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Assessment of Acetylation and Mercerization on Hardness for Raffia Palm Fibre

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Abstract: *Natural fibers are getting attention from researchers and academician to utilize in polymer composites due to their ecofriendly nature and sustainability. The aim of this study is to assess the hardness for acetylated and mercerized fibre at different fibre length and two varying temperatures. The matured raffia palm fibre were cut, extracted,gathered,retted, dried, treated and modified. After the fibre was dried,they were treated using 5% acetic anhydride and 10% sodium hydroxide solution at two varying oven drying temperatures of 30^{o}C for acetylated fibre and 50^{o}C for mercerized fibre with differentfibre length of 50mm, 60mm, 70mm and 80mm. The resultsshows thatfibre treated with 5% acetic anhydride concentration gave the hardness of 185HB at 80mm fibre length using 30^{o}C oven drying temperature. While fibre treated with 10% NaOH concentrationgave the highest optimum hardness value of 315HB at 50^{o}C using 70 mm fibre lengths. Therefore the hardness of 315HB at 70mm fibre length using 50^{o}C oven drying temperature gave the highest value and this may be due to increase in concentration of sodium hydroxide and oven temperature during the treatment. The result shows increase in hardness with the mercerized fibre.The developed fibre can be reinforced with polymerfor the production ofautomotive and so on. It concluded that chemical treatment of the natural fiber improved adhesion between the fiber surface and the polymer matrix which ultimately enhanced physicomechanical and thermochemical properties of the NFPCs.*

Keywords - *Acetylation, Mercerization, Oven bath temperature.*

I. Introduction

The increase in environmental consciousness and community interest, the new environmental regulations and unsustainable consumption of petroleum, led to thinking of the use of environmentally friendly materials. Natural fiber is considered one of the environmentally friendly materials which have good properties compared to synthetic fiber (May et al., 2013). A late current industry research identified that the worldwide natural fiber reinforced polymer composites industry sector reached U$2.1 billion in 2010. Current pointers are that interest in NFPCs industry will keep on growing quickly around the world. The utilization of NFPCs has expanded considerably in the shopper merchandise as developing industry sectors throughout the last few years. As indicated by evaluations, over 5 years (2011-2016), the NFPCs industry is estimated to grow 10% worldwide (Uddin, 2013). Natural fibers in simple definition are fibers that are not synthetic or manmade. They can be sourced from plants or animals (Ticoalu et al., 2010). The use of natural fiber from both resources, renewable and nonrenewable such as oil palm, sisal, flax, and jute to produce composite materials, gained considerable attention in the last decades, so far. The plants, which produce cellulose fibers can be classified into bast fibers (jute, flax, ramie, hemp, and kenaf), seed fibers (cotton, coir, and kapok), leaf fibers (sisal, pineapple, and abaca), grass and reed fibers (rice, corn, and wheat), and core fibers (hemp, kenaf, and jute) as well as all other kinds (wood and roots) (Faruk et al., 2012). Fiber reinforced polymer matrix got considerable attention in numerous applications because of the good properties and superior advantages of natural fiber over synthetic fibers in term of its relatively low weight, low cost, less damage to processing equipment, good relative mechanical properties such as tensile modulus and flexural modulus, improved surface finish of molded parts composite, renewable resources, being abundant (Shalwan and Yousif, 2013), flexibility during processing, biodegradability, and minimal health hazards. NFPCs with a high specific stiffness and strength can be produced by adding the tough and light-weight natural fiber into polymer (thermoplastic and thermoset) (Xie et al., 2010). On the other hand, natural fibers are not free from problems and they have notable deficits in properties. The natural fibers structure consists of (cellulose, hemicelluloses, lignin, pectin, and waxy substances) and permits moisture absorption from the surroundings which causes weak bindings between the fiber and polymer. Furthermore, the couplings between natural fiber and polymer are considered a challenge because the chemical structures of both fibers and matrix are various. These reasons for ineffectual stress transfer during the interface of the produced composites. Accordingly, natural fiber modifications using specific treatments are certainly necessary. These modifications are generally centered on the utilization of reagent functional groups which have ability for responding of the fiber structures and changing their composition. As a result, fiber modifications cause reduction of moisture absorption of the natural fibers which lead to an excellent enhancement incompatibility between the fiber and polymer matrix (Ray and Bousmina, 2005). The wide applications of NFPCs are growing rapidly in numerous engineering fields. The different kinds of natural fibers reinforced polymer composite have received a great importance in different automotive applications by many automotive companies such as German auto companies (BMW, Audi Group, Ford, Opel, Volkswagen, Daimler Chrysler, and Mercedes), Proton company (Malaysian national carmaker), and Cambridge industry (an auto industry in USA). Beside the auto industry, the applications of natural fiber composites have also been found in building and construction industry, sports, aerospace, and others, for example, panels, window frame, decking, and bicycle frame (Shinoj et al., 2011). In a review of chemical treatments of natural fibers, Kabir et al., 2012 concurred that treatment is an important factor that has to be considered when processing natural fibers. They observed that fibers loose hydroxyl groups due to different chemical treatments, thereby reducing the hydrophilic behavior of the fibers and causing enhancement in mechanical strength as well as dimensional stability of natural fiber reinforced polymer composites. Their general conclusion was that chemical treatment of natural fibers results in a remarkable improvement of the NFPCs.

