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Experimental Analysis of Mechanical Properties of Sea Shell Particles- Polymer Matrix Composite

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Abstract: **Sea shell is available in nature. In general, sea shell has more strong which incorporated with Orthophthalic resin. Sea shell particle size is varying in polymer matrix composites. In this composite, various sizes of particles are 75µ, 150µ, 300µ, 425µ and 600µ and the content of particles is 30gm are used. Here, mechanical properties (impact strength, hardness, flexural strength, tensile strength) are evaluated as per ASTM standard and optimise the results. The fractured surfaces are analyzed with the help of SEM pictures.**

Keywords: **sea shell particle, resin, composite, mechanical properties.**

I. INTRODUCTION

Natural materials can exhibit remarkable combinations of stiffness, low weight, strength, and toughness which are in some cases unmatched by manmade materials. In the past two decades significant efforts were therefore undertaken in the materials research community to elucidate the microstructure and mechanisms behind these mechanical performances, in order to duplicate them in artificial materials [1, 2]. This approach to design, called biomimetics, has now started to yield materials with remarkable properties. The first step in this biomimetic approach is the identification of materials performances in natural materials, together with a fundamental understanding of the mechanisms behind these performances (which has been greatly accelerated by recent techniques such as scanning probe microscopy) [3-7].

The upper left corner of the map shows soft and tough materials such as skin, with a mechanical behavior similar to elastomers. The lower right corner of the chart shows stiff but brittle minerals such as hydroxyapatite or calcite. Most hard biological materials incorporate minerals into soft matrices, mostly to achieve the stiffness required for structural support or armored protection [8]. These materials are seen in the upper right part of the map and show how natural materials achieve high stiffness by incorporating minerals while retaining an exceptional toughness. Alternatively, one can consider how natural materials turn brittle minerals into much tougher materials, in some cases only with a few percent additions of biopolymers. These materials have in general relatively complex structures organized over several length scales (hierarchical structures with mechanisms operating over several length scales, down to the nano scale [9, 10].

2. MATERIALS AND METHODS

2.1 Collection and processing of sea shells:

Sea shells are collected from the sea shore. The shells were cleaned and sun dried for three days before grinding. The shells were sieved with a hand sieve size of different micron level. The shells are crushed and made into fine particle. The particles are separated into five sets. They are 75µ, 150µ, 300µ, 425µ and 600µ. These five mesh size is the parameter of the composites. The weight of the sea shell particle is 30g in the composite lamination.

2.2 Unsaturated polyester resin:

The unsaturated polyester resin was weighed by placing a petridish on the electronic weighing machine and the particulate added gradually into the petridish until the desired weight of particulate necessary for a particular formulation was

achieved. The process was repeated for other weight fractions of particulate needed. . Pouring of the polyester into the beaker is stopped when a 100g of polyester is reached. The beaker is removed from the weighing machine and is placed aside.

2.3 Weighing of the sea shell:

The two particulate was weighed using an electronic weighing machine based on the weight percentage of the particulate to be added to the polyester resin. A petridish is placed on the electronic weighing machine and the particulates are added gradually into the petridish, the weight indication is observed as more particulate are continually added. Pouring of the particulate into the Petridis is stopped when the desired weight of particulate necessary for a particular formulation is achieved. The process is repeated for other weight fractions of particulate needed. The beaker is removed from the weighing machine and is placed aside.

2.4 Weighing of the catalyst Methyl ethyl ketone peroxide (MEKP):

The catalyst (MEKP) was weighed using an electronic weighing machine. A beaker is place on the weighing machine and in it is placed a test tube the catalyst is added gradually into the test tube with the help of a syringe, the weight indication is observed as more drops of catalyst are continually added. Pouring of the catalyst into the test tube is stopped when a 1g of catalyst is obtained. The test tube is removed from the weighing machine and is placed aside.

2.5 Weighing of the Accelerator (Cobalt Naphthanate):

The Accelerator (Cobalt Naphthanate) was weighed using an electronic weighing machine, a beaker is placed on the weighing machine and in it is placed a test tube the accelerator is added gradually into the test tube with the help of a syringe, the weight indicator is observed as more drops of accelerator are continually added. Pouring of the accelerator into the test tube is stopped when a 0.5g of accelerator is obtained. The test tube is removed from the weighing machine and is placed aside.

