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Moisture Absorption and Chemical Resistance Studies on Pineapple Fiber Reinforced Vinyl Ester Composite

M. S. Abilash, V. Arumugaprabu*, N. Rajini, P.Sivaranjana, Marxim Rahula Bharathi B

Abstract: *This research discusses the moisture absorption and chemical resistance studies on pineapple fiber reinforced Vinyl ester composite. A composite material was developed with pineapple fiber as reinforcement in the Vinyl ester matrix. Pineapple fiber of three different weight percentages 30%, 40% and 50% wt as well as fiber length of 30mm, 40mm and 50mm respectively taken for the study. The moisture absorption and the chemical resistance property of the composite were investigated as per the ASTM standard. Five different chemicals were used to investigate the chemical resistance behavior of the composite. The initial and final weight loss of the composites was calculated to find the moisture resistance property. The chemical resistance property was increased with the addition of treated jute fiber. All the tested composites exhibited positive results on the chemical resistance test.*

Keywords: *Chemical treatment, Pineapple fiber, Hybrid composite, chemical resistant test.*

I. INTRODUCTION

Most of the researchers are focused on the replacement of the synthetic fiber polyester-reinforced composites as the natural fiber reinforced polymer composites [NFPC]. Researchers focus on these materials [NFPC] having a high specific strength, modulus property, low weight ratio and costs. Environmental concerns are also good in natural fiber composites materials when compared to the synthetic fiber polyester [8] such as low density, low cost, biodegradability, flexibility during the process, minimal health hazard and high flexural modulus [9]. This research focuses on the study of pineapple fiber with Vinyl Ester resin that belongs to fiber reinforced polymer composites.

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***** Correspondence Author (s)

M. S. Abilash, School of Automotive and Mechanical Engineering. Kalasalingam Academy of Research and Education, Krishnankoil-626 126, India. Email: abilash.nivas@gmail.com

V. Arumugaprabu, School of Automotive and Mechanical Engineering. Kalasalingam Academy of Research and Education, Krishnankoil-626 126, India. Email: v.arumugaprabu@klu.ac.in

N. Rajini, School of Automotive and Mechanical Engineering. Kalasalingam Academy of Research and Education, Krishnankoil-626 126, India. Email: rajiniklu@gmail.com

P.Sivaranjana, School of Automotive and Mechanical Engineering. Kalasalingam Academy of Research and Education, Krishnankoil-626 126, India. Email: p.sivaranjana@klu.ac.in

Marxim Rahula Bharathi B, Department of Mechanical Engineering, Aditya College of Engineering, Surampalem, Andra Pradesh, India. Email: bmrb.2009@gmail.com

II. MATERIALS AND METHODS

A. Material used

Pineapple was belongs to the Bromeliaceae family. Pineapple fiber was extracted from the pinapple leaves. This pineapple fiber was purchased from the local vendor in Chennai, India Marts Pvt Ltd. The matrix used in the composites is Vinyl ester resin was procured from St.Marys Fiber Pvt. Ltd Cochin, India. Methyl ethyl ketone peroxide (MEKP) is used as an accelerator in vinyl ester resin. The property of MEKP is a colourless oily liquid and also slightly less sensitive to shock and temperature and more stable in storage in nature. Cobalt naphthenate is a mixture of cobalt derivates of naphthenic acid. These coordination complexes are widely used as oil drying agents for autoxidative cross-linking of drying oils. It is used as a catalyst in vinyl ester. N-N dimethyl aniline is an organic chemical compound, a substituted derivate of aniline. It consists of a tertiary amine, featuring a dimethyl amino group attached to a phenyl group. This oily liquid is colorless when pure but commercial samples are often yellow. It is used as a promoter in vinyl ester resin.

B. Composite fabrication and mechanical testing

For the present research pineapple fiber hybrid composite was fabricated using compression moulding process. Nine different combination composites were fabricated on the varying proportion of pineapple fiber as reinforcement. Pineapple fiber cut into various lengths of 30mm, 40mm and 50mm were used as reinforcement.

C. Moisture and chemical resistance properties

The moisture resistance studies have been carried out as per ASTM D570-98, and as per ASTM D 543-87 standard, chemical resistance characteristics of the composites was found. The effect of few solvents such as benzene and ammonia, the effect of few acids such as acetic acid, nitric acid and hydrochloric acid were studied on the prepared composites. The composites were weighted initially and subjected to immersion in chemical solutions for 24 hours at room temperature. At the end of 24 hours, the specimens were taken out, dried, pressed and weighted. Using the measured weight of samples before and after the moisture, chemical test, the percentage of weight loss/gain was determined by using the following equation.

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Percentage of Weight loss

= Final weight- Initial Weight/ Initial weight × 100 .

