Accepted Manuscript

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PII: S1359-835X(17)30154-9
DOI: http://dx.doi.org/10.1016/j.compositesa.2017.04.005
Reference: JCOMA 4632

To appear in: *Composites: Part A*

Received Date: 28 October 2016
Revised Date: 30 March 2017
Accepted Date: 7 April 2017

Please cite this article as: Hamidreza Ghaffar, S., Fan, M., McVicar, B., Interfacial properties with bonding and failure mechanisms of wheat straw node and internode, *Composites: Part A* (2017), doi: http://dx.doi.org/10.1016/j.compositesa.2017.04.005

Interfacial properties with bonding and failure mechanisms of wheat straw node and internode

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Abstract

The interfacial properties with bonding and failure mechanisms of different anatomical sections of wheat straw stem, namely node and internode, inner and outer surface, with various resins are investigated. An environmentally friendly pre-treatment was employed which led to an improved interface between resins and the micro porous surface of straw. The results showed that chemical functionalities of various surface profiles altered the bonding performance, i.e. extractive, aliphatic fraction of waxes, and silica concentrated on the outer surface, inhibited the bonding quality and the establishment of robust interface. The pre-treatment however, could significantly ($P < 0.05$): i) modify the surface of straw with the partial removal of extractives, waxes, and silica which made it more hydrophilic and more compatible with water based resins, ii) cause the microcellular structure of straw to expand and hence inspire the mechanical entanglement on a micro level upon resin solidification and, iii) increase the tensile strength of node and internode by modifying the cellulose crystallinity. The combined effects of resin, straw and interface led to hierarchical damage process, which could be modelled into four main failure mechanisms representing strong to weak bonding quality.

1. Introduction

There is a rising interest in utilising straw biomass for novel hybrid bio-composites with competitive mechanical and physical properties in the face of climate change and demands for sustainable economic growth. Wheat straw could represent a great alternative to wood in manufacturing bio-composites [1–4]. Wheat straw is a polymeric composite with cell walls made up of mainly cellulose, hemicellulose and lignin. The cellulose and hemicellulose are fibrous materials and the lignin is the binder holding the fibres together providing rigidity to the strong fibres. The chemical composition of wheat straw is similar to wood but its structure is looser and its strength is lower. It contains less lignocellulose cells and more ash and extractive with lower molecular weights than wood. The hydrophobic extractives such as waxes on wheat straw