*Rosiyah Yahya *, Noordini M. Salleh,*
Normasmira A. Rahman, Aziz Hassan

Fibre Length, Thermal and Mechanical Properties of Injection-Moulded Glass-Fibre/Polyamide 6,6 Composite: Effect of Moisture Absorption

11TH INTERNATIONAL CONFERENCE ON FRONTIERS OF POLYMERS AND ADVANCED MATERIALS

(11TH ICFPAM)

UNIVERSITY OF PRETORIA, SOUTH AFRICA

20 – 25 MAY 2011

Fibre Length, Thermal and Mechanical Properties of Injection-Moulded Glass-Fibre/Polyamide 6,6 Composite: Effect of Moisture Absorption

Rosiyah Yahya *, **Noordini M. Salleh, Normasmira A. Rahman, Aziz Hassan**

Polymer & Composite Materials Research Laboratory,
Department of Chemistry,
University of Malaya

Outline

- **Introduction**
  - Background & Objective
- **Experimental**
  - Preparation, Characterisation & Testing
- **Results and Discussion**
  - FLD, Thermal & Mechanical Properties
- **Conclusion**

Introduction

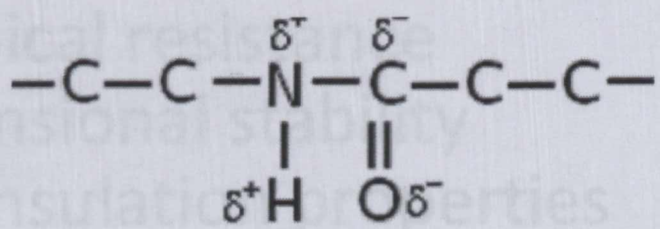
- **Composites**
  - two or more distinct components combined together to achieve superior characteristics not attainable by either constituents acting alone.

- **Glass fibre / Polyamide 6,6 composites**
  - outstanding mechanical properties
  - extensively used in many engineering applications

Introduction

Polyamide 6,6

- Thermoplastic polymer
- Relatively easy to process
- Hygroscopic material (RT ~2.5% water)
- Melting point : 255˚C - 265˚C
- Contains amide bonds (H-bonds)

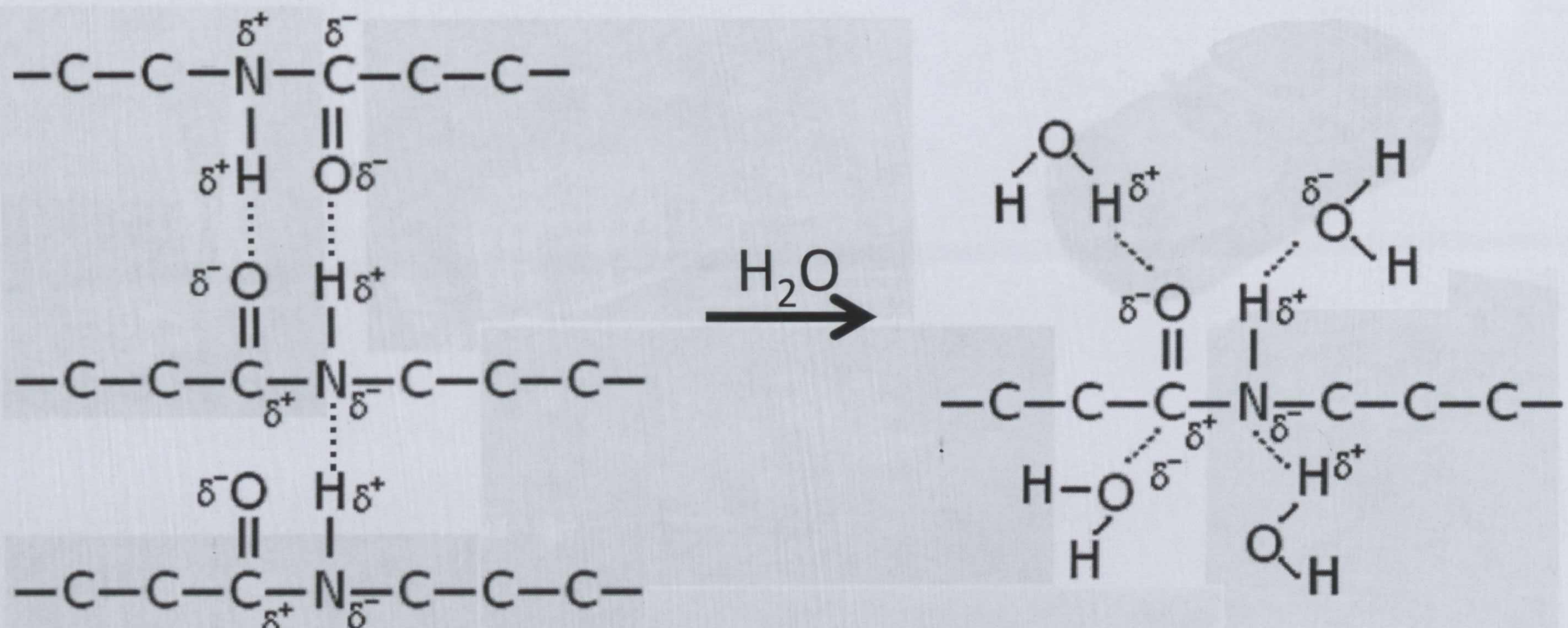


- **E-glass fibre**
- Diameter : 14 µm
- Density : 2.56 g/cm^3
- Structure has polar surface silanol groups (chemical interactions)

