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STUDIES ON GLASS FIBRE REINFORCEMENT COMPOSITES BASED ON NOVOLAC VINYL ESTER/FURAN RESIN INTERACTING BLEND

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Abstract:

The Novolac vinyl ester (NVER) resin and Furan resin (FR) (Poly-2,5- furyl methylene) were thoroughly mixed at various proportions by adding with suitable catalyst. Such a interacting blend in form of viscous syrup was employed on glass fibre and thus glass reinforced composites (GRC) were casted by 'hand layup' method. The so called GRC were formed due to interacting crosslinking between NVER, Styrene and FR as well as 'insitu' Diels-Alder reaction between NVER and FR. All the GRC laminate samples were studied for their physical and mechanical properties. ASTM standards were employed for such measurments. The resultant parameters show that produced GRC laminate samples have good mechanical properties.

Keywords: Novolac vinyl ester, Furan resin, Diels Alder reaction, Glass fibre reinforced composites, laminate, mechanical properties.

INTRODUCTION

Vinyl esters resins have broad range of applications from microelectronics to aerospace materials[1]. Such resins are formed by acrylation of various epoxy resins. The most of epoxy resins commercially diglycidyl ether of bisphenol-A and novolac resin and their acrylation with acrylic acids and blending with styrene monomers. These Vinyl Ester with Styrene as reactive monomer diluents are commercially available for many applications[2-8]. The active group in these vinyl esters are acrylate group which have tendency to react with diene known as Diels-Alder reaction. One of the ring furan ring is active diene and thus which display the Diel's Alder reaction[9]. The furan resins likepoly(2,5-furanyl methylene), phenol furfuryl resin, furfuryl acetone resins etc. are also well known for their many useful applications for laminate manufacturing[11]. The importance of Furan resins and their low cost due to production from most of agricultural waste like rice husk, bagasse, maize cob etc. Regarding this the present authors reported recently[12] the blending of vinyl esters of DGBA resins with furan resin for Glass fibre reinforcement. In continuous of this work[10],the present work comprises the commercial Novolac Vinyl Resin– Furan Resin interacting blends for glass fibre reinforcement. The study drafted as follow:

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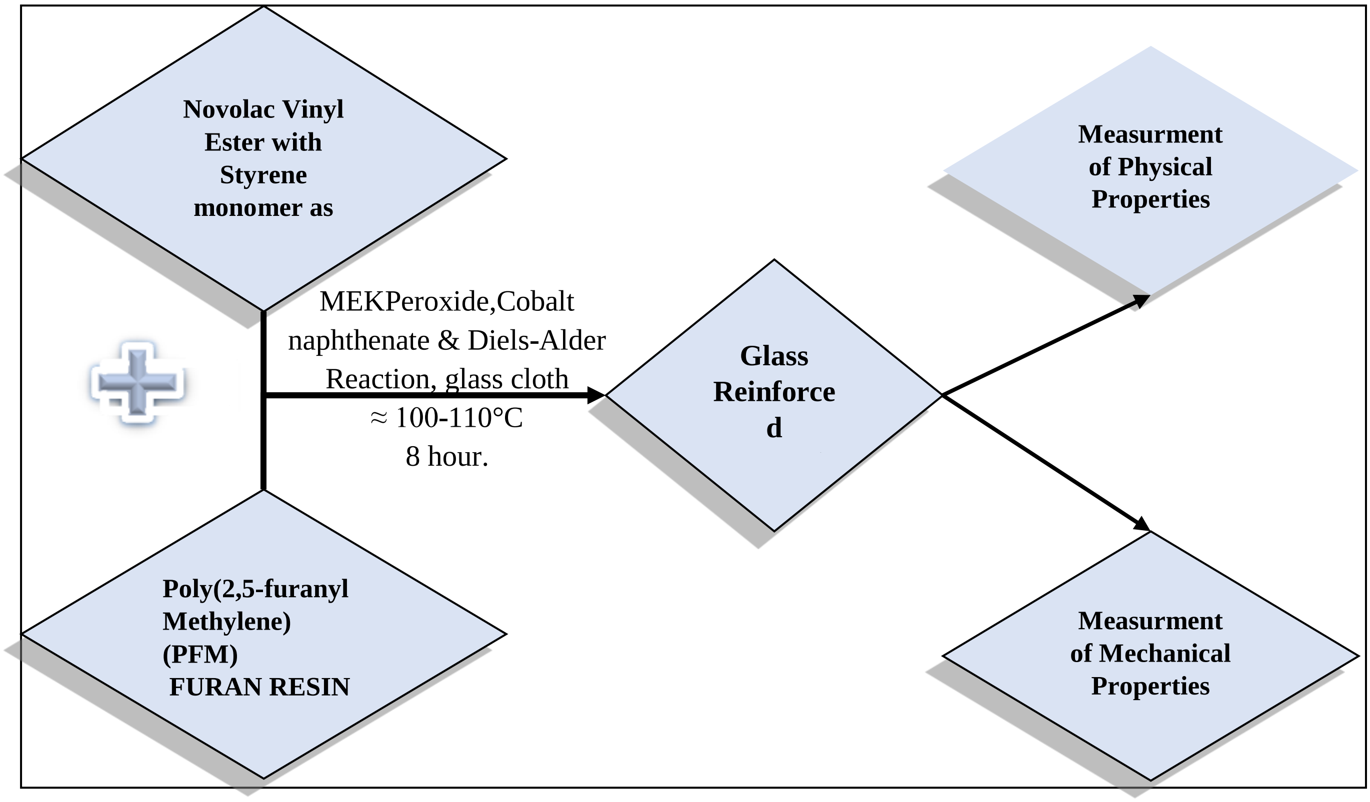

