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Article

Mechanical Investigation of Polymer Hybrid Composites with Effect of Filler Loading

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ABSTRACT

The mechanical investigation of polymer hybrid composite materials under varying filler loading conditions was conducted. The hybrid composites were formed which constituted by S-glass fiber with natural reinforcement of hemp fabric with natural filler of seashell reinforced epoxy system. The tensile, flexural, hardness, and impact properties of hybrid specimens were tested as per the ASTM standard. The secondary reinforcement as seashell filler was used to form hybrid at varying weight percentage, namely, 3%, 6%, and 9%. Scanning electron microscope study was also carried out on the material developed to get the understanding of fracture that has taken place in filler/matrix and reinforcement interaction under mechanical loads. The test results reveal that the mechanical properties of the hybrid composites have been greatly influenced by filler used in the material system.

Key words: Filler, Hybrid, Fiber, Epoxy.

1. INTRODUCTION

Composite materials are extending the paths of designers in every branch of engineering, and however, the amount to which this is happening can easily pass unperceived. In composites, resources are pooled in such a way as to facilitate us to make better use of their merits while minimizing to some extent the effects of their deficiencies. This process of optimization can let go a designer from the constraints linked with the collection and manufacture of predictable materials. He can make use of strength and stiff materials, with properties that can be tailored to suit particular design requirements and due to the ease with which compound shapes can be man-made, the complete rethinking of a traditional design in terms of composites can often lead to both cheaper and improved solutions [1]. Filler-based polymer composites have a good origin and as a result newer to the field usually expect to find an area of well-understood science with few challenges remaining [2]. Reinforced composites with fibers are always recognized for its lightness and enhanced mechanical abilities for various engineering applications. Natural filler such as seashell is used as secondary reinforcing materials in biodegradable type polymer composites, due to its properties when compared to other. This filler can be easily milled into particulate form; the seashell is formed by calcium carbonate in two forms aragonite and calcite or a mixture of them with other organic compounds [3]. The literature survey is based on the following aspects: Karthik *et al*. [4] have studied three body wear test on PMMA in biocomposite. The seashell filler is in nanosize with varying percentage being developed by stirring and ball milling. The result reveals that the occurrence of seashell particulate has improved wear. Reddy *et al*. [5] conducted flexural test on hybrid with epoxy resin (L12 grade), hardener (K-6), E-glass fiber, and fly ash. The results obtained show better flexural strength. Javeed and Venkateswarulu [6] have investigated the material which was composed of glass fiber-reinforced epoxy composite. The results obtained show maximum flexural strength. Varma *et al*. [7] studied the mechanical abilities of glass/jute material system. The jute was treated with chemicals. It was observed that titanate treatment of jute fabric results in improved characteristics and mechanical values of hybrid.

2. MATERIALS AND METHODS

2.1. Seashell Filler

Seashells were gathered from the beach. The seashells were cleaned thoroughly and dried before it was transformed into particulate form. Later, they were sieved to study different sizes of particles obtained to be used as filler. The scanning electron microscope (SEM) analysis was done using an SEM equipped with a field emission gun equipment and energy-dispersive X-ray (EDX) results reveal that the composition of the seashell powder containing more amounts of calcium was present followed by oxygen potassium and silica contents. Figures 1 and 2 show the EDX analysis and SEM images of seashell particulates. The particulate found to be irregular and calcium content present in higher level.

2.2. Matrix and Reinforcement System

The epoxy resin (Lapox L12) and hardener K-6 were used to form a polymer matrix system. Fibers used were plain weave woven S-glass fiber of 193 gsm and hemp in fabric form is used as a part of material system. The untreated seashell particulates obtained were used at 3%, 6%, and 9% weight percentage.

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2.3. Laminate Fabrication

S-glass fiber with hemp fabric as reinforcements and epoxy resin as matrix was used. Seashell natural filler was used at varying percent, was well mixed with the hardener at required ratio to form hybrid composites. Hand layup technique was used followed to develop laminates. Later, the specimens were cut as per ASTM [8] standards.

3. MECHANICAL TESTING

3.1. Tensile Test

The tensile test (ASTM D638 standard) was carried out using UTM on hybrid composite specimens with different compositions, as shown in Figure 3.

3.2. Flexural Test

The flexural test was performed as per ASTM D790 standard to bend and fracture. The samples prepared are shown in Figure 4.

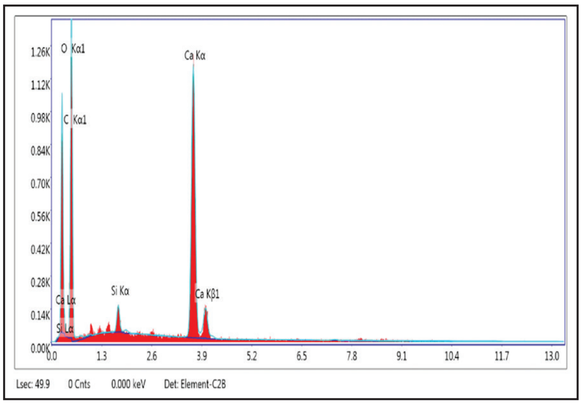

Figure 1: Energy-dispersive X-ray result of seashell filler.

