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SEA SHELLS AND NATURAL FIBRES COMPOSITES: A REVIEW

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Abstract
The main objective of this work is to study the mechanical and chemical properties of the known mollusc shells like periwinkles, clams, land snails, green oysters, lacre etc., generally these mollusc shells are known for their rich calcium carbonates and other macromolecules(mostly proteins and polysaccharides).the shells were checked for their mechanical properties such as crushing strength, tensile strength, fineness, fracture property, abrasiveness etc., It was also very important to check their richness in calcium and their carbonates and oxides. Since the depletion of sources has to be managed, implementation of composites reinforced with seashell fillers will find its significance. Thus the recent studies on the various mollusc shells have been reviewed and the profitable suggestions have been made at the end. Some of the important suggestions may include potential of seashell composites to act as biomaterials, as filler materials in concretes in civil engineering, artistic composites with better mechanical properties etc.
Keyword: Mechanical properties, sea shells, mollusc shells, composites, organic compounds.

1.0 Introduction

Mollusc shells are fascinating organic compounds with strong mechanical performances. These shells are mainly made of calcite and aragonite crystalline polymorphs. Fleischli *et al* [1] has quoted generally that natural materials exhibit outstanding properties due to their structural alignment and nacres called as mother of pearl is considered as a standard for the properties of seashells. Barthelat [2] have researched on the nacres and established a fact that nacre is an iridescent material and forms the inner layers of seashells from gastropods and bivalves. Chateigner [3] have suggested that nacres have good lamellar structure and better microstructures than any other sea shells. McNaughton *et al* [4] has demonstrated that calcium utilization from oyster shell and limestone by chick was dependent upon the particle size of the supplement and they have preferred that the use of a medium to fine particle size calcium supplement in the diet. Barthelat [5] have stated that the seashells exhibits better stiffness, strength and hardness due to their microstructure. Falade [6] have investigated the suitability of palm kernel shells as fillers for structural and non structural purposes. Nimityongsul [7] have investigated the possibilities of the use of coconut husk, corn ash and peanut shell ash as reinforcing fillers. Mollusc shells are themselves natural composites bio engineered ay nanoscales. Kaplan *et al* [8] have suggested that this feature could provide toughness and could be a profitable property for the development of bio-composites. Olivia *et al* [9] had other ideas on the utilization of sea shells and they have made a study on replacement of sand with oyster shells.

2.0 Results and discussion

2.1 Mechanical properties of sea shell composites

Composites are produced with a combination of a matrix material generally a metal, a fibre and filler materials glued together using a resin. The main aim of composites is to yield better results when compared to

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traditional metal components. In modern day composites fibers and particles are embedded in matrix of other material. With growing global awareness, utilization of natural fibres in composites has been steadily increasing. Similarly researches are being done in sea shell's abilities as possible fillers in modern world. The most important properties such as hardness, toughness, water absorbent qualities, crushing strength, tensile strength are found to be satisfied by different sea shells. The composites prepared from the seashells are tested for various mechanical properties like toughness, tensile strength, impact strength, flexural strength etc.

2.2 CNSL composite to increase the mechanical properties

Umar *et al* [10] have examined the increase in mechanical properties of composites when cashew nut shell liquid (CNSL) resin is reinforced with periwinkle shells and they have also prepared samples of composites with different compositions of shell powder and have found that the mechanical properties increased with increase in concentration of seashell powder as well as decreased with increase in size of the powder. Raghu *et al* [11] and Ismail *et al* [12] have conducted similar experiments and fetched similar results.

2.3 Sea shell as filler for concrete

Kanie *et al* [13] have stated that one of the methods to improve the mechanical properties of the composite is by adding the filler material in the continuous phase. Olivia *et al* [9] prepared a concrete reinforced with seashell powder and the finely powdered seashell is added as a filler material to the concrete and for different concentrations of powder the compressive strength was poor however the tensile and flexural strength increased with increase in concentrations proving the tensile behavior as good and they have also concluded that ground shell concrete is better for use than concrete. Another study was conducted by Safi *et al* [14] as they have suggested that mixing oyster shell did not cause a reduction in the compressive strength significantly due to a good adhesion between seashell and cement paste.

2.4 Inspection of tensile and compressive strengths in seashell layers

Cortie *et al* [15] have inspected the mechanical properties of sea shell and concluded that tensile stress in inner layer of the sea shell is counter balanced by the compressive strength acting on the outer layer of the shells and they have also found that the shells contain the protein glue upto 5% are responsible for fracture toughness which is similar to ordinary glass and they have also said that the shells has superior toughness.

2.5 Mechanical and water absorption properties in composites of unsaturated polyester

Odusanya *et al* [16] have determined the mechanical and water absorption properties in unsaturated polyester composites reinforced with varying weight fraction of seashell and they have added ground seashell of 250microns with unsaturated polyester resin and developed a composite with varying fractions of seashell fillers and they have also prepared a composite in addition with a catalyst and an accelerator and the test samples were underwent for various mechanical tests and the best result occurred with 10%weight seashell filler samples. Water absorption test has also been carried by immersing the test samples under water for 168 hours and the results proves that the material with 10% weight for the tensile strength is better only for pure polyester(0% filler materials).