Commonly used as reinforcing agent due to:

- Low cost
- High tensile strength
- High chemical resistance
- High dimensional stability
- Excellent insulation properties

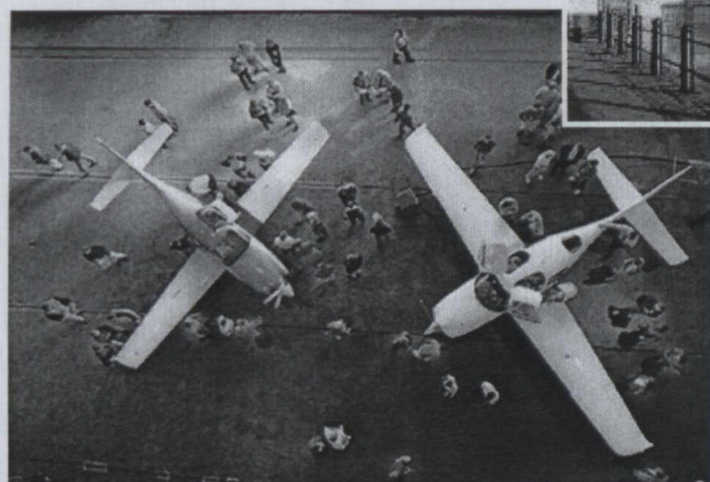
- *Plasticisation effect of water*

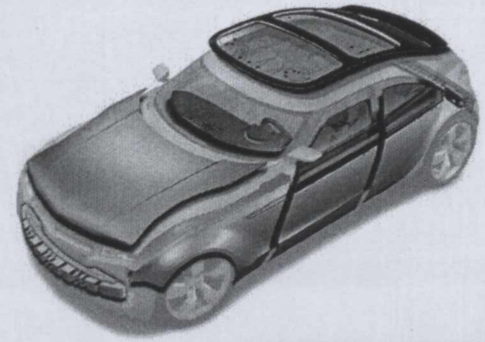
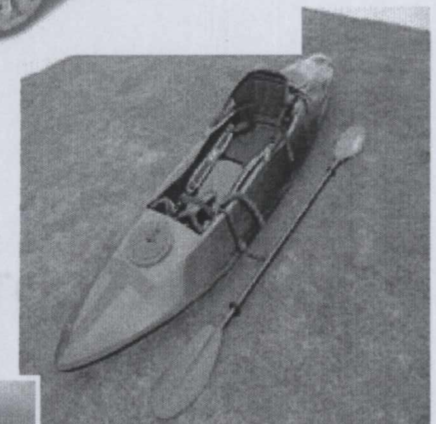


Water penetrates the amorphous region, readily breaking the H-bonds of the amide group and increases chain mobility

