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Investigation on Mechanical Properties of Carbon Fibre Reinforced Nano Composite Materials

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ABSTRACT:
In this study 12 laminates of, carbon fiber fabric composites with the dispersion quality of MWCNTs as nanofillers in the resin systems. The epoxy resin used was Epikote 828 and dapsone (DDS) as the hardener. The compressive, and flexural properties of MWCNT_modified- Epikote 828 as compared to Epikote828/DDS neat systems were also investigated. From the results, the addition of MWCNT_short into Epikote 828 has significantly enhanced the compressive and flexural modulus.

Keywords: Carbon fibre, MWCNT, Epikote 828 , dapsone (DDS), Compressive, ILSS, Flexural.

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I. INTRODUCTION

Carbon Fiber reinforced composite materials have been used widely in many industries, such as automobile, aerospace and military, sports equipment, wind turbines, aerospace and automotive applications [1-3]. The compressive strength of woven CFRP composites is mainly affected by the micro-buckling failure occurs in the produced parts. This failure occurs as a result of the low shear strength of the polymer matrix or epoxy resin, as well as the imperfection of the fibre waviness during the manufacturing process [4].Thin panels used in aircraft structures are prone to buckle as a result of compressive load, which then can lead to delamination due to interlaminar shear stress (ILSS) [5]. When compared to glass fibers, carbon fibers have higher tensile modulus and lower density but they are more expensive and have low compression strength. Main goal of glass-carbon hybridization is to enhance mechanical properties such as flexural strength [6], fracture toughness [7] and fatigue life [8], and thermal properties [9] while reducing the cost compared to a full carbon fiber composite. Based on the exhaustive literature survey no author has been to CFRP with various lengths of MWCNTs incorporated in to epoxy resin. Finally in this paper to calculate carried out to The compressive, ILSS and flexural properties of MWCNT_modified-Epikote 828 as compared to Epikote828/DDS neat systems were also investigated. From the results, the addition of MWCNT_short into Epikote 828 has significantly enhanced the compressive and flexural modulus.

II. MATERIALS AND METHOD

Plain carbon fabrics of 200 GSM were obtained from Arun fabrics (Bangalore) respectively, epoxy resin (Epikote 828/ DGEBA) and hardener (Diaminodiphenyl sulfone (DDS)) were obtained from sigma Aldrich (USA). Selections of two types of nanofiller with different lengths (MWCNT_short/828 and MWCNT_long/828) were obtained from united nanotech pvt. Ltd (Bangalore) Epoxy resin and hardener were mixed mechanically for about five minutes at the ratio of 100:30 by weight, according to manufacturer’s recommendation.MWCNT fillers were used as reinforcement in epoxy resin with weight percentage variation of MWCNTs fillers were manually mixed with the resin MWCNT filled resin was dispersed using a three-roll-mill (EXAKT 80E Technologies Germany), which enables the introduction of very high shear forces (up to 200,000/s) throughout the suspension. Then the mixture brushed on the fabrics. Nylon mold release film, bottom distribution mesh, bottom peel ply, wetted fiber fabrics of 12 layers, upper peel ply, and upper distribution mesh were laid onto the steel plate sequentially. Suction pipes for vacuuming and letting out the excess epoxy were installed. Finally they were covered with a nylon vacuum bag and sealed. Then the air in the system was evacuated with a vacuum pump up to – 0.8 bar pressure. Fabrics were cured at 70 ^{o}C for an hour and post cured at 110 ^{o}C for four hours [10]. Finally, peel plies were removed and the produced fabrics were cut into the sizes required for standard tests by a high speed circular saw. Both conventional and carbon laminated composites with nano additives have been fabricated by the vacuum bagging technique[11]. Compressive, and Flexural test were conducted to specimens according to ASTM standards D695-02 [12] and D7264/D7264M–15 [13] respectively. For tensile tests Instron 8801 universal testing machine and for 3-point bending tests Shimadzu AGS-X universal testing machine was used.

