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Effects of plasma treatment on the sorption properties of coconut fibers

Daniel Magalhães de Oliveira[a*], Maria Odila Hilário Cioffi[a], Kelly Cristina Coelho de Carvalho Benini[a], Herman Jacobus Cornelis Voorwald[a]

[a]*São Paulo State University (UNESP), School of Engeneering (FEG), Department of Materials and Technology, Fatigue and Aeronautical Materials Research Group, 12516-410, Guaratinguetá, São Paulo, Brazil.*

Abstract

This work compares the effects of plasma treatment on the sorption capacity of untreated and treated coconut fibers. Non-woven mats of coconut fibers were firstly molded by hand, than washed with boiling water, dried, and finally treated by argon plasma jet. Treated and untreated coconut fibers mats have been analyzed by the absorption and contact angle measurements, besides the scanning electron microscopy (SEM) analysis. These characterizations show that the plasma treatment provides to coconut fibers an increase in hydrophilicity and surface roughness, enabling them better sorption properties.
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* Corresponding author. Tel.: +55 12 31232865
E-mail address: daniel.steiger@live.com

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1. Introduction

Environmental concerns and waste problems explain the growing interest on natural and sustainable materials, like natural fibers, in order to replace synthetic or non-renewable sources materials. Therefore it is necessary to develop new uses for these waste/renewable materials, preserving the environmental and economic factors [1]. A feasible application for this natural material is as reinforcement for composites called as green composite materials [2]. Natural fibers like coconut, flax, hemp, jute, pineapple and sisal are increasingly being used in the construction and automotive industries in various applications, e.g. automotive industries as Mercedes Benz, Toyota and DaimlerChrysler have introduced natural fiber composites for interior and exterior applications [3]. These natural fibers have specific properties as lower prices when compared to synthetic fibers (glass, carbon, Kevlar etc.), making it attractive for these industries [4]. The natural ones are easily found in the nature and thus are considerate a renewable resource, presenting properties such as low density, low cost (in general no cost), safe handling, non-toxicity, biodegradability besides be abundantly available. The sum of these characteristics make natural fibers an interesting replacement for synthetic fibers in composite materials [5].

This work is part of a larger project focused on the manufacturing of a green composite, composed by bio polyester resin as matrix and coconut fibers mats as reinforcement, and its argon plasma treatment influences. Based on that and with a big amount of research and development efforts reporting in literature to find new uses for coconut fibers, this study aims to understand the effects of plasma treatment on the coconut fibers surface. For example, the coconut has 85% of its total weight of shell waste [6]. Typically planted in tropical and subtropical regions around the world with an annual world production of 50 billion fruits nearly, it influences directly the environment of these places [7].

In order to use coconut fiber as composite reinforcement, the drawbacks are the interfacial bond strength between fiber and matrix, caused by the poor surface energy of the fiber and its weak sorption properties. This interface is a combination of physical, mechanical or chemical interactions caused by a reaction between the interfacial components. Aspects like mechanical interlocking, chemical bonding and molecular interaction affect the interface [8]. To enhance the fibers sorption aspects and consequently improve the interaction/adhesion fiber-matrix, different approaches have been tried including chemical (e.g. alkali, alcohol, hydrogen peroxide) and physical treatments (e.g. heat treatment, corona and plasma treatments) [6]. Plasma technology is a new, versatile and promising technique involving private and public investment [9]. It is a dry treatment, avoiding pre-treatment steps comparing to other types of high cost methods that use chemistry and energy for drying [10]. In addition, this method was chosen for its potential to save water and non-toxicity, considered a new alternative less aggressive to the environment, when compared to chemical treatments [11]. This technique introduces amounts of polar atoms and active groups into the treated fiber structure turning it to a more hydrophilic surface [12], [13].

Based on the facts presented, the plasma treatment was chosen as a surface treatment for coconut fibers in order to obtain a higher surface energy inducing better sorption properties and consequent enhance the interfacial fiber-matrix interaction/adhesion aiming a feasible natural polymer composite. The sorption properties of untreated coconut fiber (UCF) and treated coconut fiber (TCF) were determined. The improved sorption properties have been analyzed by the absorption and contact angle measurements, besides scanning electron microscopy (SEM) analysis, in addition a comparison between UCF and TCF was done.

2. Experimental

2.1. Materials

Coconut fibers, kindly supplied by Projeto Coco verde - Rio de Janeiro, were washed with boiling water in a glass dish in order to the fiber become more flexible in addition to take out residual impurity. Coconut fiber mats (Fig. 1) were produced between two shape glass plates, pressed by clips, dried at 70°C in an oven for 48h.

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