EXPERIMENTAL

Materials:

The Novolac epoxy resin was obtained from Gautam dyes & chemical industry, Chennai. Its specifications are:

- Its viscosity is 308cp at 25°C.Gel time is around 40 minutes at 25°C. Styrene content is 45%. Stability in dark is 6 months.
- Furan resin was prepared from 2-furanmethanol by reported method.[13]
- E-glass cloth woven fabric (epoxy/acrylate compatible) of 25 mm thickness was purchased from local market.
- Other required chemical reagents used were of pure grade.

Glass Reinforced Composites Fabrication: The Novolac vinyl ester (NVE): Furan resin (FR) composition in percentage(w/w) was prepared as follows:

	NVE(gm)	FR(gm)
1	85	15
2	80	20
3	75	25
4	70	30
5	65	35

Table-1

The blending of Novolac vinyl ester and Furan resin composition as shown in Table-1 was taken in 250 ml beaker and agitate gently. The tetrahydrofuran solvent was poured and stirred on magnetic stirrer at $\sim 30° \pm 2°C$ for half an hour. The suitable catalyst such as MEK-

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Peroxide and Cobalt-naphthenate were added. The whole blend was then kept aside for half an hour. Ten pieces of glass cloth of 15cm×15cm were immersed into an above blend of NVE:FR. The pieces were dried at 70°C. All the prepregs were then compressed between stainless steel flat plates by using teflon sheet as releasing agent at pressure of 150 psi. Then whole assembly was put into oven and kept at 120°C for 12 hours. Further the temperature raised to 140°C for 2 hours. After cooling, the composite (laminate) obtained and it was cut into size for mechanical testing.

MEASUREMENT

Density: Specimens of size 10×10×5 mm^3 were cut from the casted composites. The density was calculated by:

$$\text{Density} = \frac{\text{Mass of specimen}}{\text{Volume of specimen}}$$

Moisture Absorption Measurement: This was measured followed by ASTM D750 method. The GRC specimen of 75×50×5 mm^3 were immersed in distilled water for half of month. The results were calculated as

$$\%\text{ absorption } = \frac{\text{Difference in weight}}{\text{Original weight}} \times 100$$

$$= \frac{\text{W} - \text{Wo}}{\text{Wo}} \times 100$$

W = Weight after absorption of GRC
Wo = Original weight of GRC

Moisture Content Measurement: This was measured followed by ASTM D4442 method. The pre-weighted test specimen (75×50×5 mm) were dried in an oven at 103°C until reproduced results. The percentage moisture content was calculated as

$$Percentage\ moisture\ content = \frac{Wo - Wg}{Wo} \times 100$$

Where, Wo = Initial mass and Wg = Final mass

Thermogravimetric Analysis (TGA): Thermogravimetric analysis of all cured blends was performed on Universal V 2.6 DTA instrument up to 600℃ in air at 10 °K/min heating rate. The thermogravimetric analysis (TGA) of all the non-reinforced cured materials reveals that all the cured samples were thermally stable upto 260℃. They start then degrading from 260℃ and followed by rapid decomposition occur at about 450℃, then about 70% at 750℃.

