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MECHANICAL CHARACTERISTICS OF CONCH SHELL POLYMER MATRIX COMPOSITES

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ABSTRACT

Innovative materials have found many applications in many areas of daily life for quite some time. Conventional materials like glass, boron nitrate, silicon carbide and metallic binders belong to the group of ceramic matrix composite materials. Substantial development in the field of polymer composites has been achieved in recent years, so that they could be introduced into the most important applications. These new innovative materials open up unlimited possibilities for modern material science and development. With this in mind, in this work a new polymer matrix composite material is developed with the conch shell material called as aragonite and epoxy resin. Test specimens prepared by in situ fabrication method with different volume percentage of conch shell particles. Mechanical characteristics such as tensile strength, impact strength and hardness values were determined. In addition, microstructural analysis reveals that conch shell materials have a crossed-lamellar microstructure and the angle between two second-order lamellae is 70–90°. Fracture morphologies indicate that crack deflection is the major toughening mechanisms.

Keywords: Ceramics, Reinforcements, Binders, Aragonite.

1. INTRODUCTION

In the recent advancement of engineering design and manufacturing technology composite materials are play a vital role. Most common engineering products used today made of polymer composites such as boat hulls, surfboards, sporting goods, swimming pool linings, building panels and car bodies. The greatest advantage of using composite materials is greater strength and stiffness with high strength to weight ratio. Another advantage of polymers matrix composite is providing design flexibility. Composites are made up of two primary materials namely matrix and reinforcement material. Matrix materials are the primary phase having a continuous character and hold the dispersed phase and share a load with it. The secondary material is reinforced in the matrix in a dispersed form. Dispersed particles is usually stronger than the matrix, therefore it is sometimes called reinforcing material.

New engineering functional materials are required for the engineers for many valid reasons which are stronger, lighter or less expensive compared with traditional materials.In recent decades many new polymer composites have been developed, some with very valuable properties. Sea shells are promising material which having well corrosion and mechanical properties. It contains calcium carbonate crystals interleaved with layers of viscoelastic proteins, having dense, tailored structures and having excellent mechanical properties.

Dispersion of fillers with organic epoxy resin has been well-known as a new method to improve the mechanical and thermal properties of polymer composites [1-4]. The strength of particles dispersed polymer composites depends on type and length of fiber material reinforced, type of filler materials incorporated, orientation of fibers with respect to the stress direction [5-6]. In addition, the response of nanocomposites could be further enhanced with increased nanoparticles volume/ weight fraction, aspect ratio, arrangement of nanoparticles (orderly, randomly), uniform dispersion of nanoparticles [7-10]. The size of interface zone i.e. around the particles zone plays influences the strength of composites where the discontinuity likely to occurs [11].

Mechanical characteristics and critical strain energy release rates were measured for strombus-gigas conch shell. This shell has a crossed-lamellar micro structure and has a large strain to fracture. In another research, characterization of shell pink conch composites were analysed, results it provides excellent mechanical properties. Strength of red abalone, giant and conch shellswascompared. A red abalone composite has the highest compressive strength and giant clam has the lowest strength and the conch has an intermediate strength values. Hardness and tensile modulus values evaluated on bio aragonite samples.

In this research work, conch shell particles are dispersed in epoxy with different volume fractions (5%, 10%, 15%, 20% and 25%) by mechanical stirring and ultra-sonication method. Mechanical properties such as tensile strength, impact strength and hardness of the composites were determined.

2. MATERIALS

2.1 Epoxy resin

Highly cross linked thermo set epoxy resin DGEBA (Bisphenol-A diglycidyl ether) widely used as matrix material (Fig.1) because of their strong adhesive properties, chemical resistance, toughness and good physical and mechanical properties which are summarized in Table.1. Tri ethylene tetramine (TETA) used as curing agent.

Figure 1: Epoxy resin

Table 1: Mechanical properties of epoxy resin

Tensile strength	**85 N/mm²**
Tensile modulus	**10,500 N/mm²**
Elongation	**0.8%**
Compressive strength	**190 N/mm²**

2.2 Conch Shell

A conch shell structure has more aragonite material (Fig. 2). It is formed by biological and physical processes, including precipitation from marine and freshwater environments.

Figure 2: Conch Shell

The EDAX graph (Fig. 3) shows the major composition of aragonite. It shows that conch shells contains maximum amount of calcium Ca, and small percentage of Na, K, others .It has structure composed of triangular carbonate ion groups (CO_3), with a carbon at the center of the triangle and the three oxygen at each corner. The carbonate ions do not lie in a single plane and lie in two planes that point in opposite directions.

