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EFFECT OF FILLER CONTENT ON THE MECHANICAL PROPERTIES OF PERIWINKLE SHELL REINFORCED CNSL RESIN COMPOSITES

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ABSTRACT

Research into bio filler materials composite is gradually taking prominence due to its renewability. In this present work, three particle sizes (400µm, 600µm and 800µm) of milled periwinkle-shell (PWS) filled cashew nut shell liquid (CNSL) resin composites were developed by compression moldings technique with varying filler content (10% to 40% by weight). The developed PWS filled CNSL composites were then characterized by tensile, flexural and impact strength tests. The effect of filler content and particle size on the mechanical properties of the PWS filled CNSL composites was investigated. Results showed that, there was an improvement on the mechanical properties as the filler content increases while properties decreases as filler size increases. All properties tensile strength, flexural strength, % elongation, tensile modulus and impact strength slightly increased as the filler loading increases. While % elongation, tensile and flexural strengths decreases as particle sizes increases, tensile modulus and impact strength increases as particle sizes increases. The optimum properties were observed at 30% filler content and 400µm particle size.

Keywords: periwinkle-shell, filler content, particle sizes, CNSL resin, mechanical properties.

1. INTRODUCTION

Due to growing concern of resource depletion, global pollution, reduction in weight and cost while maintaining high environmentally friendly, physical, chemical and mechanical properties of materials, attention is now been focused on the properties of seashells. Bio-composites have become attractive because of their wide applications [1]. Polyethylene fibers and or carbon/graphite fibers have been tested [2, 3]. Similarly because of the uncertainties prevailing in the supply and price of petroleum based products, there is every need to use naturally renewable alternatives. In many parts of the world, besides the agricultural and food purposes, different parts of plants and animals have been found to be viable sources of raw materials for industrial purposes. Towards attaining this end, interest in the more environmentally friendly bio-composites is growing due to the high performance in mechanical properties and the potential ability to substitute some petrochemicals [4].

Fillers are used in composites to improve the properties of the host matrix mostly weight and the moulding characteristics [5]. Numerous achievements have been made in natural composite fillers research. Reduction in production costs and ability to produce light-weight structures are some of the achievement. Ndoke [6] assessed the performance of palm kernel shells as a partial replacement for coarse filler in asphalt composite, while Falade [7] investigated the suitability of palm kernel shells as fillers in light and dense composite for structural and non-structural purposes. The use of coconut husk ash, corn cob ash and peanut shell ash as reinforcing fillers has also been investigated [8]. Other tested naturally occurring, renewable materials used as fillers are rice husk [9] and wood flour [10].

Periwinkles (*Turritella communis*) are small edible species of medium-sized sea snails of the marine gastropod mollusks. Adewuyi and Adegoke [11] and Osarenmwinda and Awaro [12] carried research on the use of periwinkle shells as coarse aggregate in concrete work while Huang and Xiao [13] researched on the mechanical properties of quaternized polysulfone/benzoyl periwinkle shells blends. In all these researches, attempt has not been made to use a naturally renewable matrix.

This work therefore intends to investigate the mechanical performance of periwinkle shells with respect to its requirements as reinforcing fillers in cashew nut shell liquid (CNSL) resin composite. Periwinkle shell of variable particle sizes 400 µm, 600 µm and 800 µm is been used as filler to CNSL matrix resin. Influences of the addition of these fillers on the tensile, flexural and impact properties of the resulting composites will be examined. Also the effect of filler content on the matrix will be investigated.

2. MATERIALS AND METHODS

2.1 Materials

Periwinkle shells were purchased from the local market of Calabar South-South, Nigeria while cashew nut was obtained from Obollo-Afor cashew plantation in Udenu local government area of Enugu State, Nigeria. The saline solution constituents, catalyst (Methyl ethyl ketone peroxide (HY951)), accelerator (Cobalt naphtha Nate (CDA-4301)), PVA, wax and NaOH pellets used were all supplied by NYCIL Industrial Chemicals, Onitsha Anambra State, Nigeria.