Sample No.	Percentage weight loss at various temperature			
	260℃	300℃	450℃	750℃
1.	0.1	5.2	18	65
2.	0.2	5.0	17	67
3.	0.1	4.8	16	66
4.	0.1	5.2	17	70
5.	0.2	5.0	19	72

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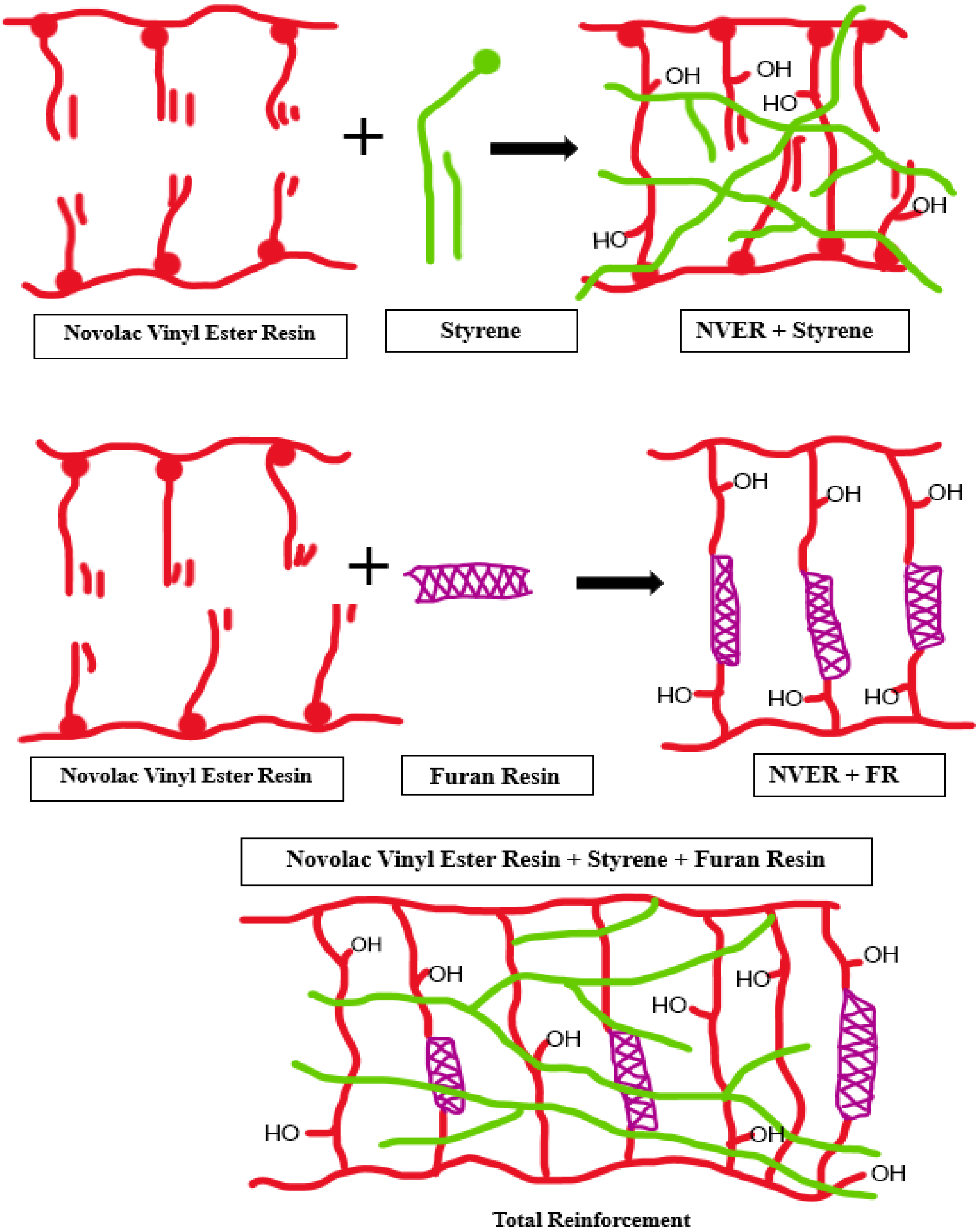
Mechanical Properties: Following ASTM standard were adopted to measure most of mechanical properties of produced laminates.