II. MATERIALS AND METHODS

2.1 MATERIALS

The following materials were usedto conduct this study, they arefibre extracted from the raffia palm (Raffia Farinifera) shown infigure 2.1. Other materials used are graduated cylinder, electric oven, plastic cup, plastic bucket,pH meter, electronic weighing scale, glass beaker, distilled water etc.

Figure 2.1: Extracted Fibre

2 METHODS

The raffia palm fronds were obtained from the swampforest of Ngolo in OmuigweAluu of Rivers State, Nigeria.The matured raffia palm fibre were cut, extracted,gathered,retted, dried, treated and modified. After the fibre was dried, the acetylationfibreswere treated with 5% acetic anhydride solutionand mercerizationfibre were treated with10% NaOH solutionat ambient temperature for 1hwith soaking time of 90mins (1hour 30mins) atdifferenttemperatures andfibre length. The fibres were washed to neutrality and oven dried at varyingtemperatures at different fibre length for the acetylation and mercerization treatedfibre.After the treatment hardness was determinedand results recorded and analyzed.

- Fibre Treatment

The fibres were treated using 5%acetic anhydride and10% sodium hydroxide solution at two different oven dryingtemperatures of 30^{o}C for acetylated fibre and 50^{o}C for mercerizedfibrewith varyingfibre length of 50mm, 60mm, 70mm and 80mm.

- Hardness Test

The resistance to permanent deformation, indentation or scratching is called hardness. The values of hardnessof thefibre samples developed were measured using Rockwell Hardness Tester on MScale by ASTM D785. The results of the hardness test were also recorded.

III. RESULTS AND DISCUSSION

The results of the hardness test conducted on acetylation and mercerizedtreated fibres are presented on table 1-2.The results and analysis of the hardness tests are shown with a bar chat in figure 1-2.

Table 1:Hardness at5%acetic anhydridesolution for dryingtemperature of30^{o}C.

Fibre Replication/Length	Hardness (HB) @50mm	Hardness (HB) @60mm	Hardness (HB) @70mm	Hardness (HB) @80mm
R1	133	124	130	120
R2	168	84	181	185
R3	152	103	177	104
R4	151	104	163	131
R5	146	110	155	172

