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Research Paper

PERFORMANCE EVALUATION OF EMU FEATHER FIBER REINFORCED POLYMER COMPOSITES

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The use of composite materials in engineering field is increasing the value of day by day. A composite material is a materials system composed of a combination of two or more micro or macro constituents that differ in form and chemical composition and which are essentially insoluble in each other. It consists of mainly two phases, i.e., Matrix and Fiber. The fibers may be polymers, ceramics, metals such as nylon, glass, graphite, Aluminum oxide, boron, Aluminum, etc. Now a day's Jute, Coir, Silk, Banana, Bamboo, fibers and animal feathers are also utilized as a fiber. The main added advantages of composite material over conventional materials is the light weight, highly corrosion resistance stable mechanical properties over cretin range of temperature and s additional improvement where resistance thermal insulation thermal conductivity high specific strength. In the present work Epoxy, Polyester is used as matrix and Emu feathers are used as fibers for producing the composites. The specimens are produced by varying the weight percentages 0%, 2%, 4%, 6%, 8% of fiber loadings. The mechanical properties such as Tensile strength, Impact strength and Flexural strength are evaluated. Its resistance to chemicals such as Hcl, Noah, NaCl, and H_2O is also tested and compare with Epoxy and Polyester resins of Mechanical properties and Chemical resistance values checked.

Keywords: Emu feathers, Epoxy, Polyester resins, Mechanical properties, Chemical resistance, Results & Discussion, Conclusion

INTRODUCTION

Throughout history, technological innovations have helped humankind improve their standards of living, with the rapidness of development and research is so impressive. However, certain technology also creates a negative environmental impact.

Therefore efforts are invested in making use of natural based biodegradable and sustainable material that exist in nature rather than create a new material.

Textile structures reinforced composites, specifically with fibers, have gained importance in engineering and technical applications due to their light weight, higher tenacity, superior elasticity and strength, good

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thermal resistance, low density, and better rigidity.

The EFF are commonly described as a waste by-product and they are contributing to environmental pollution due to the disposal problems.

There are two main Emu feather disposal methods that exist, a burning and burying. Both of them have negative impact on the environment.

Recent studies on the Emu feather waste demonstrated that the waste can be a potential composite reinforcement.

The composite reinforcement application of the EFF offers much more effective way to solve environmental concerns compared to the traditional disposal methods. Some of the advantages of the EFF are inexpensive, renewable, and abundantly available.

The EFF as a composite reinforcement having certain desirable properties including lightweight, high thermal insulation, excellent acoustic properties, non-abrasive behavior and excellent hydrophobic properties.

The EFF has the lowest density value compared to the all natural and synthetic fibres. Castanet all found that the EFF keratin biofibres allows an even distribution within and adherence to polymers due to their hydro-phobic nature and they reported that EFF reinforced composites have good thermal stability and low energy dissipation.

The main purpose of this study is to manufacture and determine the mechanical properties of the EFF reinforced Epoxy and polyester thermo set composites.

The Emu feather fibers were tested and analyzed to identify the following properties; linear density, breaking elongation and tenacity.

The EFF reinforced composites were fabricated by hand layup technique in the laboratory.

Epoxy and polyester resin were used as matrixes and the composites were manufactured by using three different fiber loading proportions.

EXPERIMENTAL METHODS

Materials

The composite matrixes are epoxy resin (LY 556) and hybrids RTM type polyester resin manufactured and supplied by Poliya Polyester Industry and Trade Ltd. Co. (Istanbul, Turkey). The general polyester obtained from local market. The Emu feathers were collected from a farm house in Local Area. The Emu feathers were collected from a commercial poultry units were washed by using a lab dyeing machine with a polar solvent (NaCl). After the washing process the Emu features were rinsed and left to dry for 24 hours under normal room temperatures.

Methods

Prior to the composite manufacturing, the EFF samples were conditioned for 48 hours at 65% RH and 20 °C.

