HARDNESS, CHEMICAL RESISTANCE AND VOID CONTENT OF REINFORCED COW DUNG-GLASS FIBER POLYESTER HYBRID COMPOSITES

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Abstract

In this paper, Hardness, Chemical Resistance and Void Content of hybrid composites with and without alkali treatments were studied. Variation of the above mentioned mechanical properties and chemical resistance were studied with different Cow dung percentage of weight at 5%, 7%, and 10% at constant glass fiber reinforced into the polyester matrix. It is observed that mechanical properties were optimally improved at 7% when compared with 5% and 10 % weight of Fiber. Chemical resistance was also significantly improved for all chemicals except sodium carbonates and toluene. It was observed that the Void content% is reduced in treated composite when compare with the untreated composite. The effect of alkali treatment on the bonding between cow dung/glass composites was also studied. Scanning electron microscope (SEM) were also conducted on the cross sections of fractured surfaces in order to rate the performance hybrid composites were also identified.

Keywords: Cow dung, Glass fiber, Hybrid composites, mechanical properties, Chemical resistance, void content

I. INTRODUCTION

In every automobile and aircraft parts manufacturing industries, the glass with natural fibers are used because of their adaptability to different situations and the relative ease of combinations with other materials to serve specific purpose and exhibit desired properties. Unprecedented plastics usages are inevitable in these days as it is versatile material that lends itself to many uses. The turnaround in favor plastic happened not just because of color and durability for household products but also because plastics as an accessory became fashionable and trend setters. Today Polymer composites find their way into several new applications from golf clubs and tennis rackets to Jet Ski, aircraft, missile, spacecraft and marine applications. Not only with that, the other uses include spaceships, transportation, chemical equipment and machinery construction, electrical and electronics equipment, fishing rods and storage tanks. A composite is made by combining two or more dissimilar materials in such a way that the resulting material is capable with some superior and improved properties. Owing to these superior properties, polymer composites find various applications in our daily life. Composites are light weight, high strength to weight ratio and stiffness properties have come a long way in replacing the conventional materials such as metals and wood. Composites materials are attractive because they combine material properties not found in nature. Such materials often results in light weight structures having high stiffness and tailored properties for specific applications, thereby saving weight and reducing energy needs. In fiber reinforced composites, the fibers serves as reinforcement by giving strength stiffness to the structure while the plastic matrix serves as the adhesive to hold the fibers in place so that suitable structural component can be made. Fiber reinforced polymer composites have potential application in structural and non-structural areas as they have interesting properties such as high specific stiffness and strength, good fatigue performance and damage tolerance, corrosion resistance, low thermal expansion, non-magnetic properties and low energy consumption during fabrication. There are two types of fibers, that are used as reinforcements; natural and synthetic fibers. A lot of work has been done on the composites based on these fibers [1–4]. In recent years, there is growing interest in the use of natural fibers as reinforcing components for thermo plastics and thermosets. The growing interest in natural fibers is mainly due to their economical production with few requirements for equipment and low specific weight, which results in a higher specific strength and stiffness when compared to synthetic fibers composites. Also, they offer safer handling and working conditions compared to synthetic fibers. Natural fibers from renewable natural resources offer the potential to act as a biodegradable reinforcing materials alternative for the use of synthetic fibers. These fibers offer several advantages including high specific strength and modulus, low cost, low density, renewable nature, biodegradability, absence of associated health hazards, easy fiber surface modification, wide availability and relative non abrasiveness. The physical and mechanical properties of natural fibers are mainly depended on their physical composition such as structure of fibers, cellulose content, angle of fibrils, and cross section. Jute has good physical and mechanical properties compare to other natural fibers. The physical and mechanical properties of jute fiber and oil palm EFB fiber identified [5,6].Composites materials comprising two or more fibers in a single matrix, which are called hybrid composites have been attracting the attention of researchers [7–9]. Hybridization with more than one fiber type in the same matrix provides another dimension to the versality of fiber reinforced composite materials. Properties of the hybrid composite may not follow from a direct consideration of the independent properties of the individual components. [10,11] studied the tensile, flexural, and chemical resistance properties of waste silk fabric-reinforced epoxy laminates and also studied the impact, compression, density, void content, and weight reduction Studies on waste silk fabric/epoxy composites.[12,13] studied the chemical resistance of kapok/glass and kapok/sisal fabrics reinforced unsaturated polyester hybrid composites and they also studied the compressive, chemical resistance, and thermal properties on kapok/sisal fabrics polyester composites. Various researcher studied chemical resistance, physical and mechanical properties of natural fiber reinforced polymer composites [14–20]. Several authors made large quantity of work on this Hybrid composites but the main intend and scope of the author is to build a composite system which has a high performance, biodegradable and cost-effective. In this study, the authors developed Cow dung/glass hybrid composites as a function of fiber Weight. Six different samples were prepared in which three treated hybrid composites samples and three untreated hybrid samples as a function of fiber weight of 5%, 7%, and 10% respectively. Deviation of hardness, chemical resistance and Void Content was studied at different fiber weight. The effect of alkali treatment on the bonding between cow dung/glass composites was also studied. Scanning electron microscope (SEM) were also conducted on the cross sections of fractured surfaces in order to rate the performance hybrid composites were also identified.