2.2 Preparation of the composite

The composite was prepared by compression moulding technique after pre-treatment of the fillers while cashew nut shell resin (CNSL) is extracted using the “hot-oil-bath” method. The PWS were first soaked in detergent for 24 hours and then washed thoroughly with wire brush to remove dirt’s and odour; it was dried in an oven at 80°C overnight and then milled. The milled PWS power was mixed with % 5 NaOH solutions for about 3 hours at room temperature and then thoroughly washed with deionised water and then dried again in an oven overnight at 70°C. On drying 400 µm, 600 µm and 800 µm sieve were used to get different particle sizes. Sample specimens were produced at 10, 20, 30 and 40% filler content.

2.3 Mechanical testing

Tensile strength, tensile modulus, flexural strength, % elongation were measured using Universal Testing Machine - UTM (Instron 5567) while RAY-RAN Universal Pendulum Impact System for Izod-Charpy-Tension and Puncture was used for impact test. Tensile test specimen were made according to ASTM D 638M, while flexural strength test samples were made according to ASTM D 790M and impact strength test specimen were made according to ASTM D 256M. Five samples were tested for different filler content and average results were used. A crosshead speed of 5 mm/min was used. All specimens were conditioned at a temperature of 23+2°C and 50+5% relative humidity for 48 hours before testing.

3. RESULTS AND DISCUSSIONS

3.1 Mechanical properties

Figure-1 shows powdered PWS of different microns (400, 600 and 800) used for the preparation of the composite. The powdered PWS look milky white with some dark particles. The dark particles are due to the dark outer surface of this sea shell. Figure-2 shows the graph of tensile strength of the composites at different filler content of PWS. The result shows that tensile strength increase as filler content increases from 10% to 30% but decreases at 40% filler content while particle size did not affect the increase or decrease respectively. Other results [14, 15] shows similar trend. The better tensile strength at lower filler content could be attributed to better dispersion of PWS in the CNSL resin matrix, better wet ability, absence of void or porosity and good interfacial bond. The lower tensile strength at 40% filler content could be attributed to inefficient stress transfer between the particle-matrix interface due to poor interface adhesion.


(a) (b) (c)

Figure-1. Powered periwinkle shells (a) 400 µm, (b) 600 µm and (c) 800 µm.

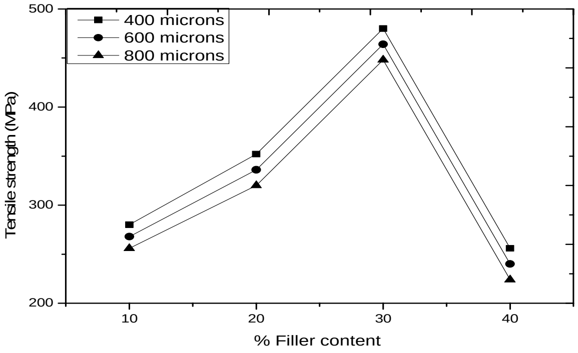

Figure-2. Tensile strength of PW/CNSL composite.

Figure-3 shows the tensile modulus of the composite at different filler content and particle sizes. Between 10 and 40% filler content the tensile modulus was virtually constant irrespective of particle size at any given filler content but gradually increases as filler content increases. At 40% content there was a sharp drop in tensile modulus across all particle sizes when compared with the 30% strength. Figure-4 also shows a gradual increase in % elongation as the filler content increases from 10 to 30% and remains the same at 40% filler content an indication that further increase of filler content will not improve the % elongation.

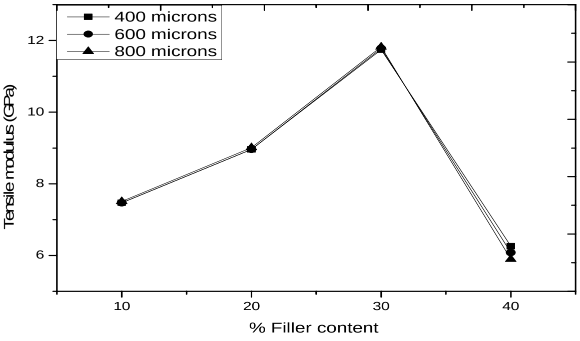

Figure-3. Tensile modulus of PW/CNSL composite.