General applications



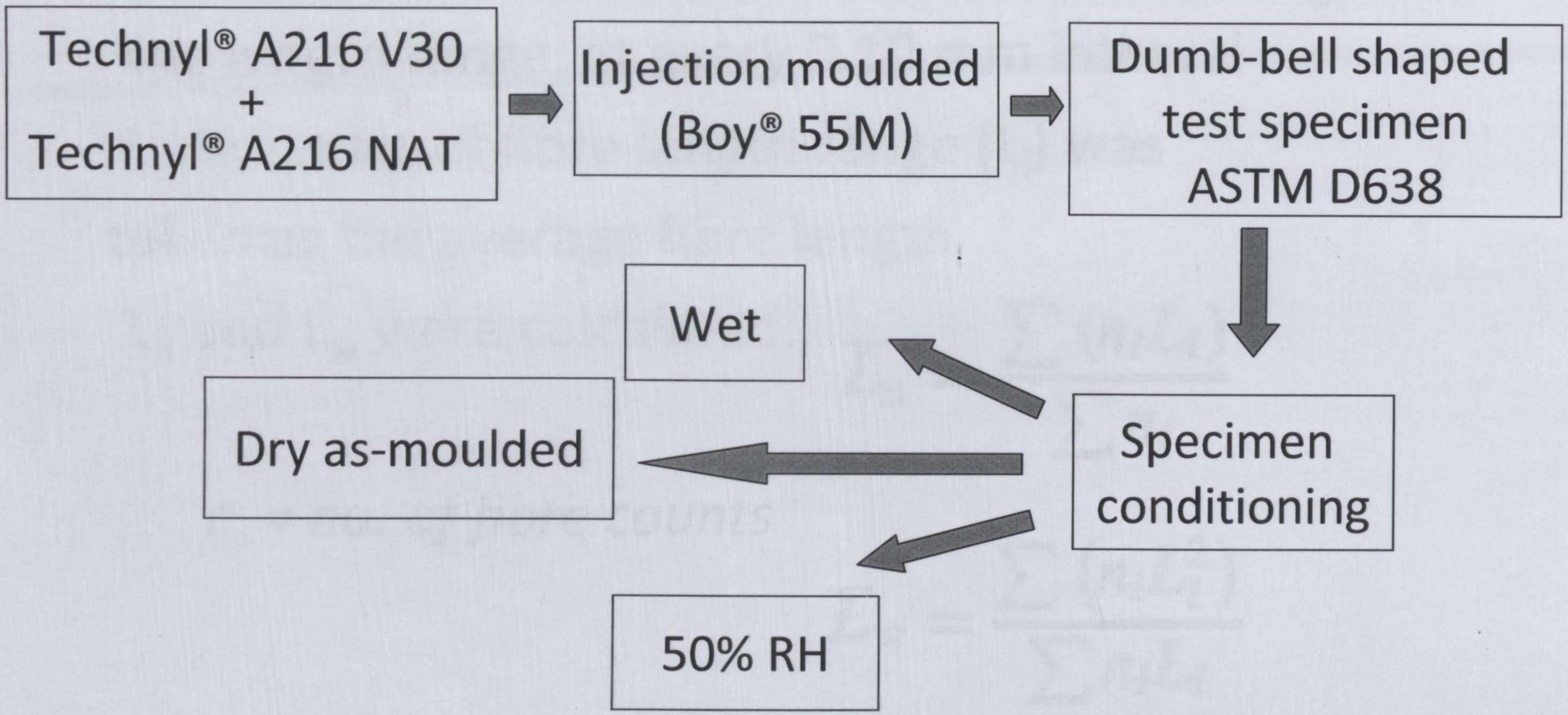

Objectives

- To investigate the influence of glass fibre as reinforcement in composites

- To study the effect of conditioning (water absorption) on thermal and mechanical properties of composites

Experimental

Specimen preparation



FLD determination

- Fibres were extracted from specimens after ashing
- 500 fibres were counted and divided according to the length range, at every 0.10 mm interval
- A mid-point of fibre length range (L_i) was taken as the average fibre length
- L_n and L_w were calculated:

$$\overline{L_n} = \frac{\sum (n_i L_i)}{\sum n_i}$$

n_i = no. of fibre counts

$$\overline{L_w} = \frac{\sum (n_i L_i^2)}{\sum n_i L_i}$$

Thermal properties determination

- **Thermogravimetric analysis (TGA)**
  - TGA 6 Analyser (Perkin Elmer)
  - thermal decomposition behaviour
  - scan rate : 10°C/min (50°C to 900°C)

- **Differential scanning calorimetry (DSC)**
  - Diamond DSC (Perkin Elmer)
  - heating and cooling treatment
  - scan rate : 10°C/min (0°C to 190°C)

Mechanical properties determination

- **Tensile and Flexural Testing**

  - Universal Testing Machine (Instron 5569)

  - load cell : 50 kN

  - cross-head speed : 1.0 mm/min (tensile)

    : 1.28 mm/min (flexural)

  - support span : 50 mm (flexural)

Results and Discussion

Fibre Length Distribution (FLD)