The fiber linear density values were determined in accordance with ASTM D1577and the tensile properties of the fibers were determined in accordance with ASTM D638M The composites were fabricated with different fiber loadings (0%, 2%, 4%, 6% and 8%). Initially, Epoxy resin was mixed in hardener using a mixer in a bowl after the Epoxy, polyester, resin was also prepared separately. The matrix materials were prepared in a portion of 73% of resin matrix and 23% of hardener by volume. Then, the fibres were spread into mould and covered with the matrix. The composites were

Table 1: Mechanical Properties of Cured Resins

Resins	Flexural Strength, MPa	Flexural Modulus, MPa	Elongation at Break, %	Tensile Strength, MPa	Elongation at Break, %	Izod Impact Strength, j/mm^2
Epoxy	160	3600	8	82	7	18
Polyester	107	3217	5.2	62	3.2	9

Table 2: Mechanical Properties of Emu Feather Fibers

Properties	EFF
Linier density, Tex	50-110
Fiber length, cm	1
Elongation, %	11.85
Breaking tensile, kg	0.85

manufactured by using a hand lay up technique with size mould of 160 mm length x 12.5 mm width x 3 mm thickness. The composites were kept for 24 hours at room temperature and subsequently put in an oven for 8 hours at 80 °C for curing. The control and the EFF reinforced composites were evaluated in accordance with ASTM D638/ D638M (Tensile Properties of Polymer Matrix Composite Materials), EN ISO 14125 (Fibre-reinforced plastic composites-Determination of flexural properties), and EN ISO 179-1 (Determination of Charpy impact properties).

Compounding

The Epoxy resin mixed into Emu feather fibre at 2, 4, 6, 8 wt% using two hand layup technique and the compounding room temperature.

EXPERIMENTAL PROCEDURE

The matrices material used for the fabrication of emu fiber reinforced composite consist of low temperature curing epoxy resin (Araldite LY556) and corresponding hardener (primary amine HY 951) supplied by Ecams construction chemicals Pvt. ltd. Resin and hardener and mixed in ratio of 10:1 by weight as recommended. Density of epoxy region system is 1.2 gra/cc. The waste emu father collect from poultry is cleaned with a mild detergent and is dried.

The fiber are free from dirt And excess pigments and the short fibers obtained. To prepare the composite slabs these fibers in pre – determined weight proportion 8% are resin forced with random orientation into the epoxy resin.

A block of size (160mm x12.5mmx3mm is thus cast with hand lay up technique, in a rubber mold.

Casting

Initially rubber mold is gently cleansed and is set free from moisture and dirt. Later a thin layer of wax is applied on inner walls of the rubber mold along with its base plate, for easy removal of cast after curing. Applied wax is allowed to dry and set.

Laminates

After wax being applied initially the proportionate mixture of resin and hardener (10:1 wt %) is taken and is poured in mold to form a uniform layer and short fibers and is spread a layer of matrix.

Curing

The casting is put under load for about 24 hours for proper curing at room temperature after this, molds are cured further a constant temperature of up to 90^{0}C in order to treat the cast and also to remove it from mold easily after wax is melt.

CHARACTERIZATION TECHNIQUES

Mechanical Properties

Specimen EFF samples were conditioned for 48 hours at 65% RH and 20 °C. The pure Epoxy and polyester composite samples are the test prepared.

Figure 1: Pure Polyester of Composites

Figure 2: Pure Epoxy of Composites

Tensile Strength

Tensile properties were evaluated to ASTM D638M using rectangle shaped samples and an INSTRON Universal testing machine model 3342 tensile tester with a cross head speed 5 mm/min. The dimension of the specimen was 160 mm in length, 12.5 mm in width and 3 mm thickness.

