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Effect of Nanoiron Particles Reinforced Blended Polymer Nanocomposites on Mechanical Properties

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Abstract: ***We report on the preparation of nanocomposites using epoxy and vinylester blend in which nanoiron filler was dispersed to evaluate the mechanical performance. Different weight ratios viz.1,2,3,4,5 & 7wt.% of nanoiron particles were dispersed into the matrix to prepare different systems to evaluate the optimization of performance. Nanoiron was also prepared by chemical reduction method and nanocomposites were prepared by hand layup process. Three blade Mechanical stirrer and ultra-sonicator was used while preparing the modified to keep the non-homogeneity nanoparticle at bay. Mechanical properties such as hardness, tensile strength, flexural strength, impact strength and compression strength properties were performed. Nanoiron particles functionalization nepotisms the fabrication composites through the remedial temperature at low as associated to the as-synthesised nano particles occupied vinylester nano composites. Mechanical property values improved owing to the standardized nanoparticle chemical bonding and spreading between vinylester matrix and nanoparticles. Then the combination nanoiron particles into the vinylester resin matrix it becomes magnetically harder. Machines generated mechanical property values were compared and analysed with system generated software analysis of variance (ANOVA) values. Machine values and ANOVA values were measured for the specimens of epoxy+vinylester+nanoiron, where the nanoiron is varying viz. 1, 2, 3, 4, 5 and 7 wt.%.***

Keywords : Mechanical properties, nanocomposites, vinylester, ANOVA

I. INTRODUCTION

Today we know well, even though not understood completely, that nanoparticles can influence polymer properties by crystallization, electrical, thermal conductivity, mechanical strength, melt processing and visco-elasticity among others [1-2]. The best two examples of the above mentioned are the large mechanical degradation stability and higher stiffness rendered to polymer matrices by nanoiron filler particles adding in small amounts. characterization of mechanical tests namely tensile, flexural, compression, hardness and impact tests on epoxy/vinylester nanocomposites at different nanoiron variations viz., 1, 2, 3, 4, 5 and 7 wt.% are presented [3-6]. Results and discussions are presented based on the type of test and their experimental results and graphs. In this case at least six samples are tested at classified interval [7-9].

Organic materials with both conducting ferromagnetic properties have received tremendous attention due to their potential applications in batteries, electrochemical display devices, molecular electronics, nonlinear optics, sensors, electrical- magnetic shields and microwave-absorbants [10-11].

The opportunity of changing the polymer blending offers cost concert steadiness and couture the expertise to create goods for precise use of applications which spreads performance of manufacturing resin's, progresses definite properties and delivers revenue for engineering and user plastics ravage reutilizing [13]. Polymer blends blend with firewood and other fiber materials seems fairly hopeful on the source of stable act, re-utilization of plastic wastelands and recyclables afterward the finish use [14-15]. Among numerous alloys and polymer combinations, alteration of epoxy and vinylester matrix blends are striking way to indorse the act of thermosetting matrix; since their combinations are predictable to raise the tensile, flexural, impact, and moistness resistance properties and the small price vinylester with outstanding mechanical and barrier possessions of epoxy. Machine values were measured for the composition of epoxy + vinylester + nanoiron [16]. In this nanocomposite, we have taken epoxy + vinylester as constant throughout all the nanoiron variations. Mechanical properties like tensile strength, flexural strength, compression strength, hardness, and impact strength will be validating through the system software and they are comparing with system values.

II. MATERIALS AND METHODS

In the present work, a commercially available vinylester, catalyst and accelerator were purchased from the V.G.R. Enterprises, Madurai, Tamialnadu, India. vinylester monomers with two reactive viny end groups facilitate the crosslinking for network formation. The liquid resin has a density of 1.231 g/cm^3 and a viscosity of 370 centipoises (cps) at room temperature. Nanoiron particles by the regular specific surface area of 45m^2/g and a diameter of 10-15 nm remained functionalized then used as nanofillers for the manufacture of nanocomposite. Trigonox 239-A (initiator or curing catalyst, liquid, organic peroxide) was procured.