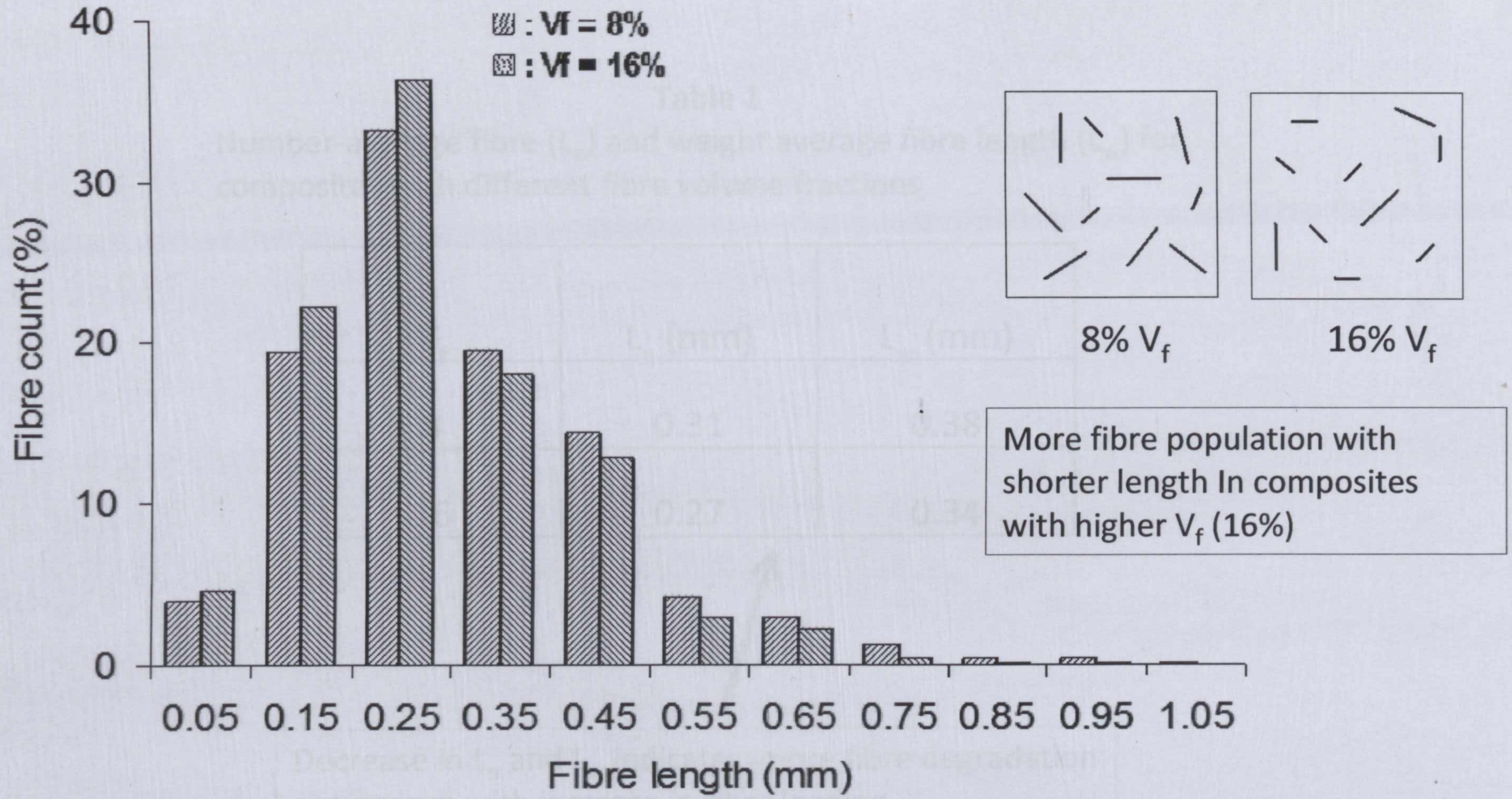


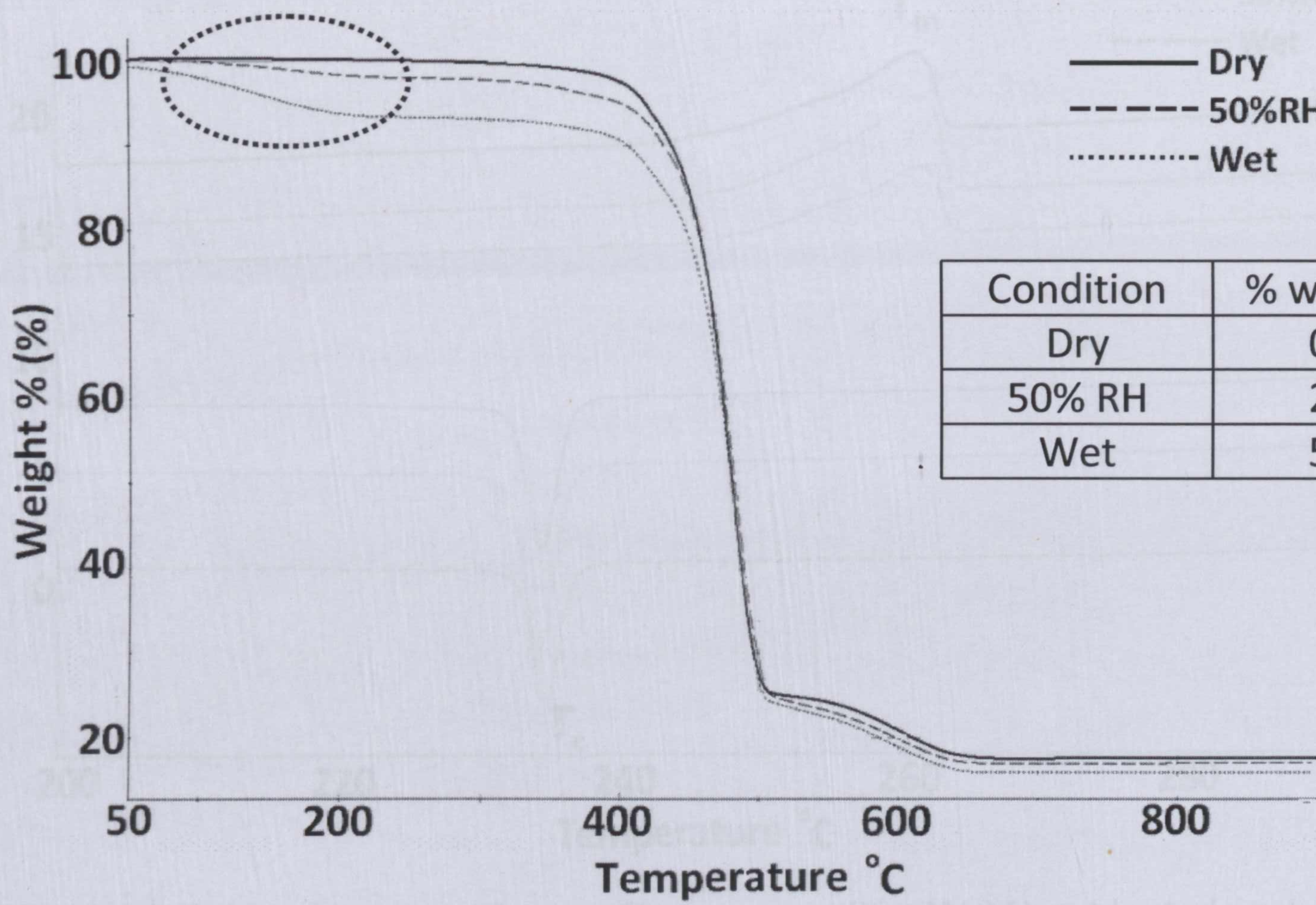
Fig. 1. FLD of injection moulded (tensile specimen) composites