III. RESULTS AND DISCUSSION

3.1 Compressive Test

Compressive test results for all types of produced composites are shown in Fig. 3.1. It can be seen from the graph that all the five types of MWCNT_short28 into Epikote 828 composites showed positive effect. In other words failure strains of all composites are greater than that of neat epoxy composite. The highest effect about 35% and the lowest effect about 1% was observed for the MWCNT_short28 and MWCNT_long 28 concepts respectively. The comparison of Epikote 828+DDS epoxy resin, MWCNT_long/828 epoxy resin and MWCNT_short epoxy resin tested result values are shown in Table 3.1.

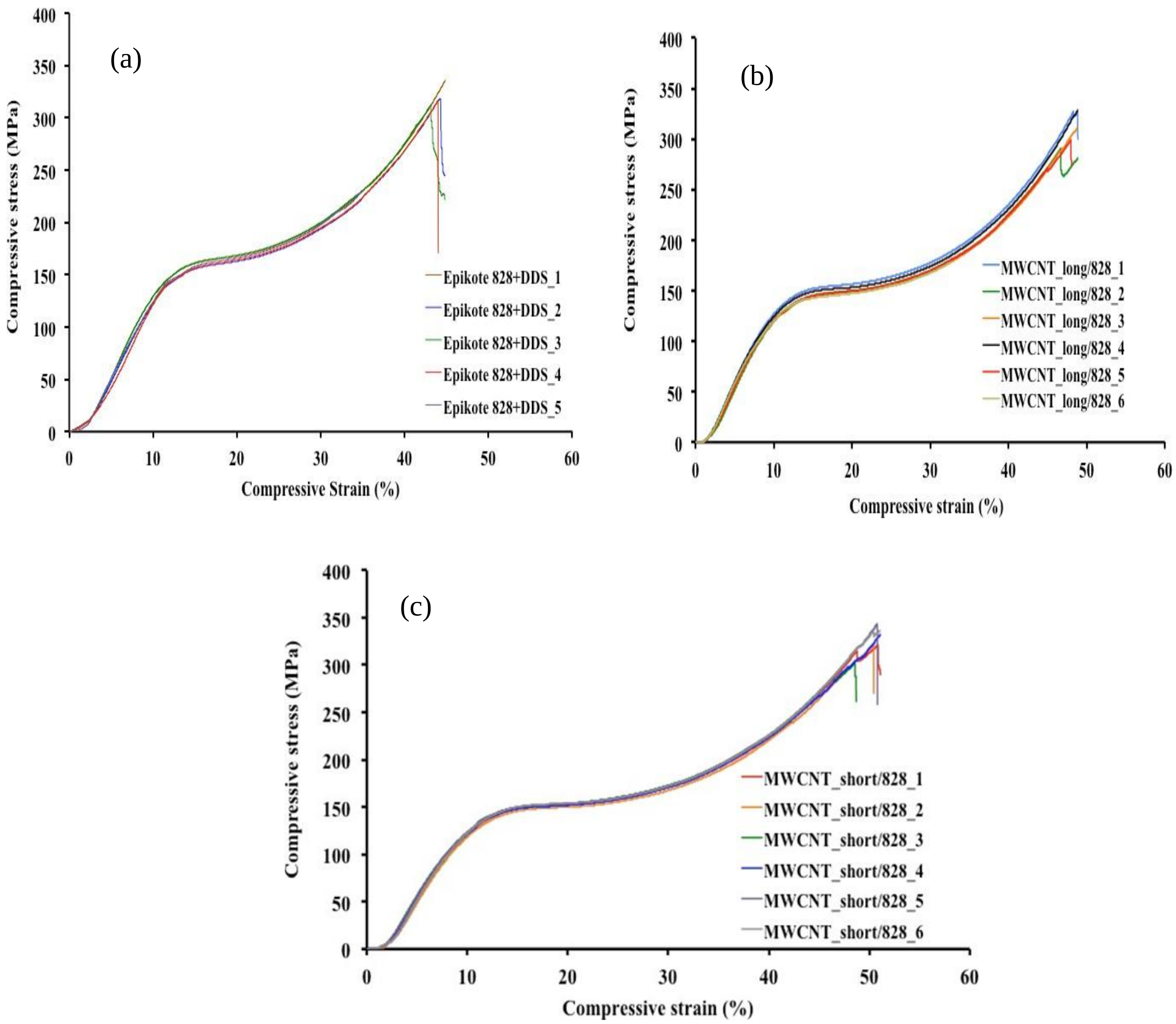

Fig.3.1 Compressive Stress – strain curves of (a) Epikote 828+DDS epoxy resin (b) MWCNT_long/828 epoxy resin
(c) MWCNT_short/828 epoxy resin composites

Table 3.1 compressive properties of (a)Epikote 828+DDS epoxyresin, (b) MWCNT_long/828 epoxy resin and (c) MWCNT_short epoxy resin composites

Compressive properties	Sample type		
	Epikote 828+DDS	MWCNT_long/828	MWCNT_short/828
Compressive modulus(GPa)	1.61 ± 0.12	1.56 ± 0.07	1.72 ± 0.08
Compressive stress at yield,σy MPa)	155.34 ± 1.92	140.72 ± 0.27	140.27 ± 0.33
Compressive strain at yield point,εy (%)	13.24 ± 0.66	12.56 ± 0.50	12.47 ± 0.58