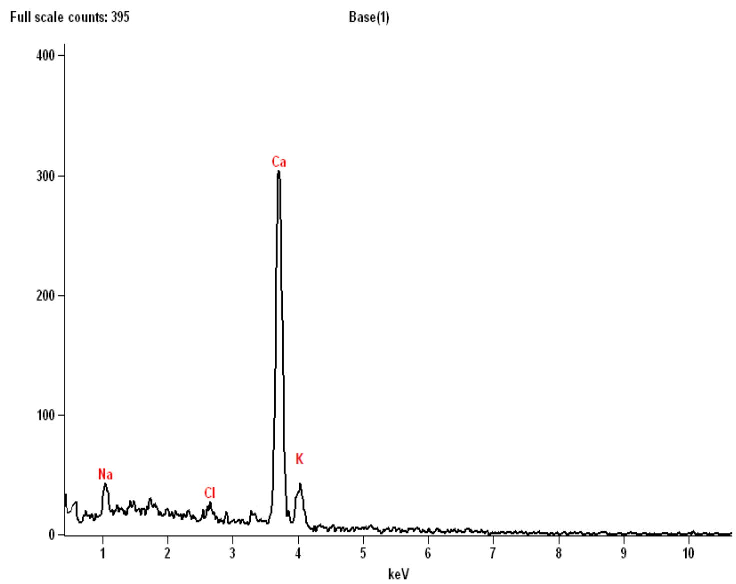

Figure 3: EDAX Graph

3. FABRICATION

Fabrication process is described in Fig.4. Four ball crushers is used to reduce the size. Crushing devices hold material between two parallel surfaces. Particles separate from alignment in relation to each other. In this the right composition of the material is prepared by the epoxy resin and the aragonite in certain grain size is mixed with catalyst the cobalt of about 3- 5% and the Kempton peroxide initiator to induce the reaction and to mix in the chamber. The material initially in the range of 50^{o}c and the mixer is poured in the die and it is finally left out to air cooling. The die is prepared as per the ASTM standard (Figure 5).

Conch shell

⇓

Crushed into micron size particles

⇓

Adding cobalt about 3-5%

⇓

Adding Kempton peroxide

⇓

Mixing in the chamber

⇓

Pouring into the standard die

⇓

Air cooling

Figure 4: Fabrication Process

Figure 5: ASTM standard die

4. EXPERIMENTAL TEST

4.1Tensile Test

The tensile test is used to measure the yield strength and the ultimate strength. In this test five set of specimen namely S1, S2, S3, S4, and S5 is tested as shown in fig 6. The ends of the test piece are fixed into the grips connected to a straining device and to a load measuring device. If the applied load is small enough the deformation of any solid body is entirely elastic. An elastically deformed solid body will return to its original form as soon as load is removed. If the load is large, the material can be deformed permanently. The maximum tensile value of 170 N/mm^2 is observed for S5 specimen i.e. for 25% of conch shell particles shown in figure 7.