Table 1

Number-average fibre (L_n) and weight average fibre length (L_w) for composites with different fibre volume fractions

V_f	L_n (mm)	L_w (mm)
8	0.31	0.38
16	0.27	0.34

Decrease in L_n and L_w indicates more fibre degradation occurrence with increase in fiber loading



Condition	% water
Dry	0
50% RH	2
Wet	5

Fig. 3. TGA curves of glass fibre composite (8% V_f) subjected under different conditions

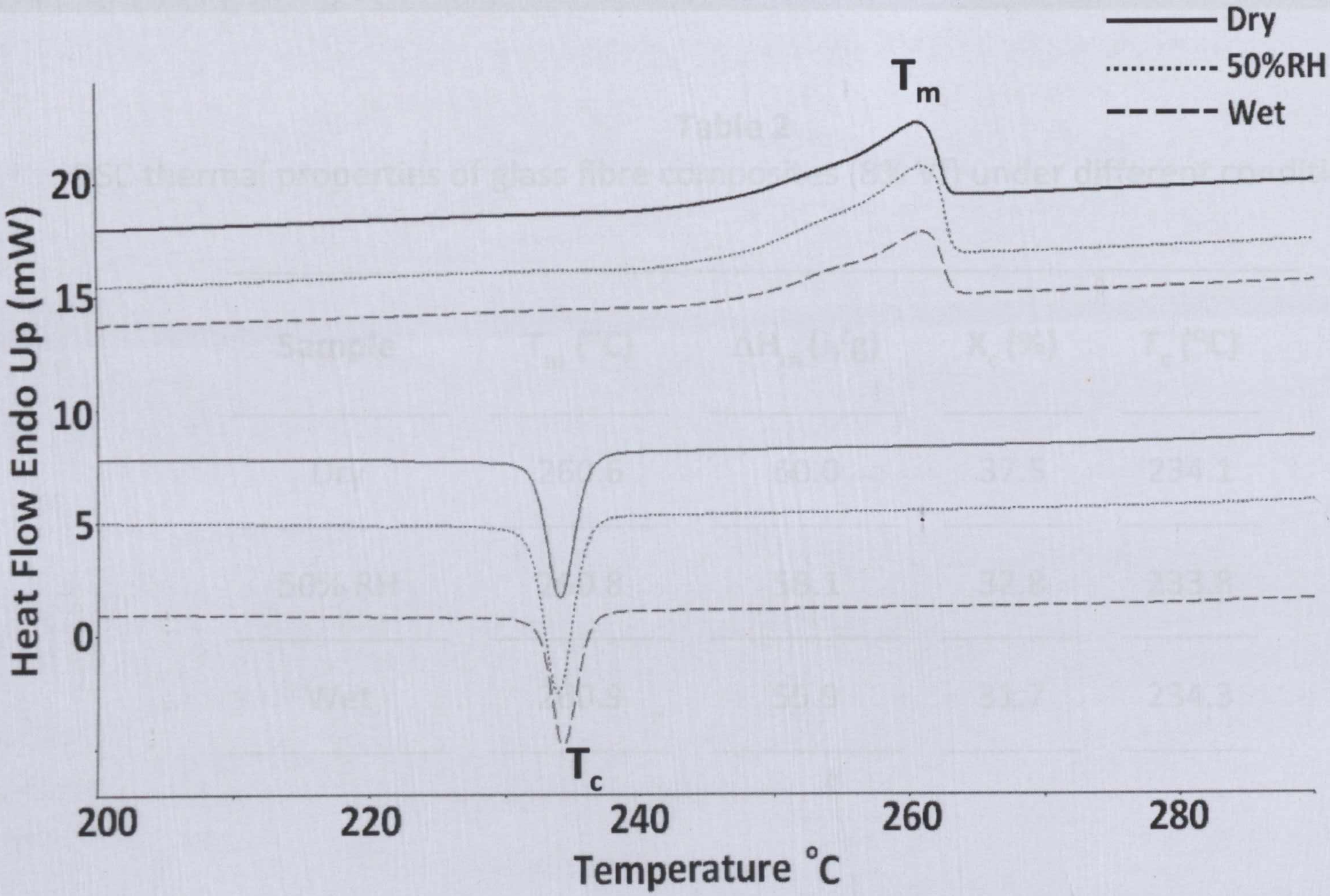


Fig.4. DSC thermograms of glass fibre composite (8% V_f) subjected under different conditions