2.6 Mixing:

In synthesizing the reinforced polyester composites, the mass of the polyester was varied with that of the reinforcement to give a total of 30grams (i.e. for every 100gram of 5wt% composition of reinforcement, there will be 95 grams of polyester and 5grams of reinforcement) this was done for particulate composition of (30wt%) and stirred manually with a glass rod and it is mixed intimately until a good mixture is obtained. Thereafter, 1g of catalyst was added and stirred for, after which 0.5g of accelerator was added and stirred. Total weight of the lamination is 300g. In this 300g, resin with accelerator and catalyst contains 270g and sea shell particle contains 30g. Therefore weight ratio of resin and shell particle is 90:10.

Table.1 Proportions of the laminates

Specimen	Mesh size of sea shell particle (μ)	Sea shell particle Weight (%)	Orthophthalic resin Weight (%)
A	-	-	100
B	75	10	90
C	150	10	90
D	300	10	90
E	425	10	90
F	600	10	90

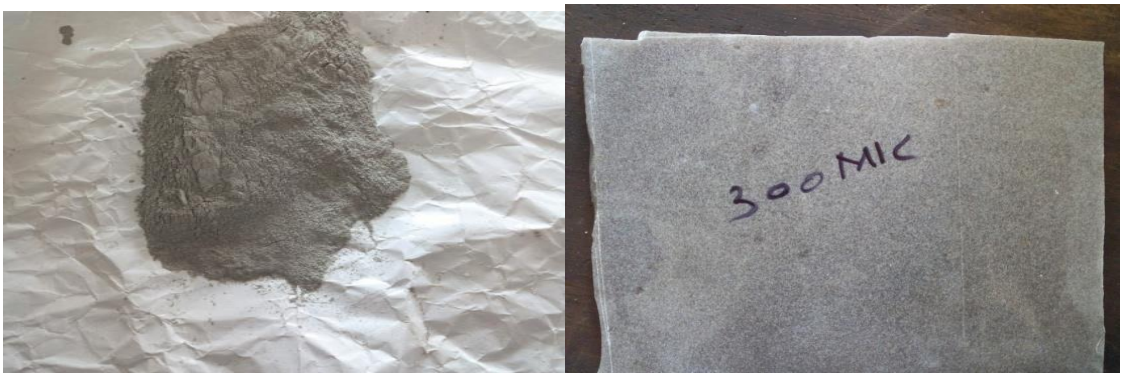
2.7 Fabrication:

The die material we used in the project is (Mild steel EN8). Dimensions: Length=300mm; Breadth=300mm; Thickness=3mm. The die consists of base plate, frame and lid. The method used is hand lay-up method. This is one of the earlier methods used for lay-up and also an easiest method. The base plate is placed on a clean surface and is cleaned with thinner and is covered with transparency sheet. The frame is also cleaned with thinner and is placed on the base plate. The orthophthalic resin is measured in the beaker and poured in the tin after that add the seashell particle in the proportion of 100ml: 10gm (ratio). The proportion is mixed well after mixing the Accelerator Cobalt naphthanate is added at a range of 10ml and mixed well. The catalyst Methyl Ethane Ketene Peroxide is added and mixed well. After reaching

a certain temperature the mixture is poured on the plate and is spreaded over it throughout. Finally it's covered my lid for curing for a certain time. The same process is carried out for all the proportions. We make 25 plates for each proportion.

(a)

(b)



(c)

(d)

(e)

Fig.1 Different size of sea shell particle along with laminates

2.8 Mechanical Testing:

2.8.1 Impact test:

This test was carried out also impact test is a standard method of determining the impact resistance of materials. An arm held at a specific height (constant potential energy) is released. The arm hits the sample and breaks it. From the energy absorbed by the sample, its impact energy is determined. A notched sample is used to determine impact energy and notch sensitivity. Test specimen is prepared as per ASTM standard D638-03. The dimension of the specimen for testing is 80mm length, 12.7mm breadth and 3mm thickness.

Fig.2 Impact test specimen

2.8.2 Hardness test:

The hardness test was carried out using Vicker's hardness testing machine. The hardness test was carried out on the polymeric material composite at different filler content size. The specimen is prepared as per ASTM standard. The dimension of the hardness specimen is 25mm length, 25mm breadth and 3mm thickness.