II. METHODOLOGY

2.1Materials

Cow dung obtained from neighborhood sources and some of these fibers were soaked in 5% NaOH solution for 30 min. To remove any slippery material and hemi cellulose, cleaned thoroughly in purified water and dried up under the sun for one day. The glass chopped strand mat was used in manufacture the hybrid composite in different fractions. The unsaturated polyester resin obtained from Sree Composites world. Secunderabad, A.P, India, Methyl Ethyl Ketone Peroxide as accelerator and Cobalt Naphthenate as catalyst, which are obtained from M/S Bakelite Hylam Hyderabad, A.P, India, were used. Acetic acid, nitric acid, hydrochloric acid, ammonium hydroxide, aqueous sodium carbonate, aqueous sodium hydroxide, carbon tetrachloride, benzene, toluene, and distilled water were supplied by Aldrich Company.

2.2. Preparation of the Composite and test specimen

In this present work the composites were prepared by hand lay-up technique. The matrix of unsaturated polyester and monomer of styrene are mixed in the ratio of 100:25 parts by weight respectively. Later cow dung is mixed systematically and then the accelerator of methyl ethyl ketone peroxide 1% by weight and catalyst of cobalt naphthenate of 1% by weight were added to the combination and mixed carefully. The releasing agent of silicon is sprayed to glass mould and the matrix mixture is poured in to the mould. The fiber is added to matrix combination, which was poured in the glass mould. The excess resign was removed from the mould and glass plate was placed on the top the casting were allowed to cure for 24hrs at room temperature and then casting is placed at a temperature of 70^{o}C for 3 hrs. The composite were released from mould and are cut to prepare test specimens.

After curing, the plate was detached from the mould box with simple tapering and it was cut into samples for

Hardness Test and Chemical Resistance Test with dimensions of ASTM D 785-08 and ASTM E 18-11 (10×10×6mm3) and ASTM D 543-87(5x5x3mm3). For consideration sake the specimen for matrix material were also prepared in similar lines. Scanning electron microscope analysis the cryogenically cooled and fractured specimen surfaces were gold coated and the fracture surface was observed using scanning electron microscope.

2.3 Rockwell Hardness Test

The hardness of treated and untreated samples reinforced with Cow dung/glass Polyester-based hybrid composites was measured using Rockwell hardness testing machine supplied by M/s. PSI sales (P) Ltd., New Delhi. In each case, five samples were tested and the average value tabulated. Test specimens were made according to the ASTM D 785-08 and ASTM E 18-11 (10×10×6mm3) [21, 22]. The diameter of the ball indenter used was 0.25 inches and the maximum load applied was 60 kg as per the standard L-scale of the tester. The testing was carried out at room temperature for all the samples. All the readings were taken 10 s after the indenter made firm contact with the specimen. All the sample surfaces were rubbed with smooth emery paper, which facilitates accurate reading. Cow dung-glass fibers impregnated in a unidirectional manner with different Cow dung fiber weight% are given in Table.1

2.4. Chemical Resistance Test

To study the chemical resistance of the composites, the test method ASTM D 543-87 was employed. Three acids, three alkalis and four solvents were used for this purpose. Acetic acid, nitric acid, hydrochloric acid, ammonium hydroxide, aqueous sodium carbonate, aqueous sodium hydroxide, carbon tetrachloride, benzene, toluene, and distilled water were used after purification. In each case, the samples (5x5x3) mm3 were pre-weighed in a precision electrical balance and dipped in the respective chemical reagents for 24 hrs. They were then removed and immediately washed in distilled water and dried by pressing them on both sides with a filter paper at room temperature. The treated samples were then reweighed and the percentage loss/gain was determined using this equation.

$$\text{Weight loss (\%)} = \frac{\text{Final weight} - \text{Original weight}}{\text{Original weight}}$$

2.5. Void Content:

For determination of voids in composites, ASTM D 2734-94 method was used. The void content was determined from the theoretical and experimental density of the composites through below equation

$$\text{Void Content} = (\rho_{theoritical} - \rho_{experimental})/\ \rho_{theoritical}$$

2.6. Scanning Electron Microscopy Analysis

A Joel JSM-6400 Japan scanning electron microscope (SEM) at 20 kV accelerating voltage equipped with energy dispersive spectroscopy (EDS) to identify the fractured surfaces were gold coated with a thin film to increase the conductance for SEM for analysis.