Differential scanning calorimetry (DSC)

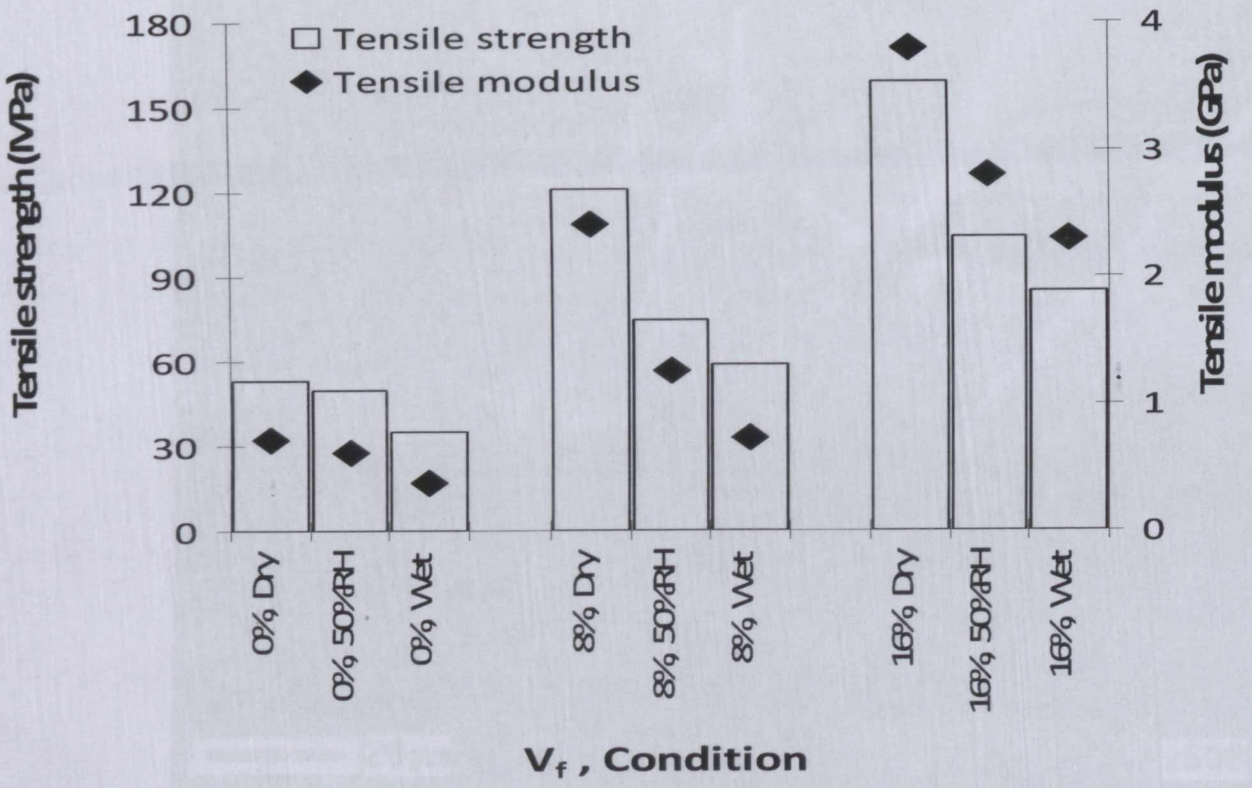
Table 2

DSC thermal properties of glass fibre composites (8% Vf) under different conditions

Sample	**T_m (°C)**	**ΔH_m (J/g)**	**X_c (%)**	**T_c (°C)**
Dry	260.6	60.0	37.5	234.1
50% RH	260.8	58.1	32.8	233.8
Wet	260.9	55.9	31.7	234.3

Changes in crystal structure due to plasticisation effect of water weakens H-bonds of the amide

Tensile properties



Water acts as plastisicer, weakens fibre-matrix interfacial shear strength and stress transfer capability

Higher V_f, more fibre-matrix interfacial area/bonding

Fig. 5. The tensile strength and tensile modulus of composites subjected under different conditions