Figure 3: Epoxy of Composites Tensile Strength

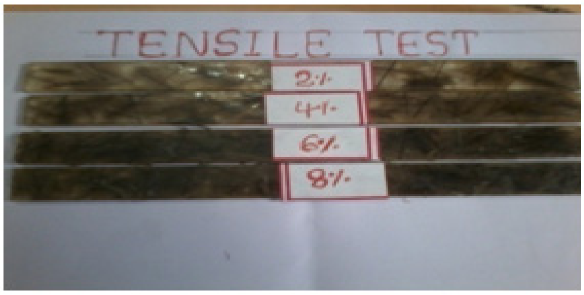


Figure 4: Polyester of Composites Tensile Strength

Flexural Strength

Flexural properties are evaluated according to ASTM D790M using an INSTRON universal testing machine model 3342 with a cross head speed of 1.3 mm/min the dimension of the specimen were 100 mm in length, 25 mm in width and 3 mm thickness.

Charpy Impact Strength

Charpy impact properties were evaluated according to ASTM D256M using impact tester model impact 104 with a notch angle 45° and depth of 2.54 mm. The dimension of the specimen was 63.5 mm in length, 12.5 mm in width and 3 mm thickness.

RESULTS AND DISCUSSION

The Emu feather fiber properties are given in Table 2. It was found that the Emu feather fiber does not have constant liner density from

Figure 5: Epoxy of Composites Flexural Strength

Figure 6: Polyester of Composites Tensile Strength

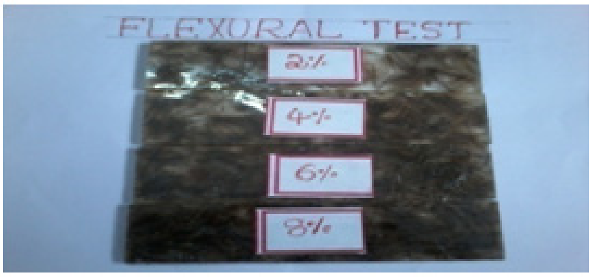


Figure 7: Epoxy of Composites Impact Strength

Figure 8: Polyester of Composites Impact Strength

quilt to fiber end the diameter decreases due to liner and density was ranged from 110 Tex to 50 Tex. The breaking tensile of EFF is better than most of the natural based fibers, especially bio degradable composite reinforcement fibers kenf baste and jute. The composite thicknesses were 3 mm, for tensile, flexural specimens and composite thicknesses were 12 mm, for impact specimen. The mechanical properties of the Epoxy and polyester composites are shown in Table 3 and Table 4 respectively the results The tensile strength results of control (0%) and fiber loaded composites were demonstrated and compared in Figure 9. This results show that the control composites tensile properties were significantly higher when compared to the EFF reinforced composites. in all cases the Epoxy matrix based composites hand better tensile properties than the polyester matrix based composites it was expected that when the fiber loading percentage increases some of the mechanical properties decreases due to the random short fiber distribution inside the composite matrix and also lack of adhesion between matrix and fiber the main concerns with short fiber reinforced composites is the difficulty in controlling the random fibers within the structure.

Therefore the physical properties of the composites can be dramatically reduced. The breaking elongation results were found to be similar to tensile results when fiber loading increased the breaking elongation decreased elongation break for Epoxy is just above 9.5 at 0% the fiber loading compared to the just above 4% for polyester the lowest breaking elongation occurred at 8% EFF Reinforced Polyester composites.

The flexural strength results are demonstrated in the control composites had considerable higher flexural comparison with

Table 3: Mechanical Properties of Epoxy Composites

% of Fiber Loadings	0%	2%	4%	6%	8%
Tensile strength (N)	1840	1620	1430	1260	1150
Elongation at break (mm)	9.9	6.3	5.8	4.3	2.8
Flexural strength (N)	240	140	120	110	95
Flexural breaking point (mm)	9.5	4.5	3.6	3.2	2.8
Charpy impact (j/mm^2)	8	12	14	16	18

