FPC

University of Tennessee

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

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PRESENTATION OVERVIEW

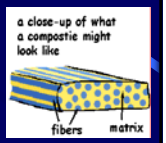
- Introduction
- Objective
- Materials and Methods
- Preliminary Results
- Expected Results
- Future works

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

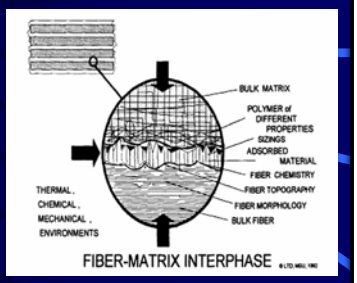
Disadvantages- High moisture absorption, poor dimensional stability, poor microbial resistance, low thermal resistance, anisotropic properties, low transverse strength, low compressive strength, demand and supply cycles

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

INTRODUCTION

Interface or interphase

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



(Jacob M, Joseph S, Pothan L A, Thomas S 2005)

INTRODUCTION

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

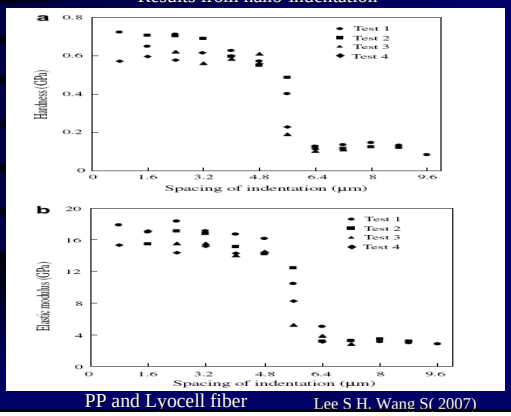
Microscopic techniques- SEM, TEM, AFM

Thermodynamic methods- Wetting study, inverse gas chromatography, Zeta potential, Dynamic mechanical analysis, Stress relaxation techniques

Summary of previous findings on interphase thickness and properties in various PMCs

Investigators	Polymer system (method)	Interphase thickness; hardness relative to bulk polymer
Munz *et al.*	Carbon fiber in epoxy (AFM force modulation)	20–80 nm est.; hardness not reported
Bogetti *et al.*	Carbon fiber in epoxy (finite element analysis of AFM nanoindentation)	0.003 μm; softer
Williams *et al.*	Carbon fiber in epoxy (nanoindentation and micro-pullout debonding)	500 nm est.; softer
VanLandingham *et al.*	Epoxy and polysulphone (AFM nanoindentation)	3 μm; harder
Winter and Houston	Glass fiber in epoxy (nanoindentation/ interfacial force microscopy)	8 μm; softer initially, then harder than bulk
Mai *et al.*	Glass fiber in epoxy (AFM force modulation)	1–3 μm; ductile in sized fibers, brittle in unsized

Results from nano-indentation



PP and Lyocell fiber

Lee S H, Wang S(2007)

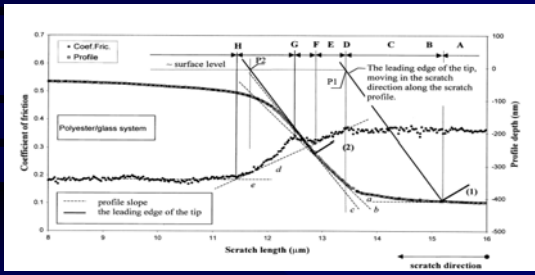
INTRODUCTION

Nano-scratching test

Equipment-Nano-indenter XP

Determines the coefficient of friction and hardness

INTRODUCTION



Hodzic A, Stachurski Z H (1999)

Scratch test for polyester/glass

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

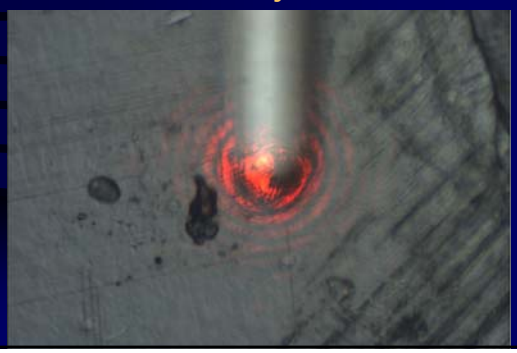
MATERIALS AND METHODS

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

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

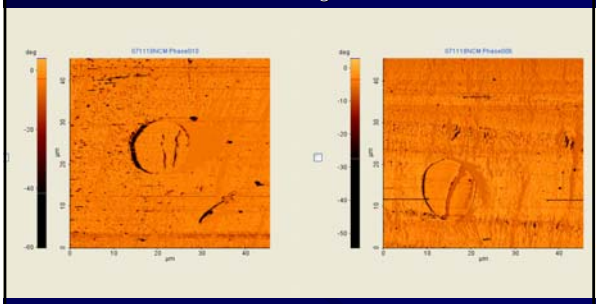
Preliminary results

Preliminary results



Preliminary results

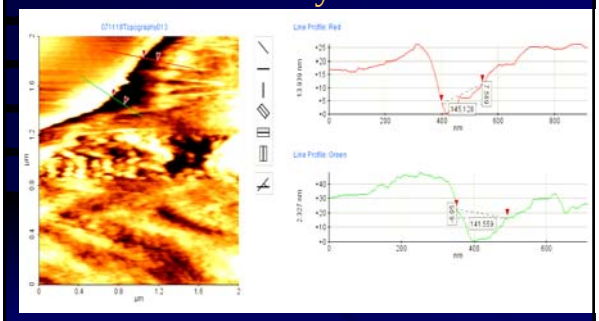
Phase images



Without treatment

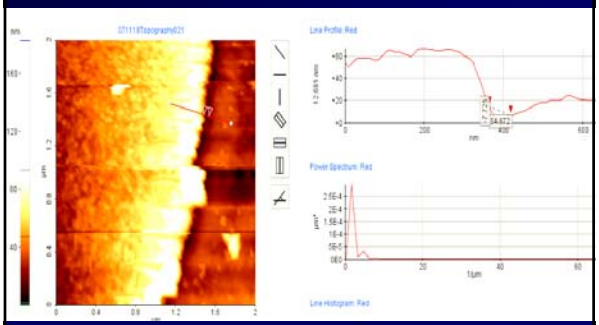
With treatment

Preliminary results



Topography

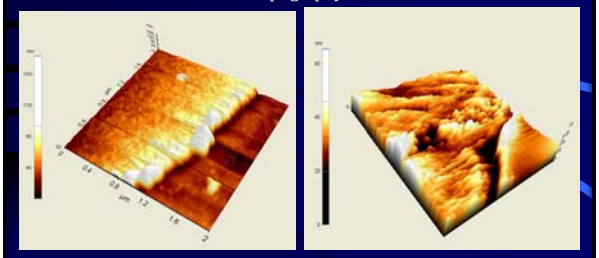
Preliminary results



Topography

Preliminary results

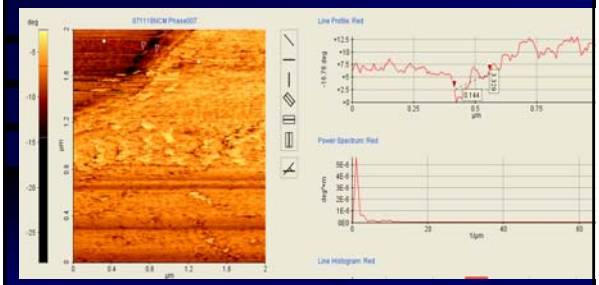
3-D Topography



Without treatment

With treatment

Preliminary results



Phase image

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

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