Compressive stress at break σB (MPa)	315.66 ± 2.90	330.73 ± 5.20	340.86 ± 5.48
Compressive strain at break,εB (%)	42.33 ± 0.97	49.12 ± 0.03	51.32 ± 0.78

3.2 Flexural test

Fig. 3.2 shows three point bending test results of all types of produced composites. Since the composites with Epikote 828+DDS epoxy resin, MWCNT_long/828 epoxy resin and MWCNT_short epoxy resin composites are nonsymmetrical, three point bending tests were conducted twice by turning them upside down. It can be interpreted that symmetric concepts MWCNT_long/828 epoxy resin and MWCNT_short epoxy showed a negative effect about -4% and -2% respectively. MWCNT_short epoxy concept showed the maximum flexural stress about 37% when the carbon fiber laminate was at the outermost of tension zone .When this concept was tested as the carbon fiber laminate was at the outermost of compression zone the hybrid effect dropped to 25%. Epikote 828+DDS epoxy resin] concept exhibited a similar manner with a aforementioned hybrid composite but with lower effects of 17% and 14%. These drops can be attributed to the relatively lower compression strength of carbon fiber. The comparison of Epikote 828+DDS epoxy resin, MWCNT_long/828 epoxy resin and MWCNT_short epoxy resin flexural tested result values are shown in Table 3.2.