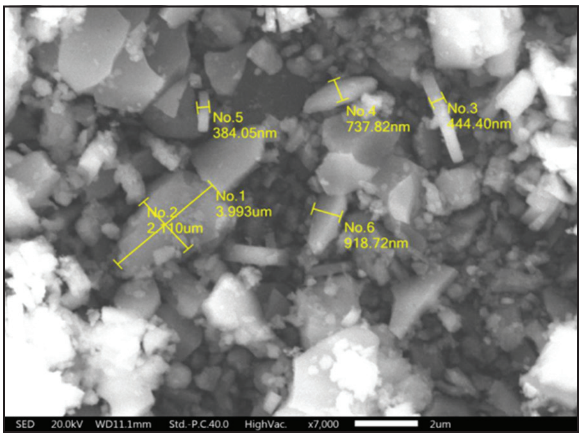

Figure 2: Scanning electron microscope images of seashell filler.

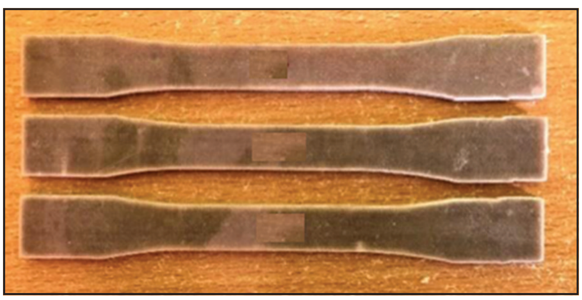

Figure 3: Samples for tensile test.

3.3. Impact Test

The Charpy impact test as per ASTM D256 was followed. The specimen will be hit by a pendulum until it fractures or breaks. The samples prepared are shown in Figure 5.

3.4. Rockwell Hardness Test

The Rockwell hardness test is done according to ASTM D785 standard. The depth of an indentation on the material that determines the hardness values. The samples prepared are shown in Figure 6.

4. RESULTS AND DISCUSSION

4.1. Tensile Test Result

The ultimate tensile stress for 6% seashell filler in hybrid composites has resulted in 102 MPa, as shown in Table 1, when compared with others. Addition of filler has increased the tensile stress, as calcium carbonate present in filler has bonded the reinforcements well with epoxy resin.

4.2. Flexural Test Result

The maximum flexural strength for 3% seashell filler in hybrid composites has resulted in 207 MPa, as shown in Table 2, when compared with others. Addition of filler has increased no much effect on the flexural stress, as filler breaking with reinforcement has raised the low resistance to flexural load.

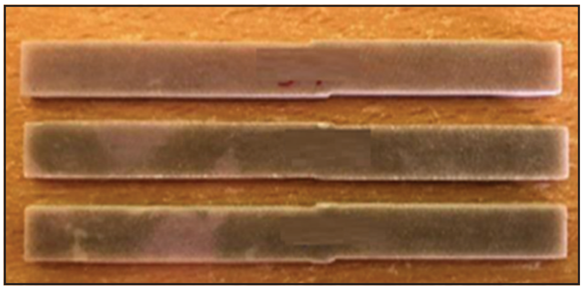

Figure 4: Samples for flexural test.

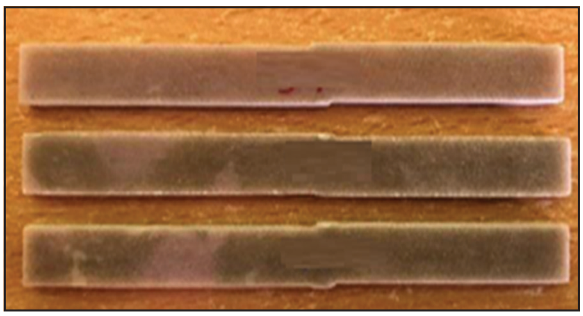

Figure 5: Samples for impact test.

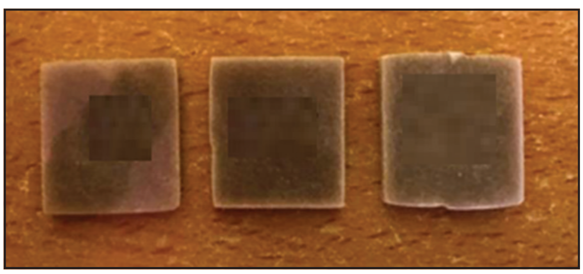

Figure 6: Samples for hardness test.