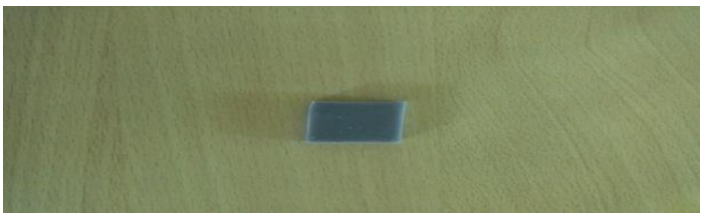


Fig.3 Hardness test specimen

2.8.3 Flexural test:

Three point flexural testing were conducted using testometric testing machine. The flexural test was carried at a cross-head speed of 20mm/min, maintaining a span of 100mm. This test was conducted at room temperature.. Universal testing machine was used to carry out the three point bending flexural test on the polymeric material composite at different filler sizes. Flexural test specimen is prepared as per ASTM standard D790-03. The dimension of the test sample is 127mm length, 12.7mm breadth and 3mm thickness.

Fig.4 Flexural test specimen

2.8.4 Tensile test:

The tensile testing was performed using universal testing machine operated at a cross head speed of 10mm/min. The tensile test specimen preparation and testing procedures were conducted in accordance with ASTM standard D 638, using dumbbell test piece. Each tensile specimen is positioned in the universal tester and then subjected to tensile load, as the specimen stretches the computer generates graph as well as all the desired parameters until the specimen fractures. A graph of load versus extension is plotted automatically by the tester and various property of the specimen determined are; tensile strength, tensile strain, modulus, tensile strain at break etc. The dimension of the test sample is 163mm length, 20mm breadth and 3mm thickness.

Fig.5 Tensile test specimen

3. RESULTS AND DISCUSSION

3.1 Impact Strength:

Impact test is carried out in Izod impact testing machine. Impact strength values are shown in Fig.6.. Impact strength values of Specimen A, B, C, D, E and F are 19.77MPa, 35.65MPa, 33.47MPa, 31.58MPa. 29.02MPa and 25.98MPa respectively. When compared about these results, specimen B is more strength due to the particle size is very tiny. It avoids the voids. So it gives more strength to the material.

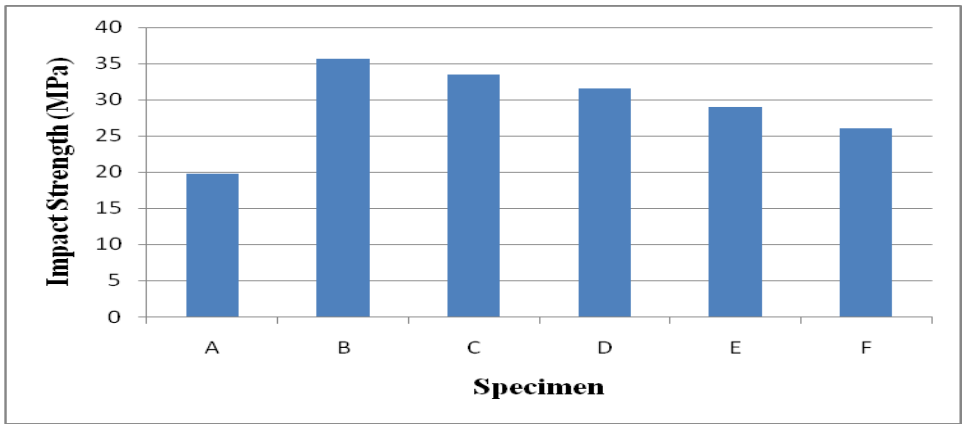


Fig.6 Impact strength

3.2 Hardness test:

Hardness test is carried out in Vicker's hardness testing machine. Hardness values are shown in Fig.7.. Hardness values of Specimen A, B, C, D, E and F are 17, 46, 41, 37, 34 and 31 respectively. When compared about these results, specimen B is more strength due to the particle size is very tiny. It avoids the voids. So it gives more strength to the material.