Table 4: Mechanical Properties of Polyester Composites

% Fiber Loadings	0%	2%	4%	6%	8%
Tensile strength (N)	1640	1560	1380	1130	1020
Elongation at break (mm)	9.4	4.2	3.2	2.8	2.2
Flexural strength (N)	210	120	90	75	50
Flexural breaking point (mm)	8.7	3.7	2.8	2.4	2
Charpy impact (j/mm^2)	2	4	6	8	16

Figure 9: % Fiber Loadings vs. Tensile Strength

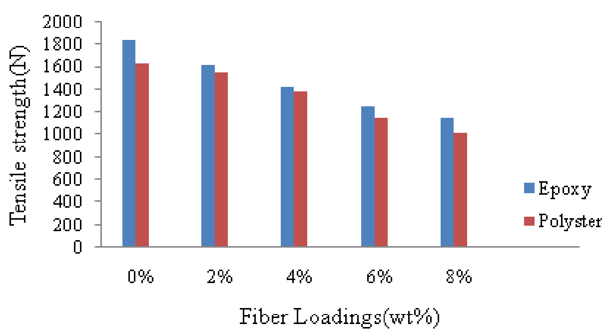


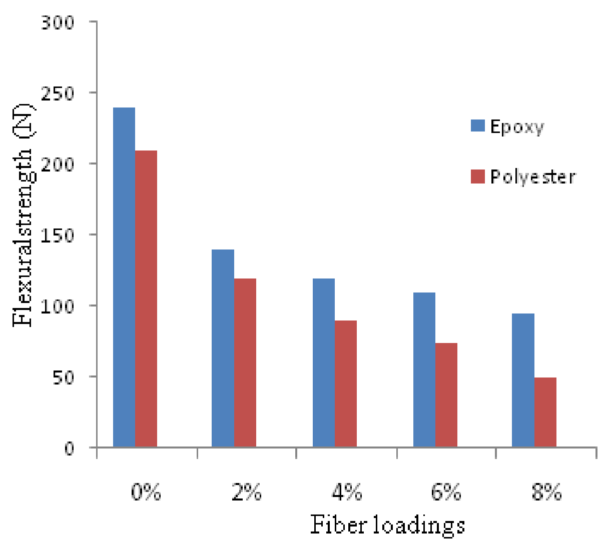
Figure 10: Tensile Strength Results of Composites

the EFF reinforced composites the flexural strength can be improved by increasing fiber loading more than 30% in this study we kept the fiber loading at maximum 8% due to the composite manufacturing method limitation the flexural strength values are reduced from 250 to 50 N which means the reinforcement materials have a positive influence on the composite physical properties. The flexural braking point values are in Tables 3 and 4 for both epoxy and polyester control compositely. Have extensively superior flexural breaking point than the EFF reinforced composites the flexural breaking point values of Epoxy resin composite increases when the fiber loading percentage rises the difference between 2%, 4% and 6%, 8% are considered the difference between 6%, 8% is very negligible.

The Charpy impact property is another key importance characteristic of the composite structure, especially due to its significance in many applications such as automotive and architecture applications.

The Charpy impact values increases with

Figure 11: Tensile Strength Results of Composites

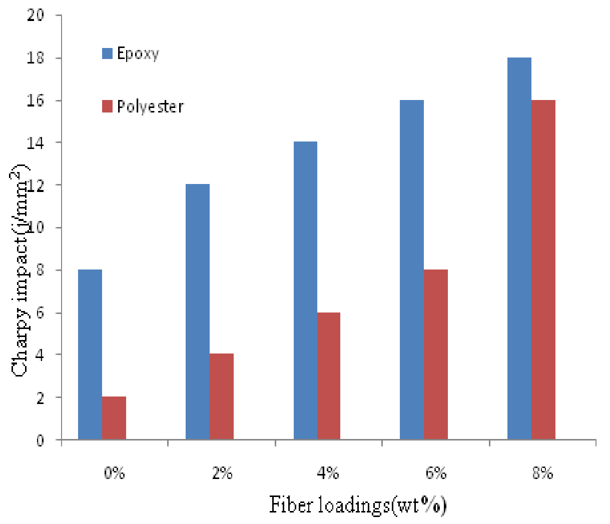


the fiber loading percentage. The 8% EFF loaded composites have enhanced impact values in comparison with the lower EFF loaded composites. The differences are obvious for polyester resin composites.