(a) Tensile Strength ASTM D635
(b) Flexural Strength ASTM D790
(c) Impact Strength ASTM D256
(d) Hardness Strength ASTM E 18-07

RESULTS AND DISCUSSION

The reaction of Novolac vinyl ester and furan resin occured via the addition reaction of acrylate-styrene copolymerization and Diels-Alder reaction of acrylate portion of Novolac vinyl ester and furan resin. Such reaction route is shown below:



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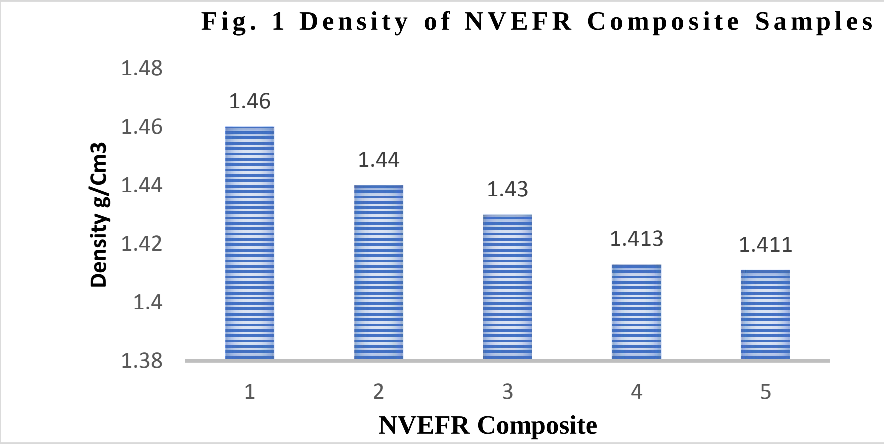
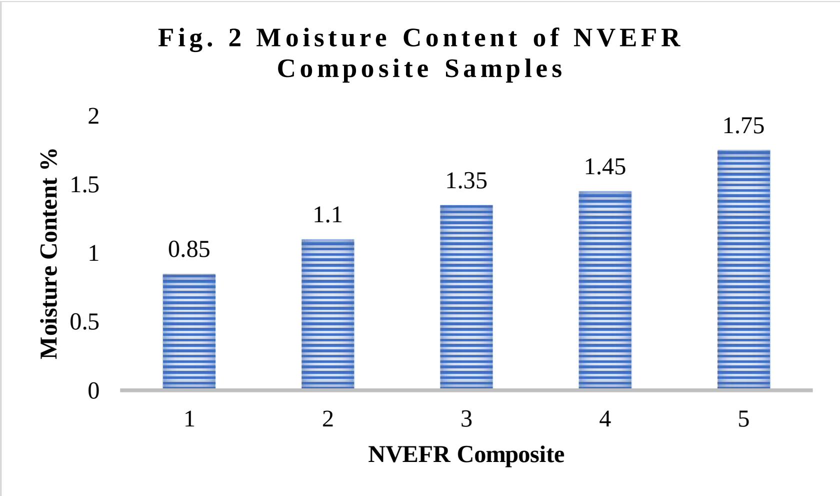
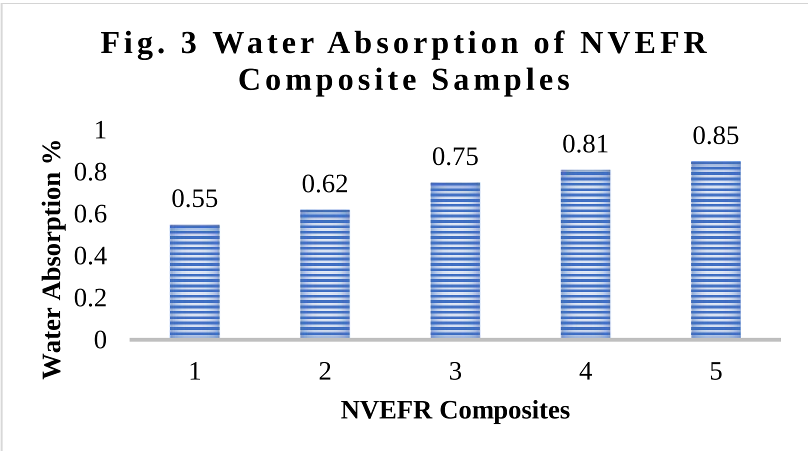
The physical properties of NVE:FR of 5 samples were evaluated as density, moisture absorption and moisture content. The density of all the NVEFR laminates in the range of 1.411 to 1.46 g/Cm^3 presented in Fig-1.