III. RESULTS AND DISCUSSION

3.1. Rockwell Hardness Test

From Table 1, it was observed that 7% fiber weight composites had a higher hardness than 5% and 10% fiber weight composites. It was observed that the treated composites posses' higher hardness than untreated as alkali treatment improves the adhesive characteristics of cow dung fiber surface by removing hemicellulose and lignin. This surface offers an excellent fiber matrix interface adhesion and results in the increase in the mechanical properties. The effect of fiber Weight on hardness measurements of Cow dung/glass Polyester hybrid composites is shown in Figure 1

3.2. Chemical Resistance Test

Chemical resistance tests are used to find the ability of a composite to withstand exposure to acids, alkalis, solvents and other chemicals. The chemical resistance tests of these hybrid composites were performed in order to find out whether these composites can be used for making articles that are resistant to chemicals. The weight loss/gain for the Treated and Untreated samples Of Cow dung/glass fibers reinforced hybrid composites with different chemicals were shown in Table 2.From this table it was clearly evident that weight gain is observed for almost all the chemical reagents except sodium carbonate and toluene

. **Table 1: Hardness of untreated and treated Polyester-based Cow dung/glass fiber hybrid composites with different fiber weight**.

S. no.	Cow dung fiber Weight%	Untreated Composite	Treated Composite
1	5	112	115
2	7	114	118
3	10	106	110

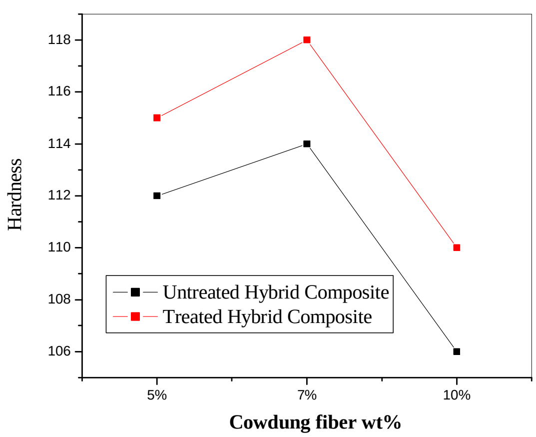

Figure 1: Hardness of untreated and treated Polyester-based Cow dung/glass fiber hybrid composites with different fiber weight

. The weight increase of the composites was larger for aqueous solutions, and this was to be expected as a result of the hydrophilicity of the fiber. It is also observed from the table that treated composites also have weight loss in sodium carbonate. The reason is attack of the carbonated hydrocarbons on the cross-linked polyester hybrid system. The positive values indicate that the composite materials were swollen with gel formation rather than dissolving in chemical reagents. It was further observed that composites were also resistant to water. This study epitomes clearly that the cow dung/glass hybrid composites are substantially resistant to almost all chemicals except sodium carbonate and toluene. Therefore, observations suggest that these hybrid composites can be used in aerospace, automobile, and marine applications for making water and chemical storage tanks.

Table 2: Chemical resistance of Polyester based treated and untreated Cow dung/glass hybrid fiber composites.

Name of the chemical	-) (%)	
	Treated	Untreated
Hydrochloric acid	+1.273	+1.985
Acetic acid	+0.441	+0.549
Nitric acid	+2.178	+2.479
Sodium hydroxide	+0.768	+0.914
Sodium carbonate	-0.445	-0.657
Ammonium hydroxide	+0.460	+0.621
Benzene	+12.426	+13.235
Toluene	- 05.810	- 07.879
Carbon tetrachloride	+2.545	+3.858
Distilled water	+1.623	+1.948

3.3. Void content

Most of the composites suffer to exhibit their exotic properties like mechanical and physical properties due to the presence of void content in the composites it reduces the mechanical and physical properties of the composites. At the time of manufacturing due to the impregnation of fiber into the matrix or during manufacturing of fiber reinforced composites, the trapped air or other volatiles exist in the composites. The most common cause of voids is the incapability of the matrix to displace all the air which is entrained within the woven or chopped fibers as it passes through the matrix impregnation. The void content (%) of Untreated and Treated composite samples with different fiber weight% is shown in Table 3. It is observed that the void content% in both Untreated and Treated samples is decreased with increasing cow dung fiber percentage. The effect of alkali treatment clearly indicates that the void content % is significantly higher at Untreated Composite when compare with the Treated Composite. Due to eliminating the hemicellulose content of the Cow dung fiber in treated composites it greatly reduces the void content in it. This helps for to show the significant improvement in mechanical and physical properties.