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Cobalt naphthenate was used as a catalyst promoter to decompose the catalyst at room temperature. Methacryloxypropyl-trimethoxysilane and tetrahydrofuran were purchased from Sigma–Aldrich Chemical Company. All the chemicals were used as-received without further treatment. All the tests were carried at ambient conditions. In this case, six identical specimens were tested. At room temperature all the tests were performed.

III. PREPARATION OF FERRITE NANOPARTICLE

Response was approved out by mixing two solutions, called as solution A (i.e. $Fecl_3$ $6H_2o$) and solution B (i.e. $Fecl_2$ $4H_2o$) to procure nanoparticles. 0.1 Mole of 27.030 gms of solution A was added 1000 ml de-ionised water, however, 19.881 gms of solution B was added in 1000 ml de-ionised water was used to make solutions. Though solution A was dissolved in solution B globule wise by 2:1 stoichiometric ratio with strong stirring. Ammonium (45ml) were dissolved in the combination; immediately black precipitate was formed with in one second. Afterward reaction, the creation particles was separated in the solution with the solid magnet and cleaned with de-ionised water. Later Freeze and overnight was utilized to dry the particles.

IV. FABRICATION OF BLENDED/NANOCOMPOSITES

The pre-considered quantity of vinylester/epoxy (i.e. 15/85; w/w ratio) was added together in an appropriate cup. Hardener/ catalyst/ accelerator/ promoter (100:10/2/2/2) portions by weight were mixed to the improved vinylester/epoxy blender. The required dimensions of a glass mould which was used for preparing model on parity with ASTM standards and that was layered by mould freeing agent allowing to free elimination of the model. Roller and Brush was used to saturate merged. The covered mould was held below the pressure at room temperature for 24 hrs. To confirm whole preserving the mixed composite models was post cured for 1 hr at 80ºC then the testing samples of the desired dimensions was cut out in the sheet. By compounding Composites were prepared with hot press machine and extrusion. Maintained at 180ºC as the processing temperature and the pressure was practically all constant. Up to 5min of time at temperature of 180 ºC the extruded composites remained hot pressed below 10MPa into sheets of appropriate thickness for preparing the samples as per ASTM standard. The thickness and sheet size were reliant on the testing procedures used in this study.

V. DETERMINATION OF THE COMPOSITES OF MECHANICAL PROPERTIES

Determination of the Compression, flexural and tensile properties of the composites was consuming a Universal Testing Machine (Instron, Series-3369) with speed of across head 5mm/min. Three-point bending and tensile strength tests were supported on similarity with ASTM D 690, ASTM-53452 and ASTM D 53455 correspondingly. Every test was completed in a displacement precise mode on a servo-hydraulic MTS testing machine in a closed-loop. Samples were measured for Impact strength on according to ASTM D 53433 in Zwick impact strength testing machine (ZIS 250). Rockwell hardness properties were performed using Rockwell hardness testing machine (Model-2000R) according to ASTM D 256. All the tests were accomplished at a room temperature of 24 ºC

VI. VALIDATION ANALYSIS OF VARIANCE

Statistical analysis (regression and ANOVA) of the responses are carried out to estimate the coefficient polynomial of the response by regression and to check the significance of the regression coefficients of independent variables and interaction variables by ANOVA. Analysis of variance (ANOVA) table is used to determine the significance of the first degree, second degree, and cross-product terms of the polynomial. In this case, the adequacy of the model is confirmed when the Model Probability > *F* is less than 0.05. Analysis of Variance validates the results from the machine values with predicted values which are generated by system software.

VII. RESULT AND DISCUSSION

Mechanical properties

Table 1 shows the attained experimental results for the effects of different nanoiron variations viz., 1, 2, 3, 4, 5 and 7 wt.% on all the mechanical properties. Tensile properties such as tensile strength and elongation at break of the nanoiron composites containing 1%, 2%, 3%, 4%, 5% and 7% weight nanoiron as filler was restrained then the outcomes are obtainable in the **Table.1**

From the **Table.2** it has been observed the F-value Model of 4.69 indicates the model is not substantial relation to the sound. For F-value so large might arise due to sound. "Prob > F" Values less than 0.0500 specify model relations are important. Here no substantial model terms in this case. Greater than 0.1 values specify the model terms are not substantial. Model reduction may increase your model If there are many unsubstantial model terms.