The moisture content for all five laminates are displayed in Fig.2. The results show that moisture content for GRC is high those have FR content more. It is in the range of 0.85 to 1.75%.

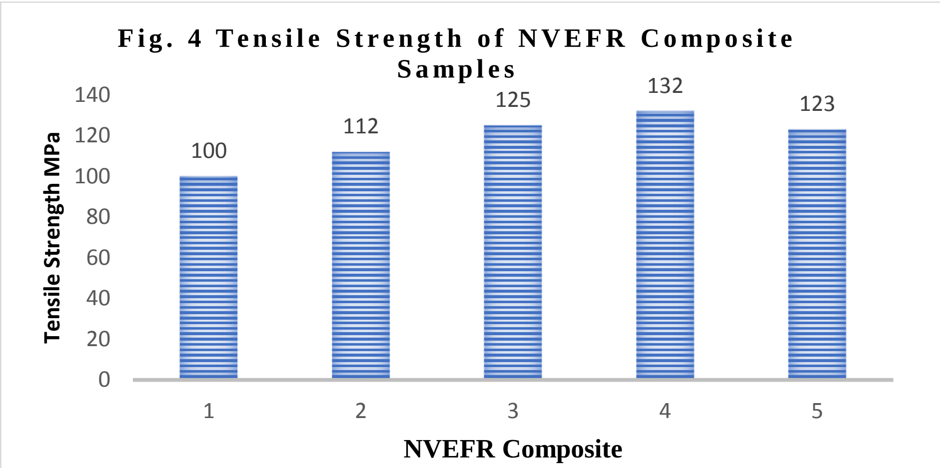


The moisture absorption data for all GRC samples are presented in Fig. 3. The values are found to be 0.55 to 0.85%.

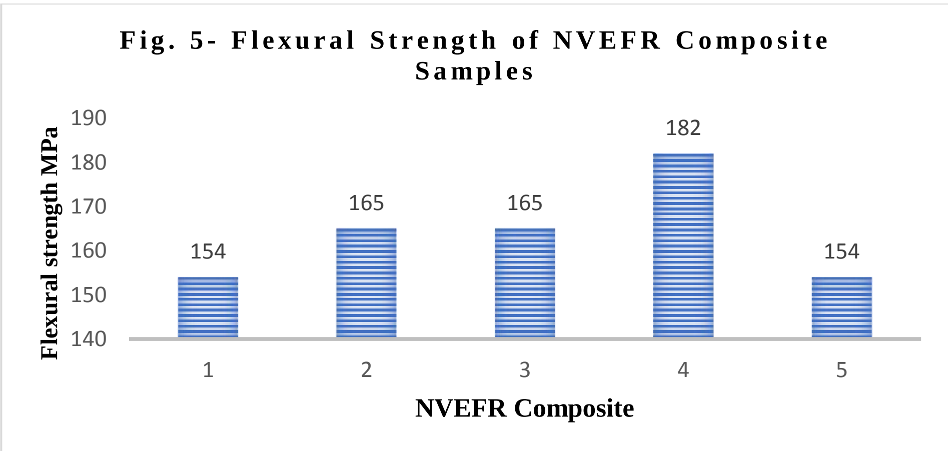


The moisture absorption is vital property for furniture making. The values are quite low (Fig. 3). This might be responsible for the presence of less voids present in GRC due to interacting NVR:FR blending as well as free –OH groups into cross linked system. Thus, the produced composites may have good outdoor applications. Overall conclusion is that the proportion of FR is high, the water absorption is high.