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2.6 Sea shell powder reinforcement in rubber

Norazlina *et al* [17] have utilized the $CaCo_3$ content in sea shells and reinforced them in natural rubber and checked their tensile properties. $CaCO_3$ from seashells is a 'green' calcium carbonate that could enhance the mechanical and thermal properties of composites. The mixing of natural rubber (NR) with $CaCO_3$ using melt blending enhanced the hardness and tensile strength of the composites. The NR/$CaCO_3$ composites were prepared with different filler loadings using the 355 µm filler size. This step was undertaken to find the optimum amount of $CaCO_3$ to give the highest tensile strength. However, from the tensile strength and melting point analysis using different filler sizes, the optimum properties were given by the 355 µm NR/40 phr $CaCO_3$ sample and the melting point at 401.12°C. The results are clearly shown in the figure 1.

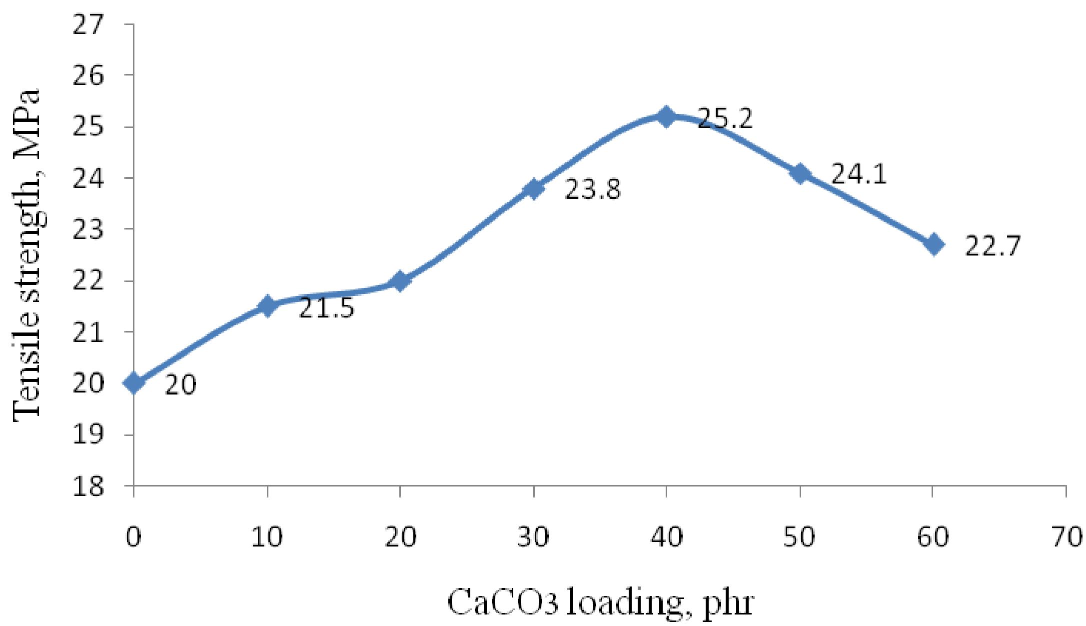

Fig 1. Effect of CaCO3 loading on tensile strength of NR/$CaCO_3$ composites

2.7 Properties of periwinkles

According to Ituen [18], who collected a group of mollusc shells such as periwinkles, clams, land and water snails and tested for its hardness, crushing strengths and calcium concentrations. He has also conducted several experiments and determined their size, surface area, crushing strength, density, porosity and its chemical constituents and concluded that the periwinkles crushing strength was found to be phenomenal while clams were rich in micro-constiuents such as calcium, sodium, potassium and phosphorous. These results also have coincided with that of Akpabio [19] who showed that Ca in clam was about 2 times as much as in calcium carbonate. The clam shell is also seen to contain the highest amounts of K and Na, as it is an important shell or livestock feeds and acid soil neutralization as well.

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2.8 Abrasiveness of periwinkles

Obot *et al* [20] tested periwinkles abrasive properties in their research as they have prepared specimens in different concentrations of periwinkle shells (PWS) and resin and they have used polyester resin, cobalt naphthalene and methyl ethyl ketone peroxide hardener and they have varied the sizes of grain using ASTM E11 standards set of sieves into p40, p60 and p140 and they have prepared three specimens with 95%, 87% wt. of PWS and 4% and 12% resin. As suggested by Kalpakjian *et al* [21] in order to be effective grits, the periwinkle shell grains should have properties such as hardness, resistance to wear, chemical stability etc., particularly wear resistance is to be taken atmost care and by using the compression moulding, the specimens were made and rockwell hardness testing machine has been employed for determining the hardness of the specimens and it was understood that the hardness and crushing strength increased with increasing resin content while wear resistance decreased drastically. However, the best abrasive properties were obtained from composition of PWS at 87%, resin at 12% and 0.5% wt. of hardeners.

