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The effect of alkaline treatment on tensile properties of sugar palm fibre reinforced epoxy composites

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Abstract

A study on the effect of alkaline treatment on tensile properties of sugar palm fibre reinforced epoxy composites is presented in this paper. The treatment was carried out using sodium hydroxide (NaOH) solutions at two different concentrations and three different soaking times. The hydrophilic nature of sugar palm fibre makes it difficult to adhere to hydrophobic epoxy and therefore posed the problem of interfacial bonding between fibre and matrix and such treatment was needed to alleviate such problem. The composite specimens were tested for tensile property determination. Some fractured specimens were examined under scanning electron microscope (SEM) to study the microstructure of the materials. Inconsistent results were obtained for tensile strengths, which indicate that the treatment is not very effective yet to improve the interfacial bonding. However, for tensile modulus, the results are much higher than untreated fibre composite specimens, which proved the effectiveness of the treatment.

Keywords: *Arenga pinnata*; Sugar palm fibre; Epoxy composites; Alkaline treatment; Tensile properties

1. Introduction

In the recent years, due to increased environmental concerns, scientists and technologists have placed so much importance on the application of natural materials. This move has encouraged industries like furniture, automotive, building construction, and packaging to search for new form of fibre composites that can substitute the conventional composite materials. Conventional composite like glass fibre composite is recently being replaced with natural fibre composites in the applications where strength is not a critical factor. Taking the advantages of natural fibre composite properties compared to glass fibre composites, such as non-abrasive to equipment and freedom from health problem due to skin irritation during handling and processing, the use of natural fibre composites are preferred.

Compared to inorganic reinforcing fibres, natural fibres have some advantages such as low density and bio-degradability, less abrasiveness, lower cost and renewable. Natural fibre composites are environmentally superior to glass fibre composites in most cases [1]. Natural fibres like jute, pineapple leaf, sisal, flax, hemp, kenaf, coir, and abaca have been used by researchers to replace the inorganic fibres (glass, aramid and carbon) in reinforced composites [2].

Unfortunately, some drawbacks of natural fibres such as thermal and mechanical degradation during processing make them undesirable for certain applications. Natural fibre reinforced composites also have several drawbacks such as poor wettability, incompatibility with some polymeric matrices and high moisture absorption by the fibres. The main problem often encountered in its use is the fibre–matrix adhesion problem due to the incompatibility between the hydrophilic natural fibres and the hydrophobic polymer matrix. This problem may be improved by chemically treating the fibre surfaces. Alkali treatment is a common method to clean and modify the fibre surface to lower surface tension and enhance interfacial adhesion between a natural fibre and a polymeric matrix [3]. Several publications have discussed the effects of alkali treatment

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on structure and properties of natural fibres such as kenaf [4], hemp [4], flax [5], jute [6] and sisal [7].

In this research, sugar palm fibre (*Arenga pinnata* or *Arenga saccharifera*) is used as a material to reinforce polymer matrix in epoxy composite. Sugar palm fibre is a kind of natural fibre that comes from a forest plant that can be found enormously in Southeast Asian countries like in Indonesia and Malaysia. This fibre seems to have properties like other natural fibres, but the detail properties are not generally known yet. Sugar palm has desirable properties like strength and stiffness and its traditional applications include paint brush, septic tank base filter, clear water filter, door mat, carpet, rope, chair/sofa cushion, and for fish nest to hatch its eggs [8]. The sugar derived from the sugar palm tree is called palm sugar or locally know as *gula kabong* and it is one of the local delicacies widely consumed by Asians for making cakes, desserts, food coatings or mixed with drinks. It is produced by heating the sap derived from the sugar palm tree [9]. Fig. 1 shows a typical sugar palm tree [10].

Previous study [10] on the tensile and flexural properties of sugar palm epoxy composites is concerned with the use of woven roving, long random and chopped random sugar palm epoxy composites and it is found that the woven roving sugar palm epoxy composites gave better properties compared to long random and chopped random fibre composites. However, all the samples showed inferior properties compared with the glass fibre epoxy composites. Hence, the treatment of fibre was needed to improve the materials.

Fig. 1. Sugar palm tree [10].

In this study, an attempt is made to study the effect of alkaline fibre treatment on tensile properties of sugar palm fibre reinforced epoxy composites.

2. Materials and methods

The preparation of sugar palm epoxy composite plate fabrication based on one type volume fraction, i.e. 10%. The laminated composite plate was produced by hand lay-up process and was cut to form a specimen test based on ASTM D638-99 [11] dimensional specimen testing to determine its tensile properties. The steps taken in the experiment include preparation of materials, i.e. fibre, matrix resin, and sodium hydroxide (NaOH) as treatment solution, parameters of treatment, fabrication of composites, testing of the tensile properties and morphological study of the sugar palm epoxy composite.

The selected raw material of the fibre for this research was sugar palm fibre and the matrix was selected from epoxy resin group. The ratio between resin and hardener for this study was 4:1 by weight. The sugar palm fibre was collected from Banda Aceh, Indonesia and retting process was applied in order to separate the stalk from the core of the sugar palm fibre. In this process, bundles of sugar palm fibre were soaked into water tank until the dirt vanished from the core section and the stalk was separated from the core. The sugar palm fibre stalks were occasionally stirred to facilitate the separation process. Water was changed several times in order to reduce the dirt resulted from the retting process. Before using the sugar palm fibre, it was dried for about two weeks under the room temperature. Fig. 2 presents a bundle of sugar palm fibre.

Chemical treatment solution used was sodium hydroxide (NaOH) and was purchased from a local supplier in Malaysia. This solution was prepared as liquid form in the bottle with concentration of 1 M. The two types of concentration for the experiment (0.25 M and 0.5 M) were prepared based on the following formula:

$$A_1 \cdot V_1 = A_2 \cdot V_2 \quad (1)$$

where A_1, concentration of solution in condition 1; V_1, volume of solution in condition 1; A_2, concentration of solution in condition 2; V_2, volume of solution in condition 2.

The alkali treatment was conducted with concentration of 0.25 M and 0.5 M NaOH, at three different soaking times namely 60 min, 4 h and 8 h. These variations were made to optimize the treatment parameter. The concentrations were ensured by the addition of water at certain percentages of the original NaOH (1 M).

Sugar palm fibres were immersed in NaOH solution at various concentrations and soaking times, and after that they were rinsed with distilled water until the rinsed solution reached neutral (pH 7). Then, fibres were dried at room temperature for 4 days.

Fig. 2. A bundle of sugar palm fibre.