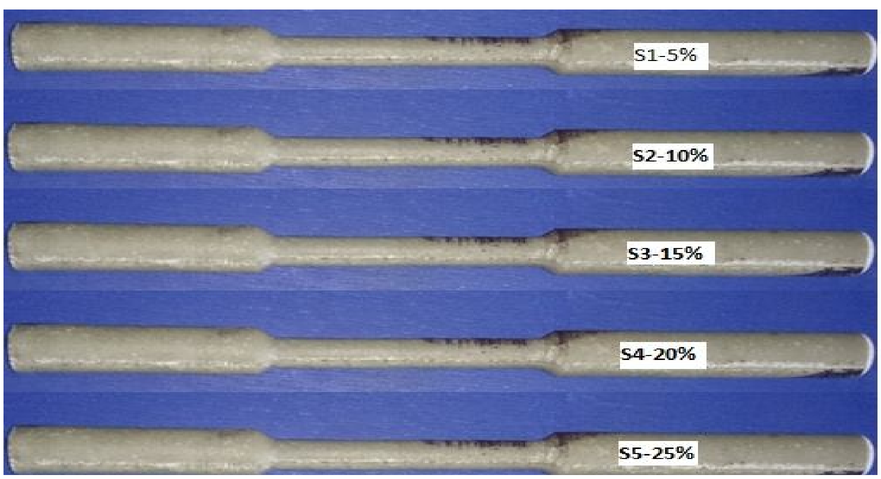

Figure 6: Tensile Test Specimen

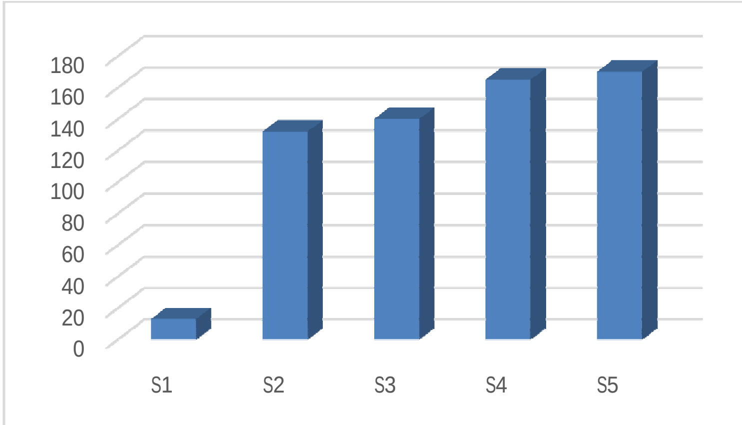

Figure 7: Tensile strength values

4.2 Hardness Test

In Brinell hardness test, a hardened steel ball indenter is forced into the surface of the metal to be tested. The diameter of the hardened steel indenter is 10mm. The load applied on the specimen is 50kg and the diameter of impression is 3.1mm.During a test, the load is maintained constant for 10 to 15 seconds. Hardness testing specimens H1, H2, H3, H4 and H5 as shown in figure.8. This table explains about the hardness test carried out on the result. The Brinell hardness number is higher for the harder materials. The H5 specimen has high hardness value of 66 which is shown in figure 9.

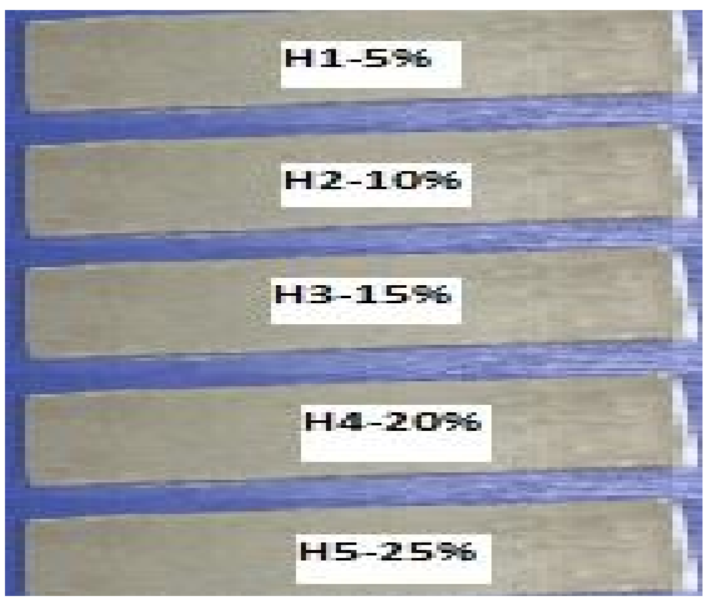

Figure 8: Hardness Test Specimen

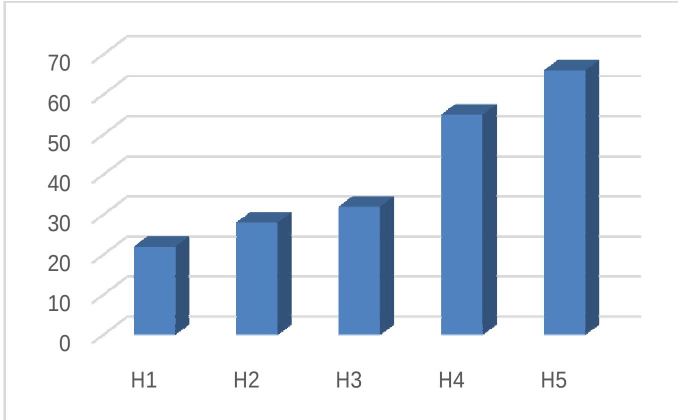

Figure 9: Brinell hardness values

4.3 Impact Test

The charpy impact test determines the maximum amount of energy absorbed by a material during fracture and absorbed energy is a measure of toughness of a material. The apparatus consists of a pendulum of known mass and length that is dropped from a known height to impact a notched specimen. The dimensions of the test specimen shown in figure.10. Impact strength values are shown in figure.11. High impact strength value of 0.55 KJ/mm^2 is observed for IM5 specimen.