The impact values of composites increases with the fiber loadings due to the test and the random short fiber reinforcement natures. Both the impact test and the short fiber reinforcement have multidirectional characteristics. Therefore if the unidirectional short fiber percentage increases for the composite structure, the impact values will increase in relation. There is sudden in polyester values at 8% fiber loading due to the test random nature.

Figure 12: Charpy Impact Strength

Figure 13: % Fiber Loading vs. Charpy Impact Strength



CHEMICAL RESISTANCE TEST

The chemical test was studied as per ASTM D543 method.

For this purpose 1N HCl, 1N NaOH, and NaCl are selected. Also resistance towards moisture is found by testing with water.

ACIDS : HCl (5% Concentration)

BASES : NaOH, NaCl (5% Concentration)

SOLVENTS: H_2O (5% Concentration)

Figure 14: Samples are Immersed in Hcl

Table 5: Sample Values of Epoxy Composites

% of Fiber Loading	Chemical	Initial Weight (g)	Final Weight (g)	Weight of Composite Loss (g)	% Weight of Composite Loss
0	Hcl	0.52	0.44	–0.08	–15.38
2	Hcl	0.48	0.40	–0.08	–16.66
4	Hcl	0.46	0.44	–0.08	–17.39
6	Hcl	0.49	0.40	–0.09	–18.36
8	Hcl	0.52	0.41	–0.10	–21.15

Table 6: Sample Values of Polyester Composites

% of Fiber Loading	Chemical	Initial Weight (g)	Final Weight (g)	Weight of Composite Loss (g)	% Weight of Composite Loss
0	Hcl	0.36	0.34	–0.02	–5.55
2	Hcl	0.45	0.42	–0.03	–7.14
4	Hcl	0.47	0.43	–0.04	–8.51
6	Hcl	0.48	0.44	–0.04	–9.09
8	Hcl	0.49	0.43	–0.06	–13.95