From the above Table.3 it has been observed that the F-value model of 4.25 indicates that the model is not substantial relation to the sound. F-value model this value might happen due to sound so, there is a chance of 13.30 %. Model terms are substantial values when "Prob > F" less than 0.05 indication. There are no significant model terms in this case. Model terms are not significant when greater than 0.1 values imply. Model decrease may recover your model if there are many insignificant model terms.

From the Table.4 it has been observed that the F-value model of 11.50 indicates that the model is significant. F-value model this value might happen due to sound so, there is a chance of 3.92%. Model terms are substantial values when "Prob > F" less than 0.05 indication. A, A^2 are significant model terms in this case. Model terms are not significant when greater than 0.1 values imply. Model decrease may recover your model if there are many insignificant model terms.

Table.1 Mechanical properties
(Experimental results for epoxy + vinylester + nanoiron)

Filler (Wt.%)	Hardness number	Impact strength	Tensile strength	Flexural strength	Compression strength
1	87.23	140.14	38.20	17.20	101.36
2	88.52	145.35	40.53	18.52	105.96
3	92.45	152.63	44.75	24.20	111.74
4	87.41	149.20	46.63	21.03	117.45
5	86.53	147.63	43.52	22.52	115.20
7	82.30	145.52	40.32	22.01	102.36

Analysis of Hardness

Table 2 ANOVA for hardness

Source	sum of Squares	df	Mean Square	F-Value	p-value
Model	40.5889445	2	20.2944723	4.696494	0.119102
A-IN	4.92915156	1	4.92915156	1.140691	0.363817
A^2	18.0422012	1	18.0422012	4.175279	0.133615
Residual	12.9635888	3	4.32119627		
Cor Total	53.5525333	5			

Analysis of Impact Strength

Table 3 ANOVA for impact strength

Source	sum of Squares	df	Mean Square	F-Value	p-value
Model	65.45571476	2	32.72785738	4.257663	0.132974
A-IN	36.91264799	1	36.91264799	4.802075	0.116106
A^2	57.13950476	1	57.13950476	7.433447	0.072157
Residual	23.06043524	3	7.686811746		
Cor Total	88.51615	5			

Analysis of Tensile Strength

Table 4 ANOVA for tensile strength

Source	sum of Squares	df	Mean Square	F-Value	p-value
Model	44.3208469	2	22.1604235	11.5049294	0.03917192
A-IN	21.0196037	1	21.0196037	10.9126551	0.04561599
A^2	41.0620583	1	41.0620583	21.318008	0.0191194
Residual	5.7785031	3	1.9261677		
Cor Total	50.09935	5			

From the Table.5 it has been observed that the F-value model of 2.96 indicates that the model is not substantial relation to the sound. F-value model this value might happen due to sound so, there is a chance of 19.44 %. Model terms are substantial values when "Prob > F" less than 0.05 indication. There are no significant model terms in this case. Model terms are not significant when greater than 0.1 values imply. Model decrease may recover your model if there are many insignificant model terms.

From the Table.6 it has been observed that the F-value model of 21.72 indicates that the model is significant. F-value model this value might happen due to sound so, there is a chance of 1.64%. Model terms are substantial values when "Prob > F" less than 0.05 indication. A, A^2 are significant model terms in this case. Model terms are not significant when greater than 0.1 values imply. Model decrease may recover your model if there are many insignificant model terms.

From the above table.7 it indicates that the actual and predicted hardness values for the epoxy + vinylester + nanoiron with Iron Nano as an input parameter. The percentage deviation between predicted and actual values indicates accurate prediction within the limits of ± 4%.

From the table 8 it indicates that the actual and predicted impact strength values for epoxy + vinylester + nanoiron with Iron Nano as an input parameter. The percentage deviation between predicted and actual values indicates accurate prediction within the limits of ± 3%.