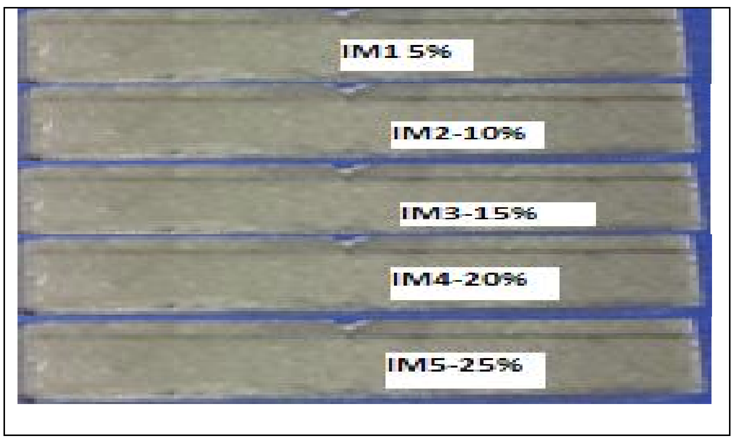

Figure 10: Impact specimen

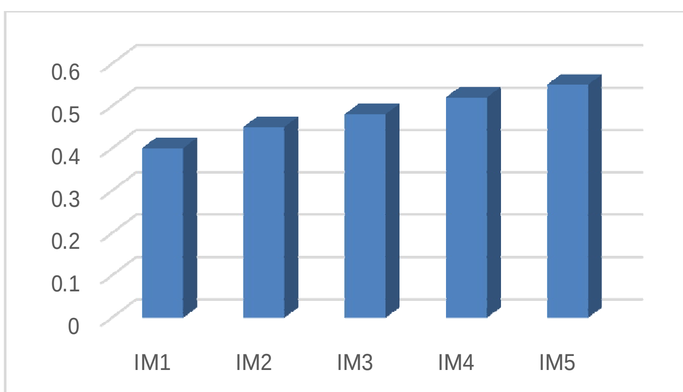

Figure 11: Impact strength

5. MICRO STRUCTURAL ANALYSIS

Scanning Electron Microscope (SEM) is a type of electron microscope that produces images of a sample by scanning it with a focused beam of electrons. In this paper the microstructures of pink conch shell are characterized by using SEM(Figure.12). The microscopic analysis indicates that the pink conch shell is with crossed-lamellar microstructure and the angle between two second-order lamellae is 70–90°. The cracking and fracture morphologies indicate that the crack deflection, bridge and fiber pullout are the main toughening mechanisms.

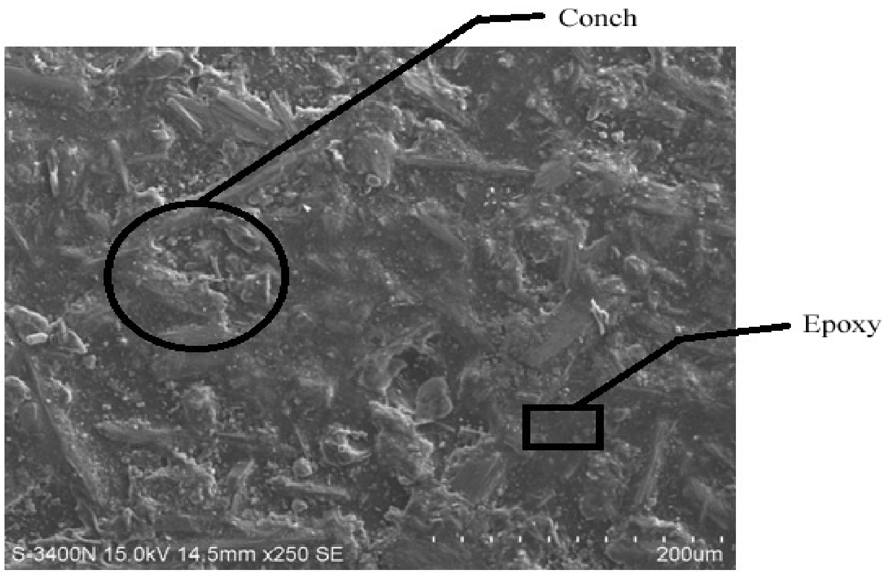

Figure 12: SEM image

6. RESULTS AND CONCLUSIONS

From the experimental tests the following observations were evaluated. For the material conch, the tensile strength is finding to be 170 N/mm^2 and the elongation is up to 22%.The elongation percentage is varying in different thermosetting matrix i.e. in PE- 16%, PA- 25%, PP- 10% and in PES - 19%. The impact strength of the conch material is 0.55 KJ/mm^2 where the impact strength of carbon reinforced PP, PE is just about 30N/mm^2, 40N/mm^2.The hardness value of conch material is 66 BHN. From these result of hardness, impact strength and yield stress the conch material can be replaced as reinforcing materials. It is very economical and has high hardness.

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