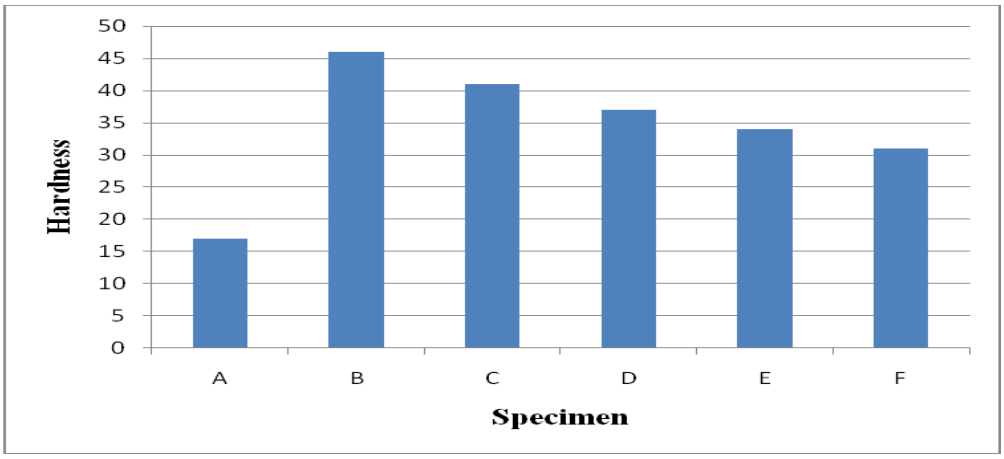


Fig.7 Hardness

3.3 Flexural test:

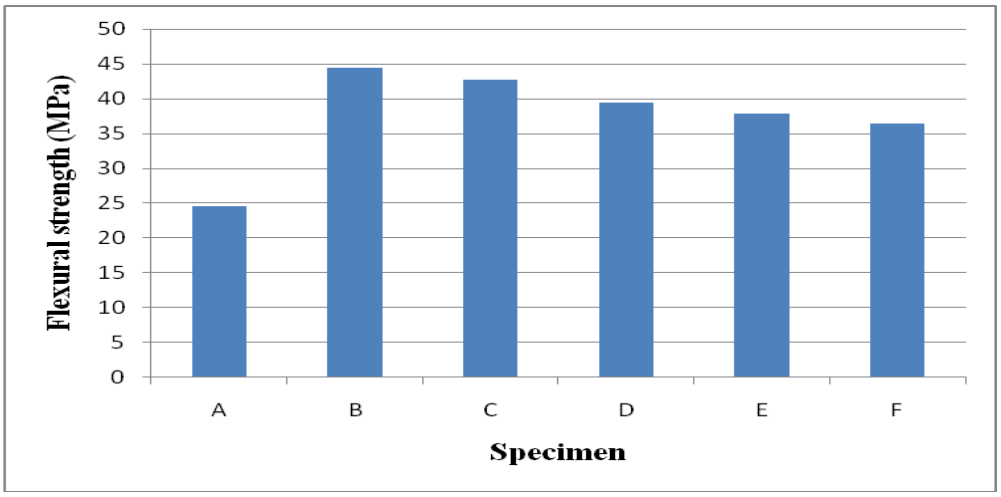


Fig.8 Flexural strength

Flexural test is carried out in Universal testing machine. Flexural strength values are shown in Fig.8. Flexural strength values of Specimen A, B, C, D, E and F are 24.58MPa, 44.44MPa, 42.78MPa, 39.5MPa. 37.89MPa and 36.44MPa respectively. When compared about these results, specimen B is more strength due to the particle size is very tiny. It avoids the voids. So it gives more strength to the material.

