Characterization of interphase in natural fiber reinforced polymer composites using nano-scratching and Atomic Force Microscopy

Sandeep Sudhakaran Nair
Dr. Siqun Wang

PRESENTATION OVERVIEW

• Introduction
• Objective
• Materials and Methods
• Preliminary Results
• Expected Results
• Future works

INTRODUCTION

Natural fiber-reinforced polymer composites
Applications: boat hulls, bathtubs, door panels and rear shelf panels in cars, archery bows

Advantages: Biodegradable, renewable, low density, desirable fiber aspect ratio, recyclable, high specific properties, low energy consumption, carbon dioxide neutral, no residues when incinerated, with natural fiber composites, car weight reduction up to 35% is possible.
INTRODUCTION

Natural fiber-reinforced polymer composites

Disadvantages - High moisture absorption, poor dimensional stability, poor microbial resistance, low thermal resistance, anisotropic properties, low transverse strength, low compressive strength, demand and supply cycles

Major disadvantage - natural fibers are hydrophilic while that of thermoplastic matrix are hydrophobic in nature leads to a weak adhesion at the interface

Interface or Interphase
- Transition region that possesses neither the properties of fiber nor matrix

Characterization techniques
- Micro-mechanical techniques - single fiber pullout, microdebond test, micro-nano indentation techniques
- Spectroscopic techniques - X-ray photoelectron spectroscopy, FTIR, Laser Raman spectroscopy, Nuclear magnetic resonance, photo acoustic spectroscopy
- Microscopic techniques - SEM, TEM, AFM
- Thermodynamic methods - Wetting study, inverse gas chromatography, Zeta potential, Dynamic mechanical analysis, Stress relaxation techniques

(Jacob M, Joseph S, Pothen L A, Thomas S 2005)
INTRODUCTION

Nano-scratching test

Equipment - Nano-indenter XP

Determines the coefficient of friction and hardness
INTRODUCTION

Scratch test for polyester/glass

Hodzic A, Stachurski ZH (1999)

Objective

Estimation of the width and mechanical properties of interphase of various natural fiber reinforced polymer composites

MATERIALS AND METHODS

Lyocell fiber H100- Diameter-12 μms
  - Length Around 30 mms

Thermoplastics polymer preferred – PP

Coupling agents –MAPP, silane treatment (γ-APS)
MATERIALS AND METHODS
Thermoplastic with MAPP were blended using MINILAB extruder – 200 C, 100 rpm, 10 min
Silane treatment for fibers
Polymers were compression molded into .254 mm films using 12” Carver press
Fibers unidirectionally placed in between films and films were compression molded- 200 C(PP), 10 min

MATERIALS AND METHODS
Composites were cut into small blocks and mounted to ultra microtome and cross sectionally cut- glass knife and then diamond knife

MATERIALS AND METHODS
Scanning by different modes of AFM
Mainly contact, non-contact and thermal mode
Phase image by non-contact mode – determining the stiffness difference in the interphase
MATERIALS AND METHODS

Nano-scratching will be done on the samples using nanoindenter-XP.

Profile depth – hardness, Coefficient of friction will be used for characterizing interphase.

Preliminary results

Preliminary results
Preliminary results

3-D Topography

Expected results

- Interphase width depends on the adhesion between polymer and the fiber
- Better adhesion gives much more wider interphase width
- Coefficient of friction and hardness varies along the interphase from fiber to matrix
Future works

- Preparing more samples with different coupling agents and treatments
- Nano-scratching
- Phase images of the samples
- Making composites using cellulose films

ACKNOWLEDGEMENTS

- UTFPC
- Dr. John Dunlap – Dept of Material Science, UT
- Dr. Cheng Xing- UTFPC
- USDA NRI grant number # 2005-02645
- USDA Wood Utilization Research Grant