Tensile properties

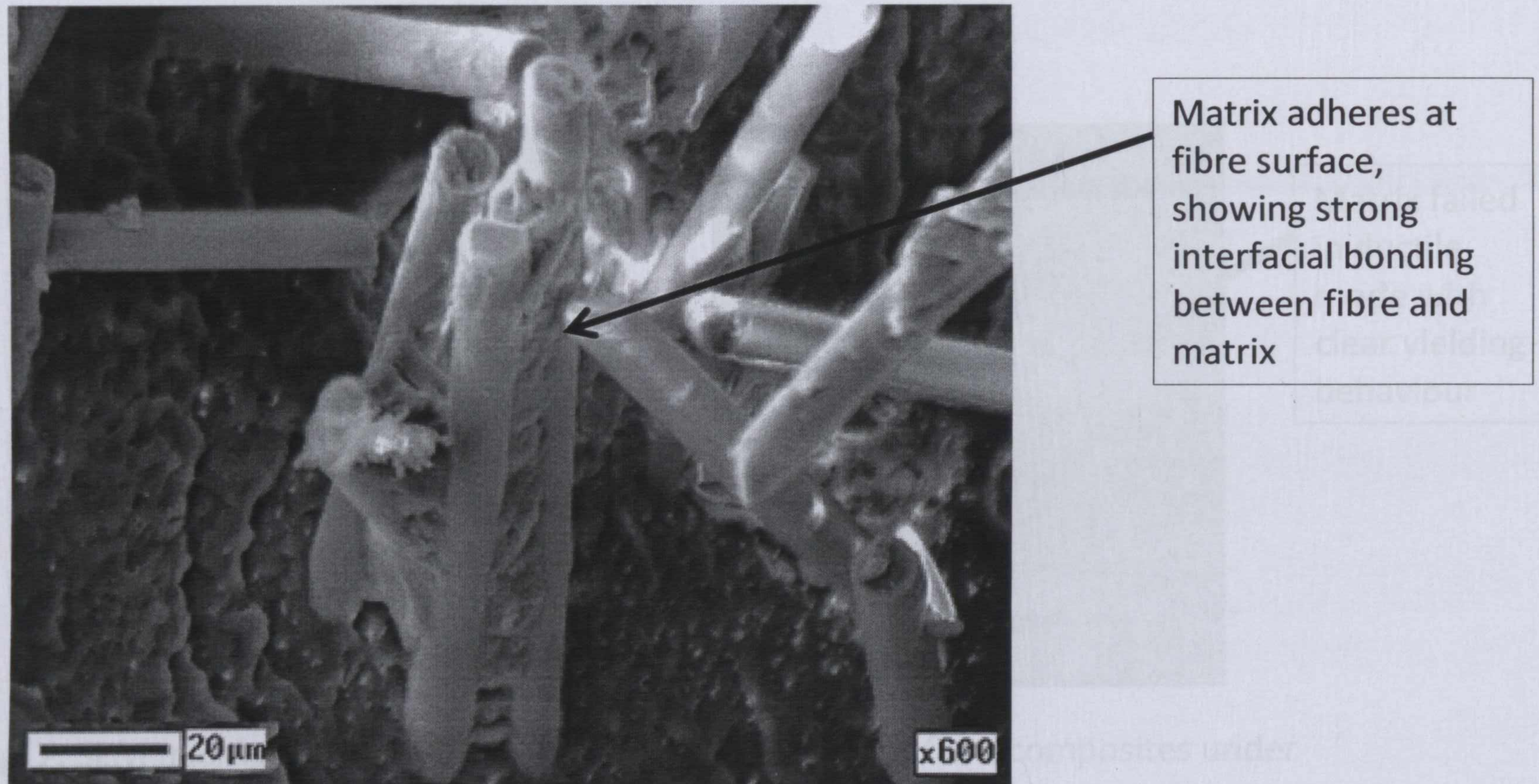


Fig. 6. SEM micrograph of tensile fracture surface of glass fibromposite under dry as moulded condition