3.4 Tensile test:

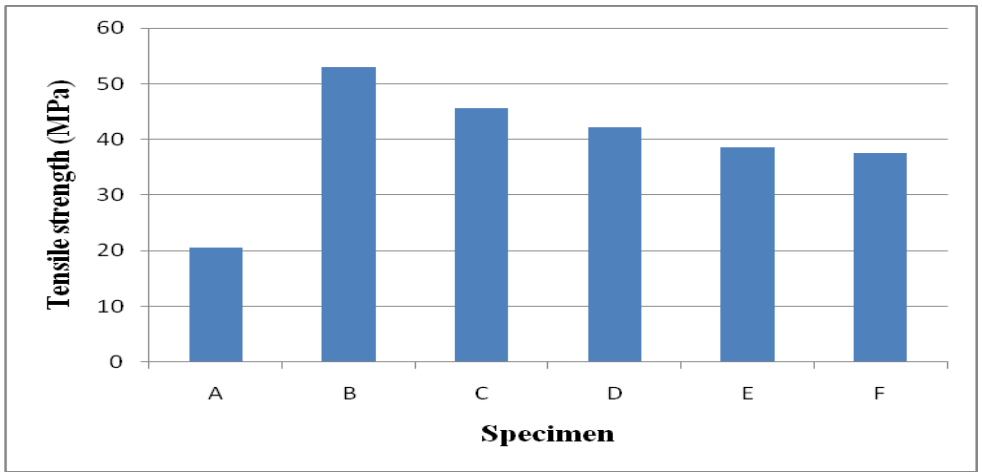


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Fig.9 Tensile strength

Tensile test is carried out in Universal testing machine. Tensile strength values are shown in Fig.9. Tensile strength values of Specimen A, B, C, D, E and F are 20.55MPa, 52.99MPa, 45.64MPa, 42.11MPa. 38.49MPa and 37.48MPa respectively. When compared about these results, specimen B is more strength due to the particle size is very tiny. It avoids the voids. So it gives more strength to the material

3.5 Characterisation:

The microstructure ad the chemical compositions of the phases present in the sea shell particle was studied using Scanning Electron Microscope equipment. The sample was placed on sample holder and the images were captured under various magnifications. Prior to it, sample was applied with the gold coating to avoid charge effect, so to obtain clear images. The SEM was operated at an accelerating voltage of 5 to 20 kV. Microscopic layer is composed of parallel rows of first-order lamellae, and the first order lamellae in the middle layer are oriented 90◦ to the first-order lamellae in the inner and outer layers. Each first-order lamella in turn is composed of parallel rows of second-order lamellae, which are oriented 45◦ to the first-order lamellae. The second-order lamellae are further subdivided into third-order lamellae. The basic building blocks are therefore the third-order lath-shaped aragonite crystals with internal twins. In particular, in the middle layer, the second-order lamellae in alternating first-order lamellae are rotated by 90◦. Each first, second, and third-order lamellae are enveloped in a thin organic matrix that composes only 1 wt. % of the shell. Scanning electron microscope (SEM) images of fracture surfaces of mechanical testing is shown in below figures.

As the far field stress is increased on the fracture specimen, a white region appears and progressively increases in size. This whitening is an indication of tablet sliding and inelastic deformations, with the voids left by tablet separation scattering light (this phenomenon is similar to stress whitening associated with crazing in polymers). In the literature dealing with fracture mechanics, such an inelastic region is referred to as the process zone.