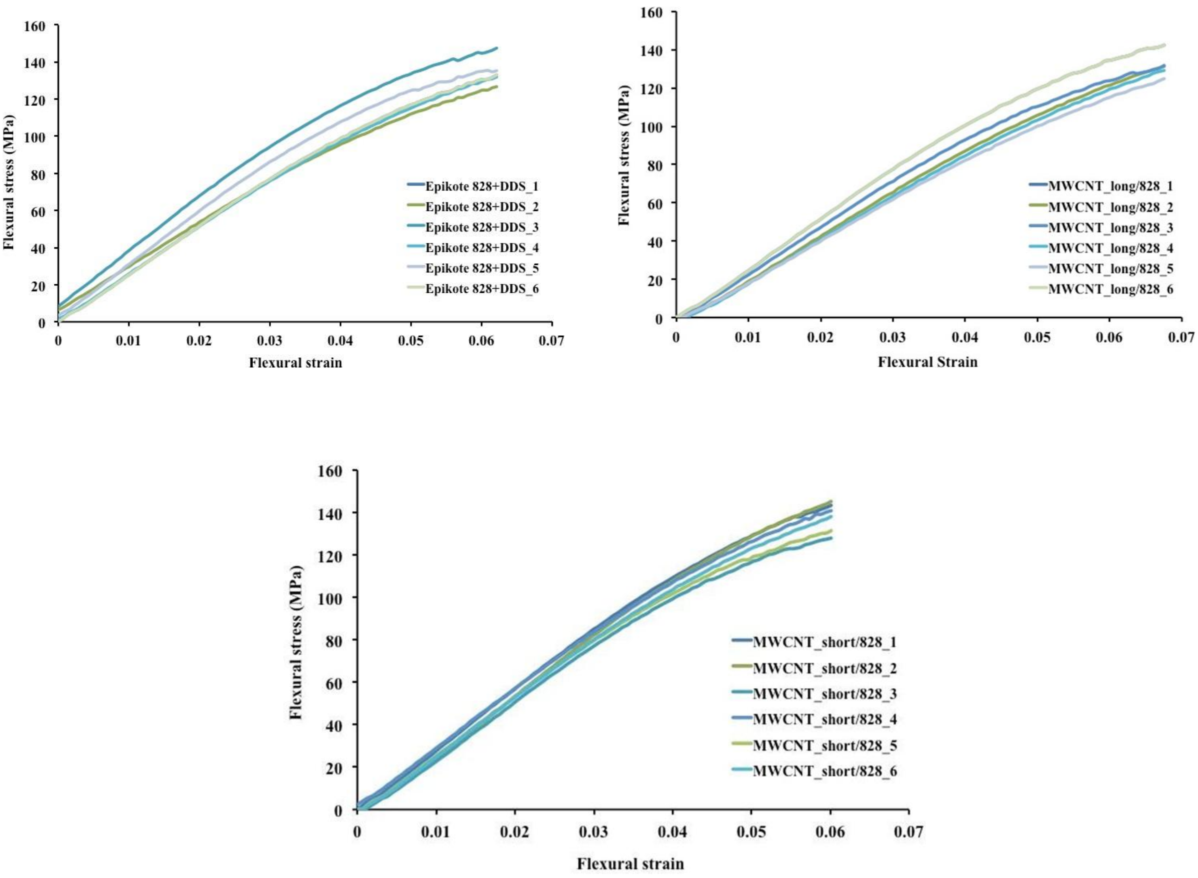

Fig. 2. Flexural stress-Strain curves for (a) (a) Epikote 828+DDS epoxy resin,(b) MWCNT_long/828 epoxy resin (c) MWCNT_short/828 epoxy resin composites

Table 3.2 Flexural properties of (a)Epikote 828+DDS epoxy resin, (b)MWCNT_long/828 epoxy resin and (c) MWCNT_short epoxy resin samples

Sample type	Flexural modulus,(GPa)	Flexural strength,(MPa)	Failure strain%)
Epikote 828+DDS	2.45 ± 0.10	136.19 ± 6.44	6.89 ± 0.53
MWCNT_long/828	2.72 ± 0.09	141.71 ± 5.78	7.11 ± 0.51
MWCNT_short/828	2.88 ± 0.07	142.61 ± 3.09	6.92 ± 0.26

Flexural tests showed that failure strain of a carbon fiber fabric composite can be improved by hybridization with MWCNT_short/828. Excluding the concepts Epikote 828+DDS s and MWCNT_long/828, flexural strain was also increased by hybridization. Moreover, production costs decreased compared to all carbon fiber fabric composite.

IV. CONCLUSION

Therefore, in this paper presented to enhance the mechanical properties mainly the Compressive and Flexural properties by introducing MWCNTs into the matrix. In order to achieve this, two types of MWCNT-modified resins were evaluated. Based on the mechanical tests results, some conclusions are made.

- ✓ Stiffer resins were successfully developed using MWCNTs. The elastic modulus of the Epikote 828 epoxy polymer measured in compression and bending was increased with the addition of MWCNTs.
- ✓ MWCNT_short/828 epoxy composite in the average, has the higher elastic modulus compared to the MWCNT_long/828 epoxy composite.
- ✓ MWCNTs were homogeneously dispersed in Epikote 828 polymer. The addition of MWCNTs improved the compressive and flexural toughness and thermal stability of the Epikote 828 epoxy polymer.

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