Analysis of Flexural Strength

Table 5 ANOVA for flexural strength

Source	sum of Squares	df	Mean Square	F-Value	p-value
Model	22.667354	2	11.33367702	2.969683	0.194411
A-IN	21.6020058	1	21.60200581	5.660221	0.097695
A^2	9.48729643	1	9.487296429	2.485889	0.212965
Residual	11.4493793	3	3.816459762		
Cor Total	34.1167333	5			

Analysis of Compression Strength

Table 6 ANOVA for compression strength

Source	Sum of Squares	df	Mean Square	F-Value	p-value
Model	214.255891	2	107.1279455	21.72365	0.016415
A-IN	81.30655669	1	81.30655669	16.48753	0.026928
A^2	207.4914333	1	207.4914333	42.07559	0.007438
Residual	14.79419238	3	4.93139746		
Cor Total	229.0500833	5			

Table 7 Actual and predicted values of hardness for epoxy + vinylester + nanoiron

Run	A:IN in %	H (actual values) MPa	H (predicted values)	% Deviation
1	1	87.23	87.7107	0.5480
2	2	88.52	89.045	0.5895
3	3	92.45	89.4524	3.3510
4	4	87.41	88.9328	1.7123
5	5	86.53	87.4864	1.0932
6	7	82.3	81.8127	0.5956

Table 8 Actual and predicted values of impact strength for epoxy + vinylester + nanoiron

Run	A:IN in %	IS (actual values) MPa	IS (predicted values)	% Deviation
1	1	140.14	141.029	0.6303
2	2	145.35	145.75	0.2744
3	3	152.63	148.821	2.5591
4	4	149.2	150.243	0.6941
5	5	147.63	150.015	1.5898
6	7	145.52	144.611	0.6285

From the table 9 it indicates that the actual and predicted tensile strength values for the epoxy + vinylester + nanoiron with Iron Nano as an input parameter. The percentage deviation between predicted and actual values indicates accurate prediction within the limits of ± 4%.

From the table 10 it indicates that the actual and predicted flexural strength values for the epoxy + vinylester + nanoiron with Iron Nano as an input parameter.

The percentage deviation between predicted and actual values indicates accurate prediction within the limits of ± 13%. The percentage deviation between predicted and actual values which indicating the prediction should be within ± 5%, due to climatically conditions it may occurs more percentage.

Table 9 Actual and predicted values of tensile strength

Run	A:IN in %	TS (actual values) MPa	TS (predicted values)	% Deviation
1	1	38.2	37.8326	0.9711
2	2	40.53	41.7021	2.8106
3	3	44.75	44.1734	1.3053
4	4	46.63	45.2462	3.0583
5	5	43.52	44.9208	3.1183
6	7	40.32	40.0749	0.6116

Table 10 Actual and predicted values of flexural strength

Run	A:IN in %	FS (actual values) MPa	FS (predicted values)	% Deviation
1	1	17.2	17.2288	0.1671
2	2	18.52	19.6607	5.8019
3	3	24.2	21.4205	12.9758
4	4	21.03	22.5081	6.5669
5	5	22.52	22.9236	1.7606
6	7	22.01	21.7382	1.2503

Table 11 Actual and predicted values of compression strength

Run	A:IN in %	CS (actual values) MPa	CS (predicted values)	% Deviation
1	1	101.36	99.7175	1.6471
2	2	105.96	108.114	1.9923
3	3	111.74	113.368	1.4360
4	4	117.45	115.478	1.7076
5	5	115.2	114.445	0.6597
6	7	102.36	102.948	0.5711

It indicates from the above table.11 that the actual and predicted compression strength values for the epoxy + vinylester + nanoiron with Iron Nano as an input parameter. The percentage deviation between predicted and actual values indicates accurate prediction within the limits of ± 2%.

VIII. CONCLUSIONS

Two highly nano disperse nano particles Fe_2O_3 & f-Fe_2O_3 was synthesized by chemical reduction method and then disolve into the epoxy/vinylester polymer. Compression strength, flexural strength, Tensile strength, Impact strength, and hardness physiognomies were studied for Fe_2O_3 & f-Fe_2O_3/vinylester nanocomposites. Tensile strength, Flexural strength, compression strength, hardness and impact strength mechanical properties were studied on machine generated values and software (ANOVA) generated values. These values were compared and evaluated to percentage deviation to test the results might be accurate. In the case of these values, ANOVA seemed to reduce p-values but the machine generated values were more as expectations.

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