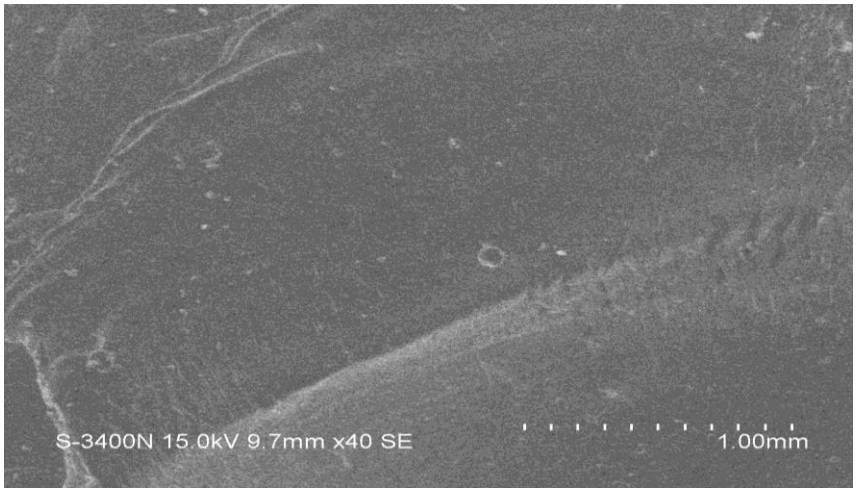

Fig.10 SEM image of Specimen B after the impact test

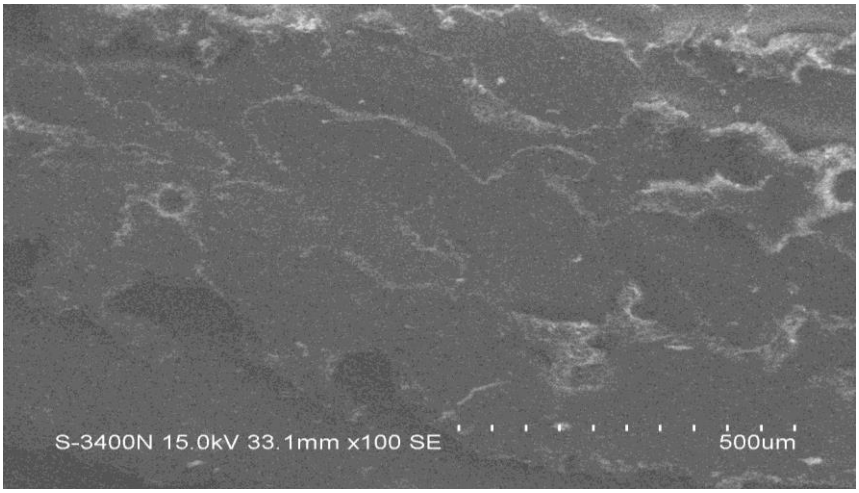

Fig.11 SEM image of Specimen B after the hardness test

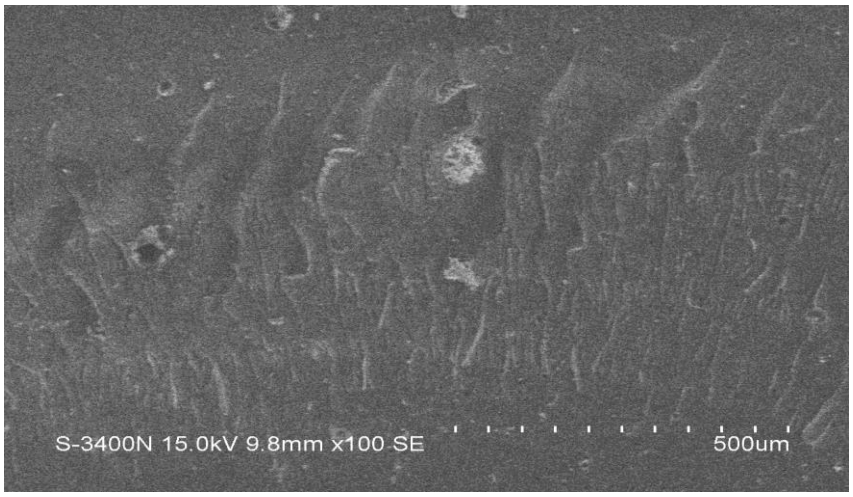

Fig.12 SEM image of Specimen B after the flexural test

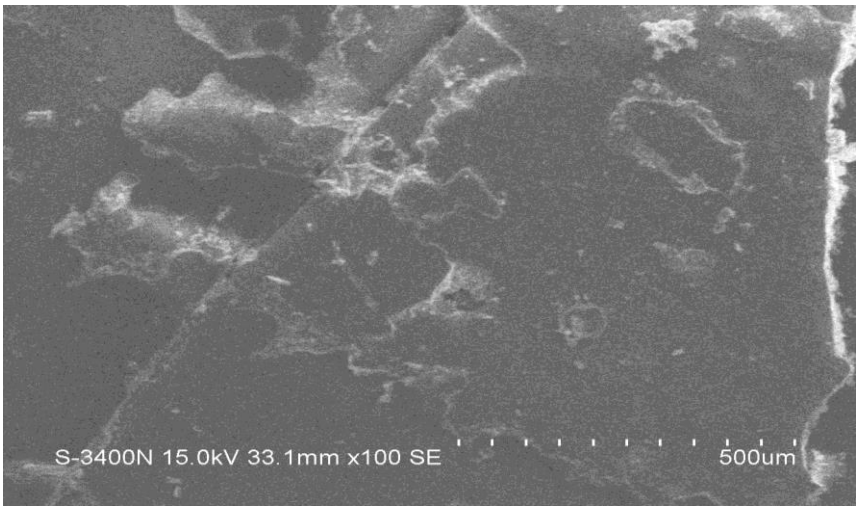

Fig.13 SEM image of Specimen B after the tensile test

3.6 Applications:

Sea shell particle reinforced polymer matrix composite is uses in the following appliances laminating, casting and casting with metal and stone fillers, compounded with large number of resins, motor housing, telephones and electrical fixtures etc.

4. CONCLUSION

Sea shell particle reinforced polymer matrix composite is prepared and tested the samples. From the results, the following conclusions are made.

In general particle have more strength, which is act as a reinforced in polymer matrix composites. In these laminations, 75μ sized composite is gives better results when compared to other size of particles content composites. Due to the particle size is very tiny. It avoids the voids. So it gives more strength to the material.

The fractured surfaces are analyzed with the help of Scanning Electron Microscopic pictures.

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