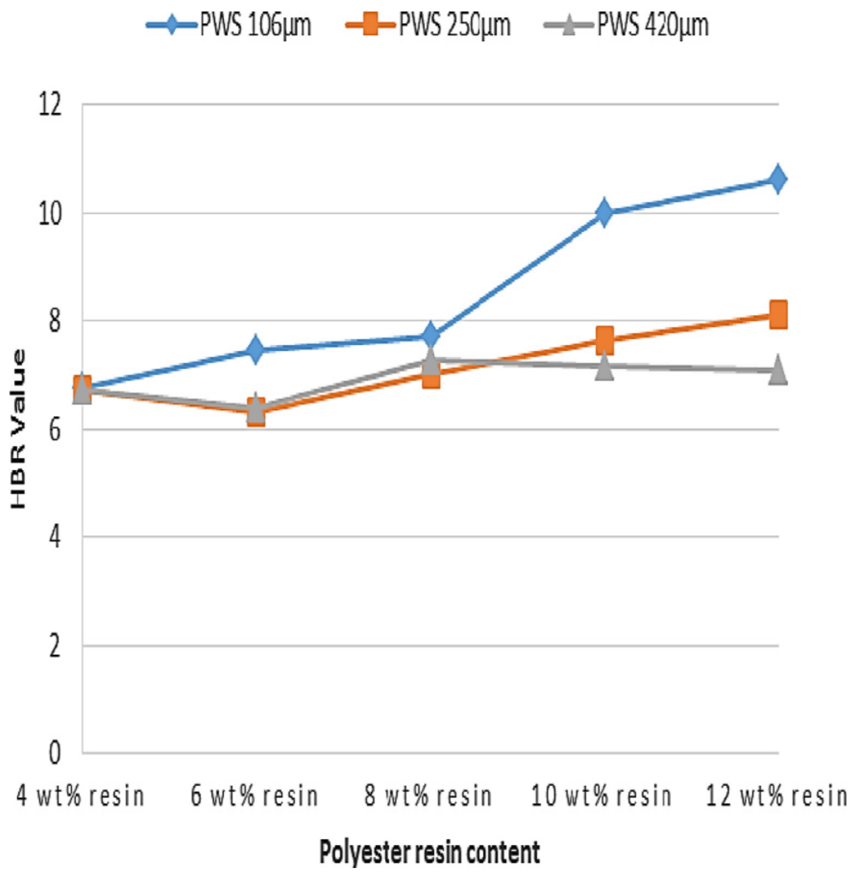

Fig 2: Hardness vs resin content

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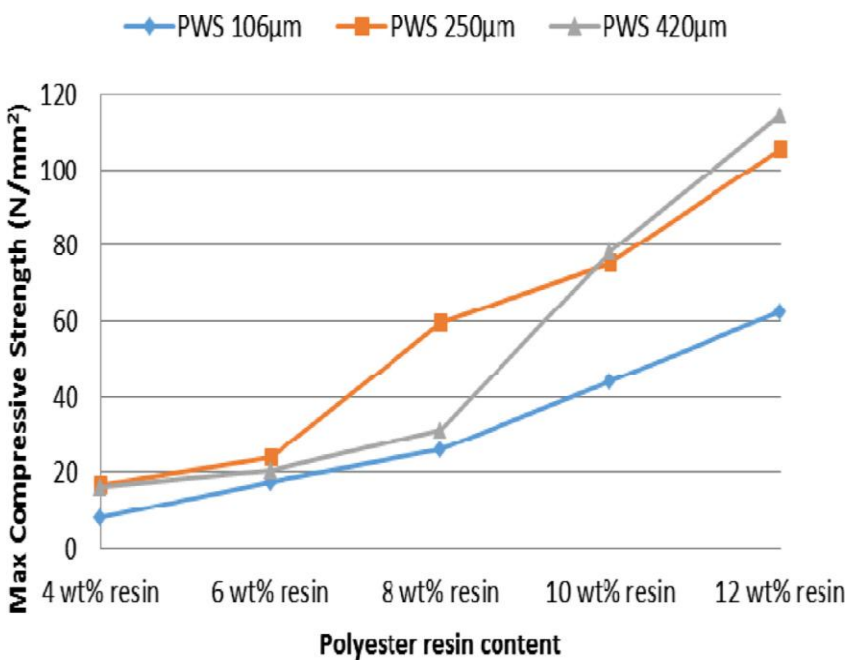

Fig 3: Compressive strength vs resin content

The above fig 2 and 3 [20] clearly shows the variation of hardness and compressive strength of the periwinkle composite with respect to the polyester resin content.

2.9 Flax, Abaca reinforcements in composites

Vijaya Ramnath *et al* (22, 23, 24) have investigated mechanical behaviour of jute-flax and jute- abaca based hybrid composites and concluded that hybrid composite shows good mechanical behaviour as compared to mono fiber composites. They also concluded that fiber orientation also have influence the strength of composites. Sathish *et al* (25) found that fiber orientation and stacking sequence have impact on mechanical behaviour of banana - kenaf hybrid composites. They also concluded that if fiber orientation changes the mechanical behaviour also changes**.**

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