Figure 15: Epoxy and Polyester Resins Chemical Resistance in Hcl

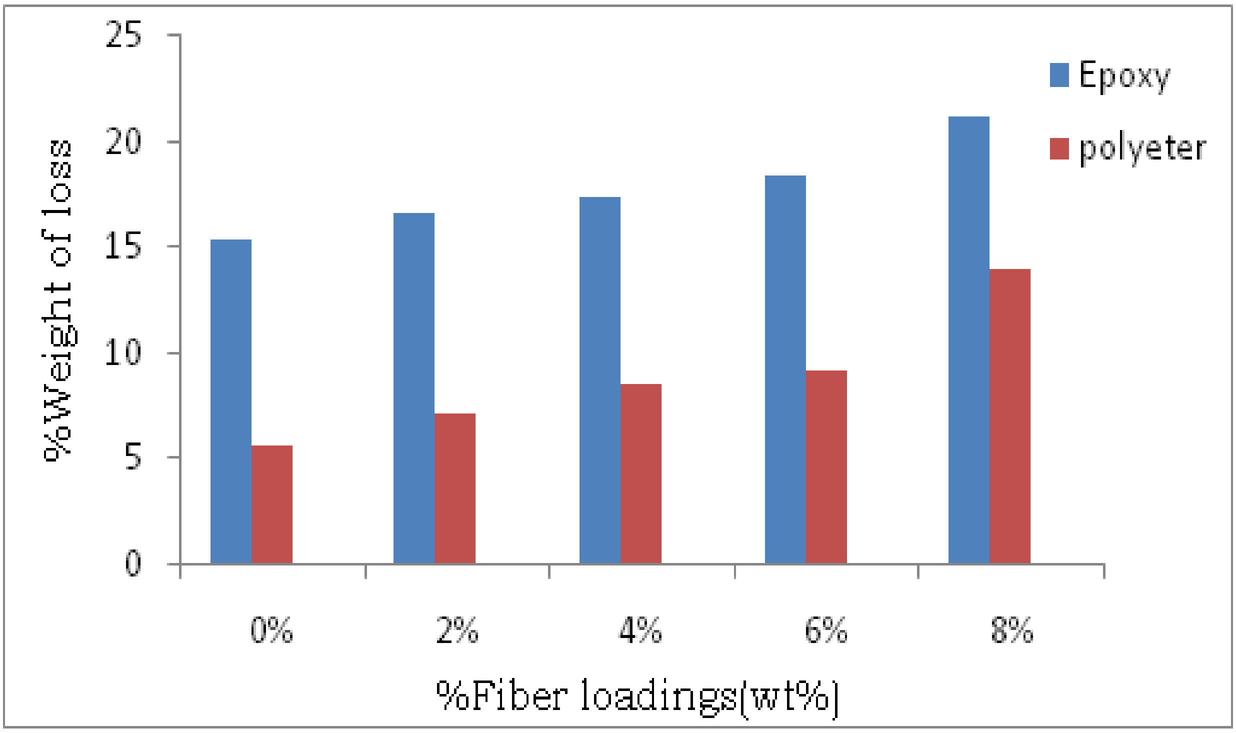


Table 7: Sample Values of Epoxy Composites

% of Fiber Loading	Chemical	Initial Weight (g)	Final Weight (g)	Weight of Composite Loss (g)	% Weight of Composite Loss
0	NaOH	0.58	0.52	–0.03	–5.17
2	NaOH	0.79	0.72	–0.07	–8.86
4	NaOH	0.84	0.76	–0.08	–9.52
6	NaOH	0.87	0.77	–0.10	–11.49
8	NaOH	0.91	0.78	–0.13	–14.28

Figure 16: Samples are Immersed in NaOH

Table 8: Sample Values of Polyester Composites

% of Fiber Loading	Chemical	Initial Weight (g)	Final Weight (g)	Weight of Composite Loss (g)	% Weight of Composite Loss
0	NaOH	0.85	0.76	–0.09	–10.58
2	NaOH	0.87	0.75	–0.12	–13.79
4	NaOH	0.98	0.82	–0.16	–16.32
6	NaOH	0.97	0.80	–0.17	–17.52
8	NaOH	0.98	0.79	–0.19	–19.38