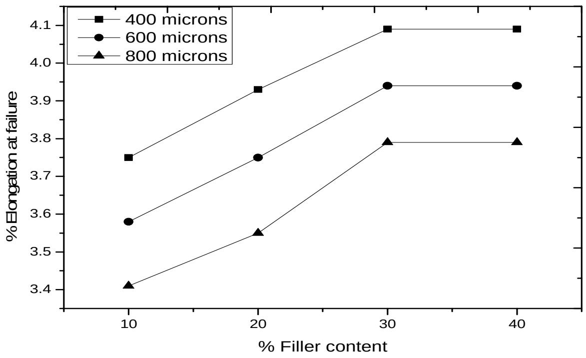

Figure-4. % Elongation at failure of PW/CNSL composite.

Figures 5 and 6 shows the flexural and impact strengths of the composite at different filler content. Like tensile strength and tensile modulus, flexural strength increases gradually as the filler content increases but decreases as the filler sizes increases. Also at 40% filler content for all filler sizes, there was a drop in flexural strength. The reduction in flexural strength as the particle size increases could be attributed to controlled mobility of matrix by filler particles. As the particle size of filler increases there is reduction in total surface area available for matrix-filler interaction. Figure-6 shows the impact strength of the composite. Contrary to other properties the impact strength increases as the filler content and particle sizes increases. There is no explanation to this but it could be attributed to continuity of matrix phase in the composite.

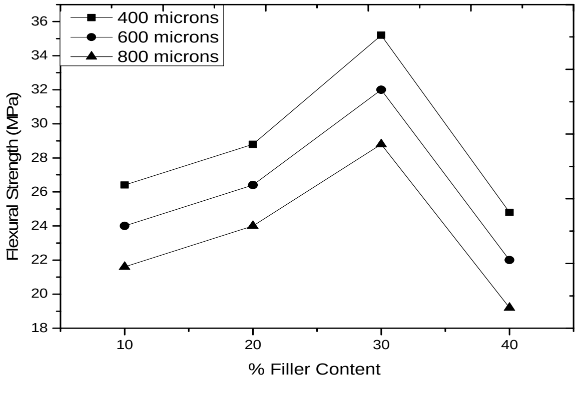

Figure-5. Flexural strength of PW/CNSL composite.

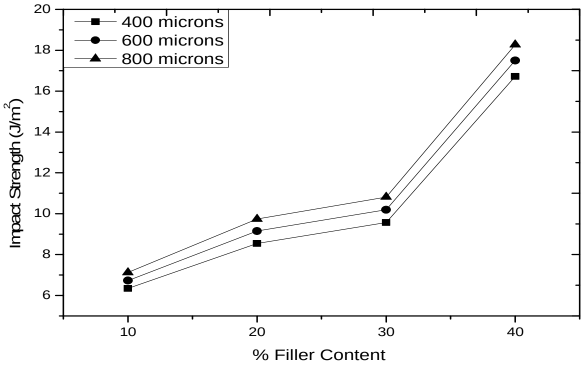

Figure-6. Impact strength of PW/CNSL composite.

4. CONCLUSIONS

Periwinkle shell is a biomaterial while CNSL resin is a natural resin, therefore the composite is a natural composite. The filler content and matrix are renewable natural materials. While the highest tensile and flexural strengths were recorded at 30% filler content and 400 µm particle sizes, the highest tensile modulus and impact strength were recorded at 800 µm particle sizes but 30% and 40% filler content respectively. At 40% filler content the properties tends to decrease indicating that the optimum properties can be achieved at 30 % filler content. In summary 30% filler content gave the best properties.

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