles gives only slightly lower modulus. For smaller concentrations of nanoparticles (3%,) and 10% the results are similar. 5% N exhibits definitely the lowest modulus . The reference plot for pure GFR epoxy laminates was not considered in the final evaluation since the matrix resin was not diluted. Accordingly only the nanoparticle composites were compared.

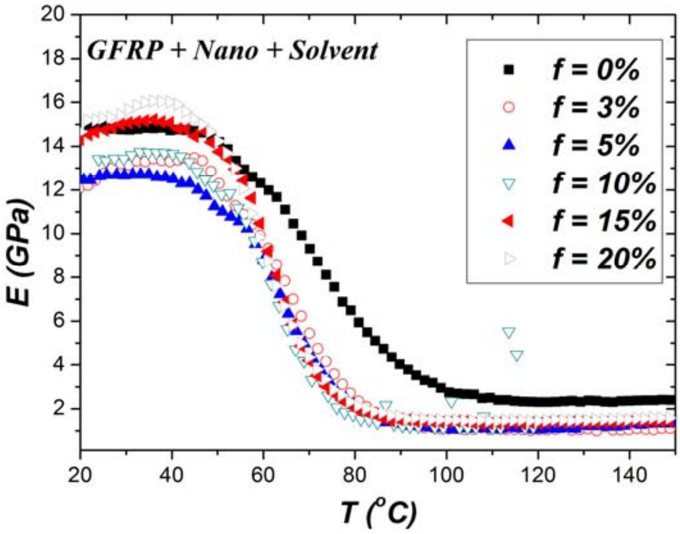

Fig. 1. Young modulus vs. temperature for glass fibre reinforced laminates with 5 nano-particle reinforced epoxy matrices

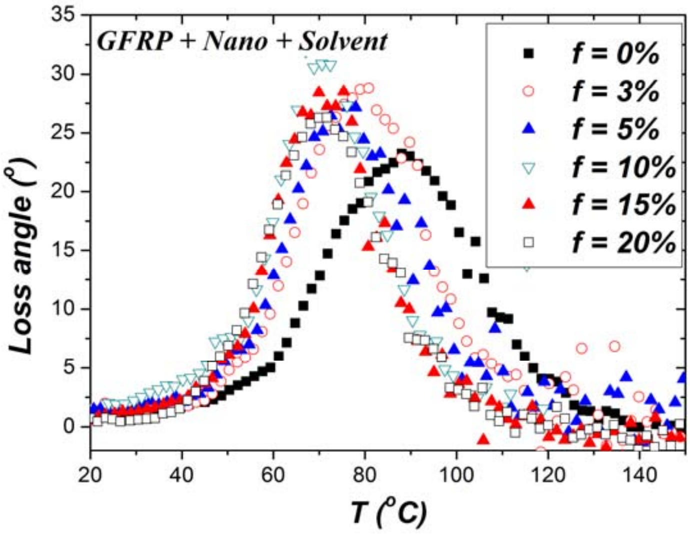

Fig. 2. Loss angle vs. temperature for glass fibre reinforced laminates with 5 nano-particle reinforced epoxy matrices

Loss angle (Fig. 2) is representative of glass transition temperature T_G. For nano composites the highest value of Tg is for the lowest (3%, 5%) nanoparticle concentrations - 80°C, 77°C respectively. The glass transition temperature for 15%, 10% and 20% nanoparticles is 75°C, 72°C , 71°C respectively which indicates permanent reduction of the T_G as nanoparticle concentration grows.

It may be concluded that the preferable concentration of nanoparticles depends on the application. It terms of stiffness requirements the 20% nanoparticles offers the best behaviour while in terms of elevated temperature applications where glass transition temperature is a criterion the results are not conclusive- the effect of nanoparticles is not clear because of the diluent effect. This evidently should be avoided in the future studies.

CONCLUSIONS

Dynamic mechanic (DMA) tests were performed to compare the mechanical behaviour of glass fibre reinforced epoxy laminate composites with SiO_2 nanoparticle reinforced matrix. The selection of the most promising nanoparticle concentrations was considered in terms of elastic modulus and glass transition temperature. The reference specimens (0% nanoparticles) did not contain diluent accordingly the results do not allow the exact comparison with unreinforced composite, nevertheless the ranking of the nanocomposites was made.

The following conclusions can be drawn:

- It terms of stiffness requirements 20% nanoparticles composites offer the best behaviour, 25% higher elastic modulus than 5% nanoparticles.
- For nano composites the glass transition temperature T_G is the highest: 80°C, 77°C for 3%, 5% nanoparticles respectively and the lowest 75°C, 72°C , 71°C for 15%, 10% and 20% nanoparticles is respectively .

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