Figure 17: Epoxy and Polyester Resins Chemical Resistance in NaOH

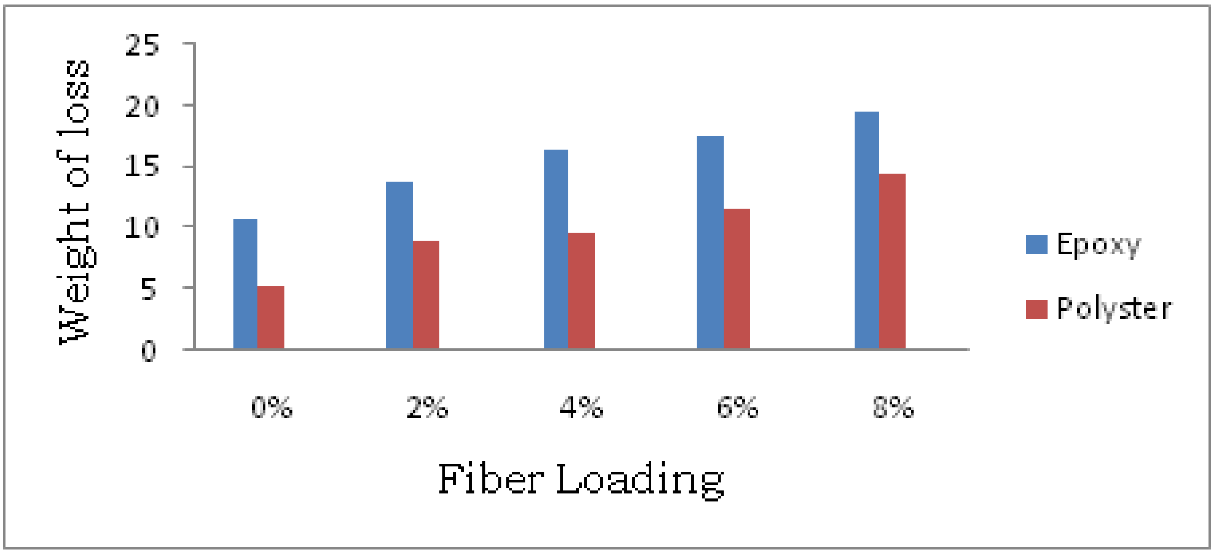


Table 9: Sample Values of Epoxy Composites

% of Fiber Loading	Chemical	Initial Weight (g)	Final Weight (g)	Weight of Composite Loss (g)	% Weight of Composite Loss
0	H_2O	0.43	0.45	0.02	4.6
2	H_2O	0.45	0.48	0.03	7.14
4	H_2O	0.49	0.54	0.05	10.20
6	H_2O	0.53	0.60	0.07	13.20
8	H_2O	0.55	0.65	0.1	18.10

Table 10: Sample Values of Polyester Composites

% of Fiber Loading	Chemical	Initial Weight (g)	Final Weight (g)	Weight of Composite Loss (g)	% Weight of Composite Loss
0	H_2O	0.42	0.43	0.01	2.32
2	H_2O	0.41	0.44	0.03	6.81
4	H_2O	0.42	0.46	0.04	8.69
6	H_2O	0.42	0.47	0.05	10.63
8	H_2O	0.43	0.49	0.06	12.24

Figure 18: Epoxy and Polyester Resins Chemical Resistance in H_2O

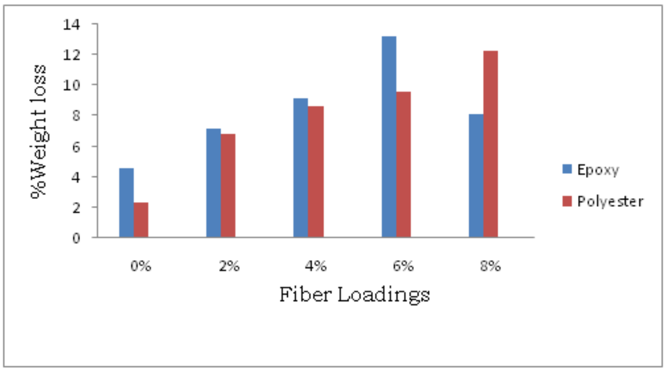


Table 11: Sample Values of Epoxy Composites

% of Fiber Loading	Chemical	Initial Weight (g)	Final Weight (g)	Weight of Composite Loss (g)	% Weight of Composite Loss
0	NaCl	0.65	0.63	–0.02	–3.07
2	NaCl	0.75	0.69	–0.06	–8.00
4	NaCl	0.78	0.70	–0.08	–10.25
6	NaCl	0.81	0.72	–0.10	–12.34
8	NaCl	0.84	0.73	–0.11	–13.09

Table 12: Sample Values of Polyester Composites

% of Fiber Loading	Chemical	Initial Weight (g)	Final Weight (g)	Weight of Composite Loss (g)	% Weight of Composite Loss
0	NaCl	0.76	0.74	–0.02	–2.63
2	NaCl	0.78	0.74	–0.04	–5.12
4	NaCl	0.81	0.75	–0.05	–6.17
6	NaCl	0.87	0.80	–0.07	–8.04
8	NaCl	0.91	0.81	–0.10	–10.98

The pre weighed samples were immersed in chemicals for 24hours, removed, washed thoroughly with distilled water and dried immediately by pressing on both sides of filter paper. The final weight of samples and weight loss or gain was determined. This test was repeated for four samples and average was taken.