Table 3: Void Content% of Untreated and Treated Composites with Cow dung fiber weight %

S. no.	Cow dung fiber Weight%		Treated
1	5		1.27
2	7	3.42	1.12
3	10	2.36	0.82

3.4. Scanning electron microscope Analysis

The scanning electron macrographs of fiber surfaces of the untreated and treated fibers were shown in the Figure 2 & Figure 3 respectively. Significant changes were observed in each case. For example, the content of white components belonging to the hemicellulose in the untreated fiber (figure 2) decreased on the alkali treatment (figure 3). This indicates the elimination of some surfaces held hemicellulose by the NaOH solution. It can also observed from the graphs after treatment surface were become rough that may be sound great in building strong interface. It can also observe that the white layer (corresponding to hemicellulose) is decreased considerably upon alkali treatment. This is as expected since the hemicellulose is soluble in aq NaOH solution. A rough and cellulose removed surface can be seen in the later figure, where as white cellulose flakes can be seen on the former microgram was the clear indication of the decrease in composites behavior.

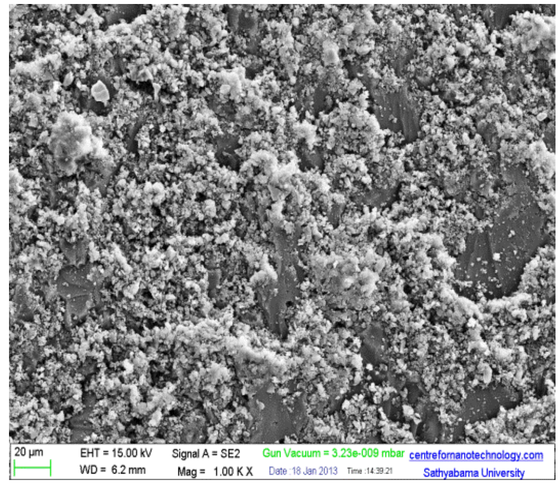

Figure 2: SEM micrograph of the untreated cow dung fiber

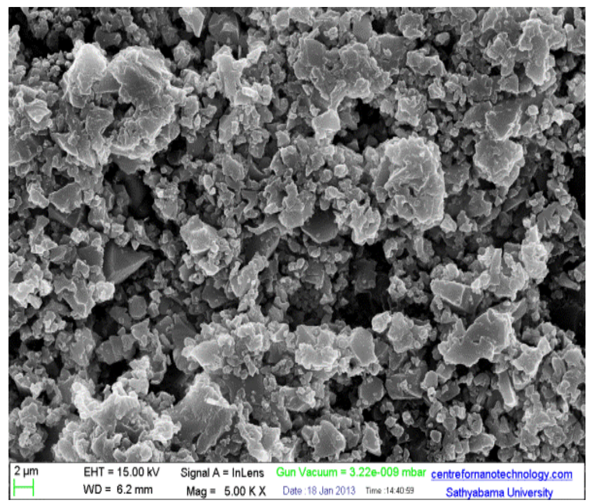

Figure 3: SEM micrograph of the treated cow dung fiber

IV. CONCLUSIONS

It is observed with the effect of alkali treatment, Hardness of the Untreated and Treated Composites is very high at 7% weight of the cow dung fiber and later with increasing of the cow dung fiber weight% Hardness is decreased. Ii is clearly evident that weight gain is observed for almost all the chemical reagents except sodium carbonate and toluene. The weight increase of the composites was larger for aqueous solutions, and this was to be expected as a result of the hydrophilicity of the fiber. The Void content % is decreased with increasing of the fiber weight% in both untreated and

and treated composites. The effect of alkali treatment clearly indicates, the void content% is higher at untreated composites when compare with the treated composites. Because due eliminating of the hemicellulose content of the fiber with the alkali treatment. From the observationof the SEM micrograph of the fractured surface the both untreated and treated composites, the hemicellulose content is removed from the fiber in treated composite when compare with the untreated composite.

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