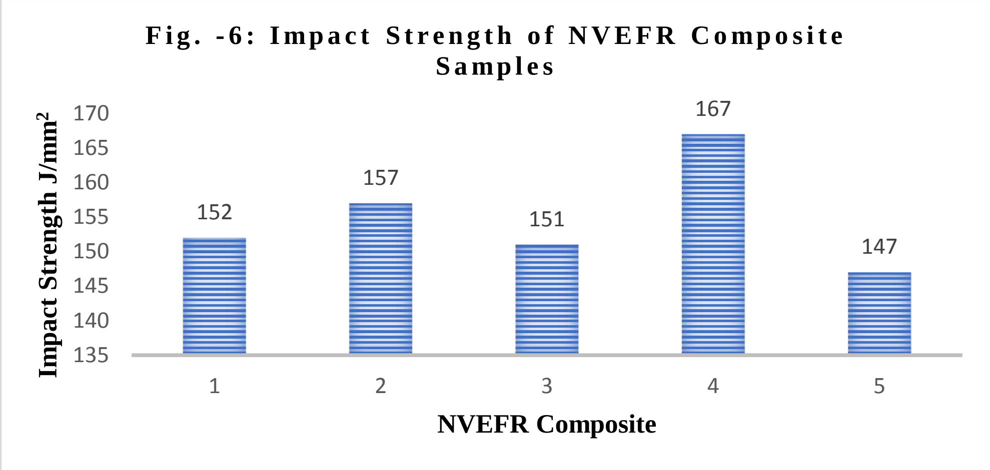
The results of mechanical properties of all five NVEFR composite samples are shown in histographically in figures 4 to 7. As shown in Fig. 4, the tensile strength of NVE-FR composites are good and increases with increase in the percentage of FR. The vinyl ester furan resin composite with 30% highest tensile strength i.e., 132 MPa. This indicates the ability of the blend of resins in enhancing the tensile strength. The uniform dispersion of the NVEFR and strong adhesion and capability with segments of FR might be responsible to improve tensile strength. These values also fall in the range indicated in literature.[13]



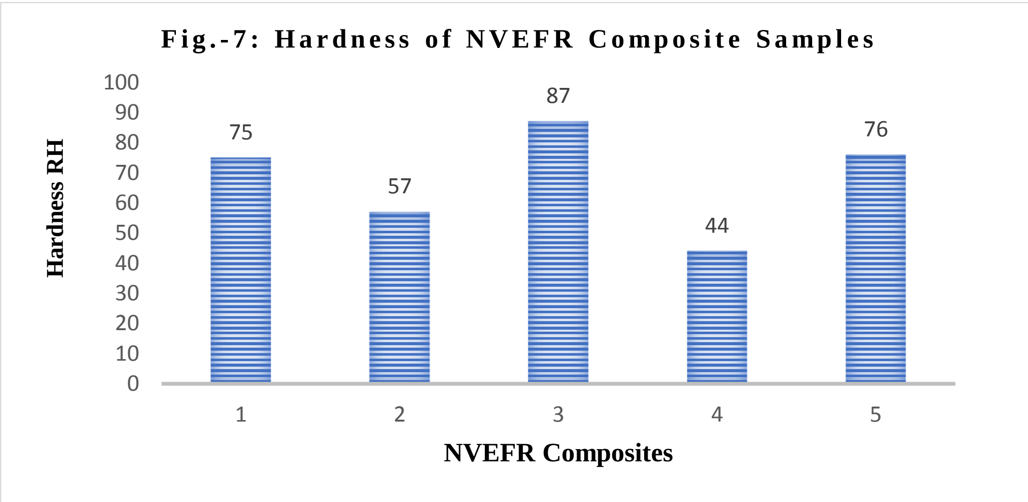
As shown in Fig. 5, there is good flexural strength (FS) of NVEFR composites in the range of 154-182 MPa. NVEFR with 30% FR have highest FS of 177 Mpa. The uniform dispersion of NVEFR and compatibility may enhance the FS of composite. At higher percentage of FR, the lower value of FS might be due to poor mobility of FR matrix into glass cloth and thus decrease in the surface area of NVEFR interaction.



The practical data for impact strength of NVEFR composite samples are dispersed in Fig. 6. The figure shows that a steady increase in FR content. However, there is decrease in impact strength for further increase in FR. This may be arised from the weak interfacial interaction between the NVE and FR matrix.[14,15]



The Rockwell hardness of NVEFR composite samples exhibited good value in the range of 44 to 87 RH. The FR with 30% composite (NVE:FR-4) have highest hardness i.e., 89 RH. This indicates the good adhesion and compability of NVE with FR matrix at 30% FR. The lower value of hardness may be due to weak adhesion of FR with glass.



CONCLUSION

In this study, the reinforced laminates have been fruthfully fabricated and characterised. All the produced laminates have good mechanical properties. The highest mechanical properties observed with FR of 30% composite. In whole experiment NVE-FR system may form interacting and interpenetrating network. This might be responsible for good mechanical strength.

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