III. RESULTS AND DISCUSSION

A. Moisture Absorption of Pineapple fiber reinforced polyester composites

The moisture absorption resistance of different composite combinations of pineapple fiber composites is presented in table.1. It is observed clearly from the results that in all cases, the positive values indicate that there is a weight gain takes place which proved that the composite is high resistance. Among all the composite combination of 30% wt and 50mm, fiber length possesses a high percentage of weight gain of about 30% which resists more moisture content. In general, the natural fibers can absorb more water, using reinforcing this with Vinyl ester matrix yields more resistance. The matrix holds the fiber firmly together creates a dense area where more amount of water absorbed with ease. As evident for this statement in the case of 50% wt and 50mm fiber length possess good moisture resistivity. Interestingly in all the cases, the percentage of weight gain in the range of 1% to 30% noted. Apart from this few composite combinations shows an increase and decrease trend in weight gain which is due to the random arrangement of the fibers were predominantly a significant reason.

Table-1 Moisture Absorption of pineapple fiber reinforced Vinyl ester composites subjected to 24 hours

Composite Combinations	**Initial weight**	**Final weight**	**% of weight gain/loss**
30% wt and 30mm fiber length	1.107	1.113	0.54
30% wt and 40mm fiber length	0.876	0.895	2.17
30% wt and 50mm fiber length	0.735	0.956	30.07
40% wt and 30mm fiber length	0.809	0.856	5.81
40% wt and 40mm fiber length	1.295	1.302	0.54
40% wt and 50mm fiber length	1.223	1.235	0.98
50% wt and 30mm fiber length	0.705	0.847	20.14
50% wt and 40mm fiber length	0.808	0.857	6.06
50% wt and 50mm fiber length	0.913	1.07	17.20

B. Chemical Resistance of Pineapple fiber reinforced Vinyl ester composites

The chemical resistance of different composite combinations of pineapple fiber composites subjected to acids is presented in table.2, and the chemical resistance of different composite combinations of pineapple fiber composites subjected to solvents is shown in table3 respectively.

Table-2 Chemical Resistance of pineapple fiber reinforced Vinyl ester composites subjected to acids for 24 hours

	HCL		
Composite Combination	**Initial weight**	**Final weight**	**% of weight gain/loss**
30% wt and 30mm fiber length	0.969	0.974	0.52
30% wt and 40mm fiber length	0.823	0.849	3.12
30% wt and 50mm fiber length	0.967	1.514	56.57
40% wt and 30mm fiber length	0.996	1.063	6.73
40% wt and 40mm fiber length	1.359	1.374	1.10
40% wt and 50mm fiber length	1.26	1.277	1.35
50% wt and 30mm fiber length	0.733	0.855	16.64
50% wt and 40mm fiber length	0.82	0.895	9.15
50% wt and 50mm fiber length	0.808	0.95	17.57
	Nitric Acid		
Composite Combination	**Initial weight**	**Final weight**	**% of weight gain/loss**
30% wt and 30mm fiber length	1.177	1.2	1.95
30% wt and 40mm fiber length	0.739	0.782	5.82
30% wt and 50mm fiber length	0.897	1.337	49.05
40% wt and 30mm fiber length	0.947	1.038	9.61
40% wt and 40mm fiber length	1.369	1.384	1.09
40% wt and 50mm fiber length	1.28	1.308	2.18
50% wt and 30mm fiber length	0.734	0.898	22.34
50% wt and 40mm fiber length	0.988	1.064	7.69
50% wt and 50mm fiber length	0.738	0.879	19.11
	Acetic Acid		
Composite Combination	**Initial weight**	**Final weight**	**% of weight gain/loss**
30% wt and 30mm fiber length	1.153	1.155	0.17
30% wt and 40mm fiber length	0.752	0.718	-4.52
30% wt and 50mm fiber length	0.678	0.946	39.53
40% wt and 30mm fiber length	0.902	0.933	3.44
40% wt and 40mm fiber length	1.376	1.384	0.58
40% wt and 50mm fiber length	1.144	1.561	36.45
50% wt and 30mm fiber length	0.786	0.917	16.67
50% wt and 40mm fiber length	0.889	0.949	6.75
50% wt and 50mm fiber length	0.801	0.903	12.73

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Table-3 Chemical Resistance of pineapple fiber reinforced Vinyl ester composites subjected to solvents for 24 hours