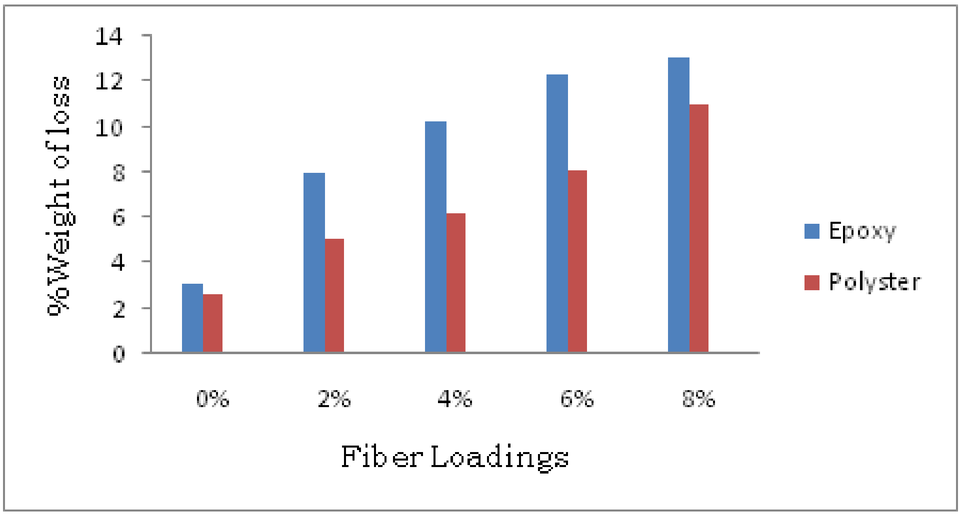
Weight gain or loss is calculated by using:

$$\text{Chemical Absorption} = \frac{\text{Wetweight–reconditionedweight}}{\text{Reconditioned weight}} \text{X100}$$

CONCLUSION

The composite samples are prepared by using the Epoxy and polyester resins by

Figure 19: Epoxy and Polyester Resins Chemical Resistance in NaCl



varying the Weight Percentage of Emu feather Fiber. The above said samples are subjected to Tensile strength, Flexural strength, Impact strength and chemical resistance tests.

For Epoxy Emu feather fiber composites as the fiber loading is increased from 0 to 8% the Tensile strength was reduced from 51.21MPa to 26MPa. The Flexural strength is also reduced from 79.6MPa to 18.71MPa,when the Fiber loading increased from 0 to 8%.The Impact strength is increasing from 8J/mm^2 to 18 J/mm^2 for increasing in fiber weight Percentage from 0 to 8%.

For Polyester Emu feather fiber composites as the fiber loading is increased from 0 to 8% the Tensile strength was reduced from 35.85MPa to 22.98MPa.The Flexural strength was also reduced from 75.45MPa to 18.50MPa,when the Fiber loading increased from 0 to 8%.

The Impact charpy strength is increasing from 2J/mm^2 to 8 J/mm^2 for increasing in fiber weight Percentage from 0 to 8%.

Among the above two pure resins the Epoxy posses better Tensile strength, Flexural strength, Impact Charpy strength and also Epoxy Emu Feather Reinforced composites shows better mechanical properties than Polyester Emu Feather Reinforced composites for all Percentage of fiber loadings.

Chemical resistance for the above samples with the solution of HCl, NaOH, NaCl (5%concentration) pure water tested. The Chemical resistance is increasing with addition of fiber for all the three solutions of HCl, NaOH, and NaCl. When the samples are immersed in water for 24hrs the moisture absorption is increased along with swelling by decreasing the water resistance strength.

By comparing the Epoxy Emu Feather Reinforced composites shows better Chemical resistance than Polyester Emu Feather Reinforced composites

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