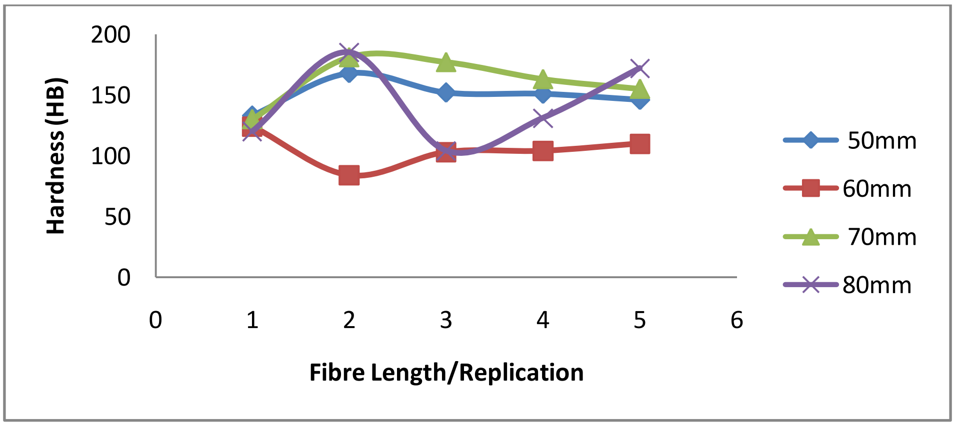

Fig. 1: Graph of hardness at5%acetic anhydride solution for drying temperature of 30^{o}C

Table 2: Hardness at 10%NaOH solution for drying temperature of 50^{o}C

Fibre Replication/Length	Hardness (HB) @ 50mm	Hardness (HB) @60mm	Hardness (HB) @70mm	Hardness (HB) @80mm
R1	308	90	131	153
R2	113	108	159	100
R3	151	177	315	197
R4	191	125	202	150
R5	142	165	250	130

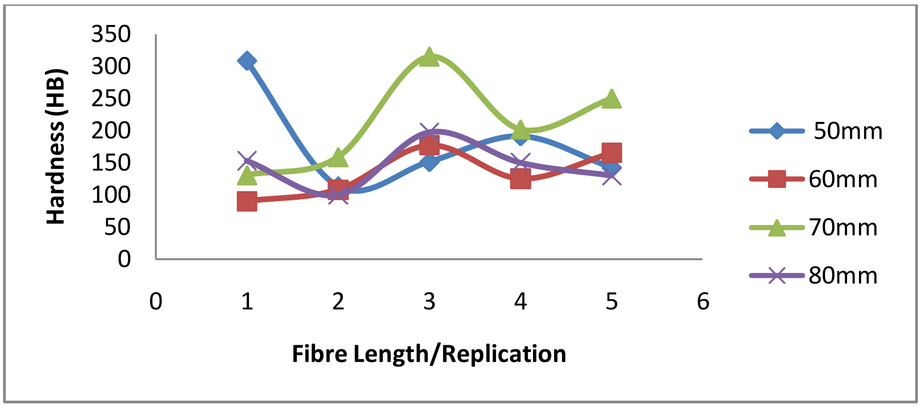

Fig. 2: Graph of hardness at 10%NaOH solution for drying temperature of 50°C

The results of hardness analysis obtained from the test conducted on the 5% acetic anhydride and 10%sodium hydroxide concentration for differentoven drying temperature and fibre length for modified fibre, shows thatfibre treated with 5% acetic anhydride concentration gave the hardness of 185HB at 80mm fibre length using 30°C oven drying temperature. Whilefibre treated with 10% NaOH concentrationgave the highest optimum hardness value of 315HB at 50°C using 70 mm fibre lengths. Therefore the hardness of315HB at 70mm fibre length using 50°C oven drying temperature gave the highest value and this maybe due to increase in concentration of sodium hydroxide and oven temperature during the treatment. The result shows increase in hardness with the mercerized fibre.

IV. CONCLUSION

Composites are engineered materials made from two or more constituents with different physical or chemical properties, which remain separate and distinct within the finished structure. The composite should also have properties which surpass the properties of the individual constituents. Composites of various kinds surround us in everyday life, natural and manmade. Examples of natural composites (not manmade) are the human bones and wood. Nature is brilliant in its construction of materials suitable for different purposes. Humans have used the idea of composite materials for ages in various applications such as building blocks from straw and clay, concrete reinforced with steel and polymers reinforced by various kinds of fibers and so on. Recently, natural fiber have gained increase value due to low cost, light weight, stiffness, competitive specific strength, improvement in energy recovery, flexibility and friendliness to the environment as well as their renewable nature. Natural fibre is used in oil and gas, offshore applications if reinforced with plastics for the production of product system like cylinder, tanks and pipes etc.

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