Composite Combination	Benzene		
	Initial weight	**Final weight**	**% of weight gain/loss**
30% wt and 30mm fiber length	1.024	1.032	0.78
30% wt and 40mm fiber length	0.916	0.939	2.51
30% wt and 50mm fiber length	0.719	0.826	14.88
40% wt and 30mm fiber length	0.93	1.008	8.38
40% wt and 40mm fiber length	1.387	1.39	0.22
40% wt and 50mm fiber length	1.287	1.098	-14.69
50% wt and 30mm fiber length	0.748	0.808	8.021
50% wt and 40mm fiber length	0.9481	1	5.47
50% wt and 50mm fiber length	0.871	1.011	16.07
Composite Combination	**Ammonia**		
	Initial weight	**Final weight**	**% of weight gain/loss**
30% wt and 30mm fiber length	1.213	1.218	0.41
30% wt and 40mm fiber length	0.718	0.804	11.97
30% wt and 50mm fiber length	1.018	1.51	48.33
40% wt and 30mm fiber length	0.881	0.923	4.77
40% wt and 40mm fiber length	1.25	1.5261	22.08
40% wt and 50mm fiber length	1.301	1.322	1.61
50% wt and 30mm fiber length	0.784	0.884	12.76
50% wt and 40mm fiber length	0.918	0.945	2.94
50% wt and 50mm fiber length	0.91	1.08	18.68

The stability of the composites to the chemical attack can be found through the chemical resistance test. This ensures the acceptability of these composites in the chemical orientated applications. The results of the chemical-resistant test are shown in the table. The numeric value in the table is the weight loss and weight gain of the composite for 24 hours of chemical immersion. It is noted that the maximum number of composites has gained weight after the chemical resistance test and any only few composites showed negative signs. The negative sign indicates the inability of composite against the chemical etching. When the composite surface exposed to the chemical, the chemical molecules starts attacking the surface. When the composite surface is damaged, and fiber reinforcement is exposed. At this condition, the chemical quickly degrades the fiber and contaminate the material. This leads to weight loss in the material. This occurred mainly because of the uneven bonding between the fiber and matrix. But the majority of the composites showed positive results against the chemical resistant test. This ensures that these composites were stable and resistant to the chemical attack. It is noted that more weight gain was noted on the nitric acid solution at 30% wt and 50mm fiber length. The increase in weight is mainly because of the hydrophilicity nature of the fiber. Overall, all the developed composites showed better resistance to the chemical attack. The improved bonding at high weight percentage reduced the possibility of a chemical attack on the fiber reinforcement.

IV. CONCLUSION

In the present work, Pineapple fiber reinforced Vinyl ester composite is successfully fabricated, and the chemical resistance test was done. From the experimental result outcome, the following conclusions were drawn. The composites showed excellent resistance to the chemical treated fiber reinforcement. This chemical resistance test indicates that the untreated fiber composites are strongly resistant to almost all substances, and maximum weight gain was noted on HCL acid. The above observations suggest that these composites can be used in chemical erosion resistance applications.

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AUTHORS PROFILE

M.S. Abilash has received master degree in CAD/CAM from Kumaraguru College of Engineering & Technology, Coimbatore, India. He is currently as the Research Scholar at Kalasalingam Academy of Research and Education in the Department of Mechanical Engineering. He has 7 years of Academic Experience

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V. Arumugaprabu working as Associate Professor in the Department of Mechanical Engineering, School of Automotive and Mechanical Engineering, Kalasalingam Academy of Research and education, Krishnankoil, Tamil Nadu, India. He graduated B.E in Mechanical Engineering at AKCE in the year 2005, Graduated M.E in CAD/CAM at Mepco Schlenk Engg., college, Graduated Ph.D in Composite Materials in the year 2014 at Kalasalingam University, India. Also worked as Post Doc Research Associate in Precision Machining Lab, School of Mechanical Engineering, Yeungnam University, South Korea in the year 2017. He has very vast research experience in the field of composite materials with nearly 50 publications in various reputed SCI Journals and has nearly 40 publications in various International and National conferences.

N. Rajini working as Professor in the Department of Mechanical Engineering, School of Automotive and Mechanical Engineering, Kalasalingam Academy of Research and education, Krishnankoil, Tamil Nadu, India.. He has very vast research experience in the field of composite materials with nearly 100 publications in various reputed SCI Journals and very vast teaching experience of 15 years.

P. Sivaranjana working as assistant professor in the Department of Chemistry, School of Advanced Sciences, Kalasalingam Academy of Research and education. Her area of research is in biocomposites and she has very vast teaching experience of 13 years.

MarximRahulaBharathi B has received his Ph.D. from Indian Institute of Technology, Kharagpur, India in Mechanical Engineering and his M.E. from AC College of Engineering and Technology, Karaikudi, Tamilnadu, India. He is currently working as Assistant Professor in the Department of Mechanical Engineering at Aditya College of Engineering, Surampalem, India. He has 6 years of research experience, and 2 years of Academic experience.