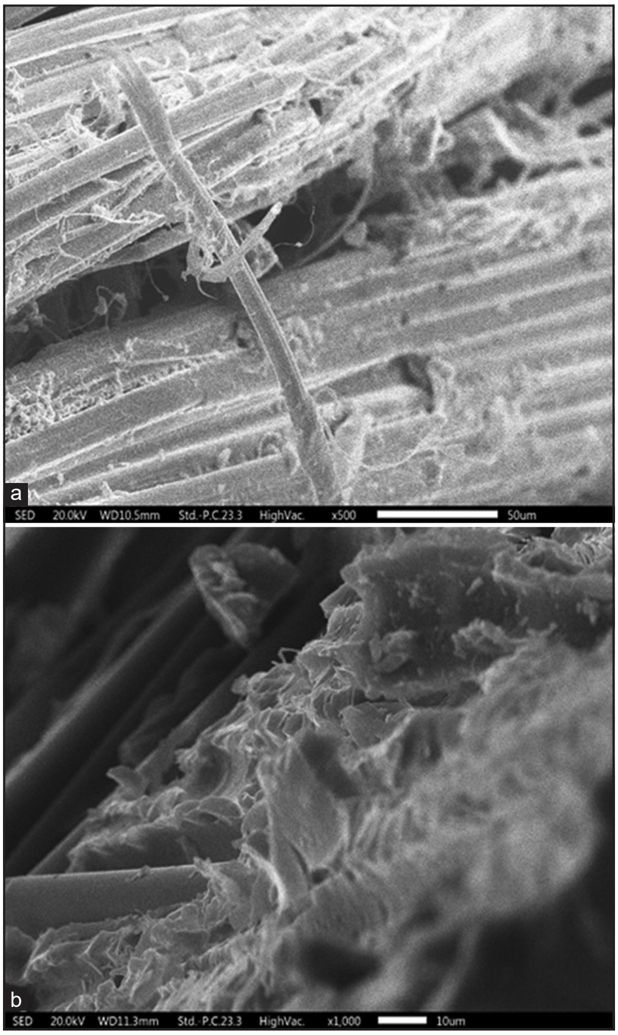

Figure 7: SEM images – fractured area of hybrid composites under tensile loading (a) low adhesion between fibers and matrix, (b) fibers exhibiting adhesion.

Table 1: Tensile properties of hybrid composites.

S. No.	Sample (%)	Maximum load in KN	Ultimate tensile stress in MPa
1.	3	5.07	97.79
2.	6	5.29	102.16
3.	9	4.59	88.50

Table 2: Flexural properties of hybrid composites.

S. No.	Sample (%)	Maximum load in N	Maximum bending stress in MPa
1.	3	351.70	207.04
2.	6	308.44	181.58
3.	9	310.85	183

4.3. Impact Test Result

The impact strength also seems to be higher for 6% seashell filler in the material system of 57 KJ/m^2, as shown in Table 3, when compared with others.

Table 3: Impact strength of hybrid composites.

S. No.	Sample (%)	Charpy impact strength (kJ/m^2)
1.	3	39.3
2.	6	57.32
3.	9	53.26

Table 4: RHN of hybrid composites.

S. No.	Sample (%)	RHN
1.	3	69
2.	6	77
3.	9	71

RHN: Rockwell hardness number

4.4. Hardness Test Result

The Rockwell hardness number, RHN is 77 for 6% seashell filler in the hybrid composite material, this value is little bit more when compared with others.

5. SEM STUDY

SEM images of hybrid composite material at breakage area for tensile tested pieces are shown in Figure 7. The basic information on crack initiation, propagation, and final fracture regions were carefully analyzed and studied in detail with the help of SEM pictures.

6. CONCLUSION

Hemp and S-glass fiber with seashell filler-reinforced epoxy polymer matrix hybrid are developed by hand layup method and tests were conducted as per ASTM standards. From the results obtained, the following conclusions are drawn. The fillers have helped in providing improved strength, which has enhanced the mechanical properties of hybrid. Due to optimized filler loading into the hybrid composite, the properties have been enhanced.

7. ACKNOWLEDGMENTS

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8. REFERENCES

1. B. Harris, (1999) ***Engineering Composite Materials***, London: The Institute of Materials.
2. R. N. Rothon, (2003) ***Particulate-filled Polymer Composites***, 2nd ed. Shrewsbury: RAPRA Technology Limited.
3. M. M. Schwartz, (1984) ***Composite Materials Handbook***, New York: Mc Graw-Hill.
4. R. Karthik, P. Sirisha, M. Ravisankar, (2014) Mechanical and tribological properties of PMMA-sea shell-based bio composite for dental application, ***Procedia Materials Science***, **6:** 1989-2000.
5. S. P. Reddy, P. V. C. Rao, A. C. Reddy, G. Parameswari, (2014) ***Tensile and Flexural Strength of Glass Fiber Epoxy Composites***, International Conference on Advanced Materials and Manufacturing Technologies, p98-102.
6. S. Javeed, S. Venkateswarulu, (2016) Tensile and flexural test on glass fiber reinforced epoxy composite, ***International Journal of Latest Trends in Engineering and Technology***, **7:** 1-7.

7. I. K. Varma, S. R. A. Krishnan, S. Krishnamoorthy (1989) Composites of glass/modified jute fabric and unsaturated polyester resin, ***Composites***, **20:** 383-388.

8. J. M. Hodgkinson (2000) ***Mechanical Testing of Advanced Fiber Composites***, Boca Raton: Wood Head Publishing Ltd and CRC Press.

***Bibliographical Sketch**

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