Tensile properties

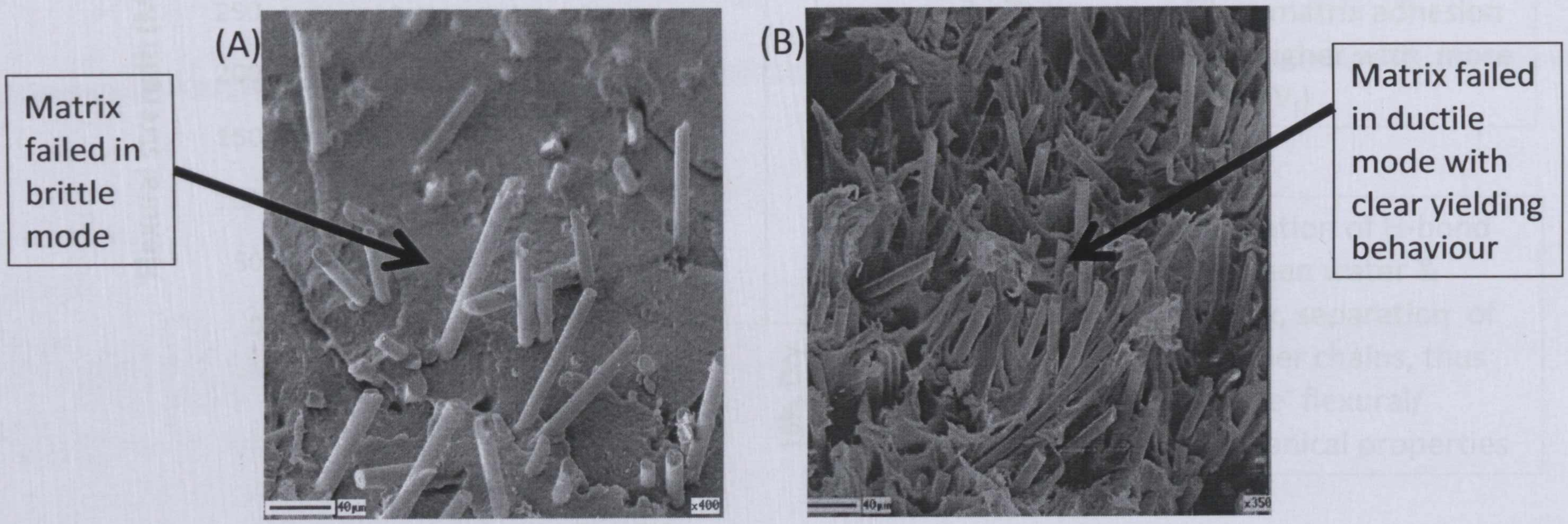


Fig. 7. SEM micrographs of tensile fracture surface of glass fibre composites under (A) dry as-moulded and (B) wet conditions

Flexural properties

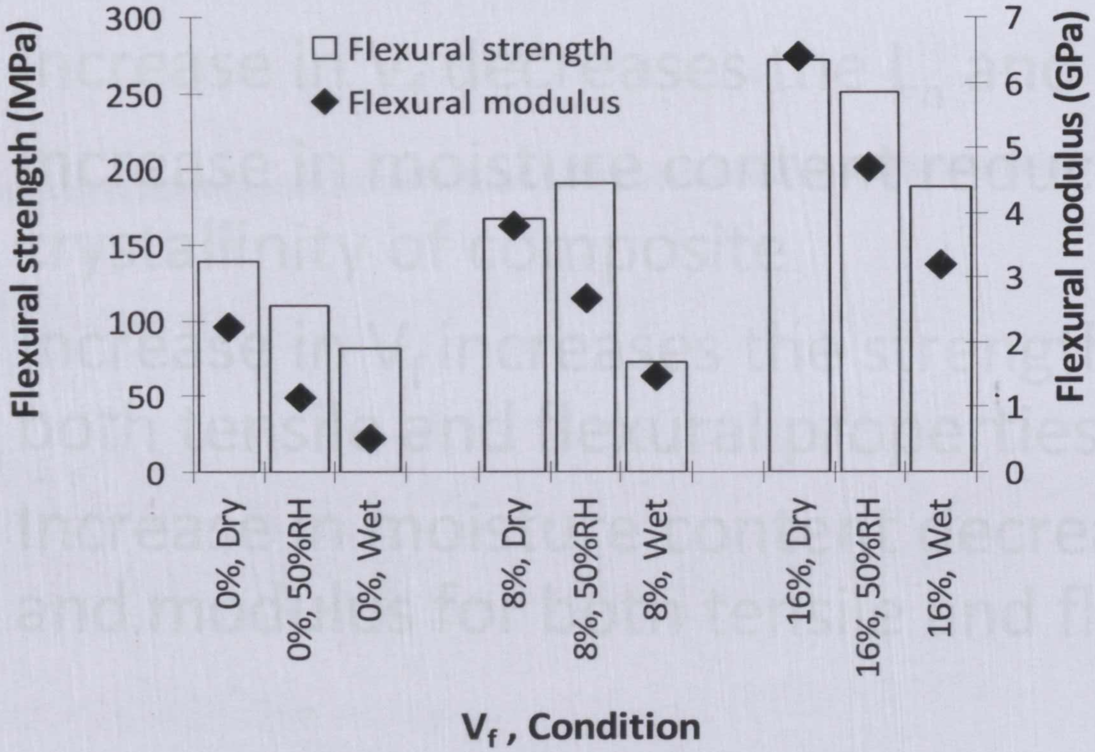


Fig.8. Flexural strength and flexural modulus of composites subjected under different conditions

Fiber-matrix adhesion gets higher with more fibre (V_f)

Formation of H-bond between water & matrix, separation of polymer chains, thus reduce flexural/ mechanical properties

Conclusions

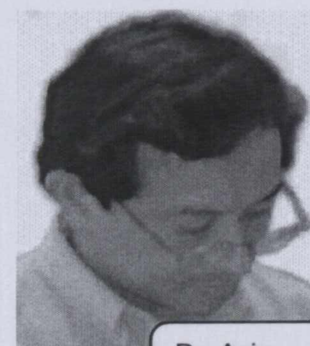
- Increase in V_f decreases the L_n and L_w
- Increase in moisture content reduces the degree of crystallinity of composite
- Increase in V_f increases the strength and modulus for both tensile and flexural properties
- Increase in moisture content decreases the strength and modulus for both tensile and flexural properties

Acknowledgements

- Government of Malaysia
- University of Malaya
  (grants IRPA 33-02-03-3054 and FP017/2008C)

Dini

masmira



Dr. Aziz

THANK YOU