
UNIVERSITI SAINS MALAYSIA

Second Semester Examination
2012/2013 Academic Session

June 2013

EBP 317/3 – Advanced Polymer Composites *[Komposit Polimer Termaju]*

Duration : 3 hours
[Masa : 3 jam]

Please ensure that this examination paper contains ELEVEN printed pages before you begin the examination.

[Sila pastikan bahawa kertas peperiksaan ini mengandungi SEBELAS muka surat yang bercetak sebelum anda memulakan peperiksaan ini.]

This paper consists of SEVEN questions. TWO questions in PART A and FIVE questions in PART B.

[Kertas soalan ini mengandungi TUJUH soalan. DUA soalan di BAHAGIAN A dan LIMA soalan di BAHAGIAN B.]

Instruction: Answer FIVE questions. Answer ALL questions from PART A and THREE questions from PART B. If a candidate answers more than five questions only the first five questions answered in the answer script would be examined.

[Arahan: Jawab LIMA soalan. Jawab SEMUA soalan dari BAHAGIAN A dan TIGA soalan dari BAHAGIAN B. Jika calon menjawab lebih daripada lima soalan hanya lima soalan pertama mengikut susunan dalam skrip jawapan akan diberi markah.]

The answers to all questions must start on a new page.

[Mulakan jawapan anda untuk semua soalan pada muka surat yang baru.]

You may answer a question either in Bahasa Malaysia or in English.

[Anda dibenarkan menjawab soalan sama ada dalam Bahasa Malaysia atau Bahasa Inggeris.]

In the event of any discrepancies, the English version shall be used.

[Sekiranya terdapat sebarang percanggahan pada soalan peperiksaan, versi Bahasa Inggeris hendaklah digunapakai.]

PART A / BAHAGIAN A

1. [a] What is a composite material? State the three other criteria that need to be satisfied before a material can be said to be a composite.

Apakan bahan komposit? Nyatakan tiga kriteria lain yang perlu dipenuhi agar sesuatu bahan boleh dikatakan komposit.

(25 marks/markah)

- [b] Derive the following expression for fiber volume fraction:

Terbitkan persamaan berikut bagi pecahan isipadu gentian:

$$v_f = \frac{w_f \rho_m}{w_f \rho_m + w_m \rho_f}$$

where v and w are the volume and weight fractions, ρ is the density.

The subscripts f and m refer to fiber and matrix, respectively.

di mana v dan w ialah pecahan bagi isipadu dan berat, ρ ialah ketumpatan. 'Subscripts' f dan m merujuk kepada gentian dan matrik.

(25 marks/markah)

- [c] Interfacial bonding is due to adhesion between the reinforcement and the matrix. For adhesion to occur during manufacture of a composite, the reinforcement and the matrix must be brought into intimate contact for 'wetting' to take place. Write a short comprehensive note on 'wetting'.

Ikatan antaramuka dihasilkan oleh pelekatan di antara penguat dan matrik. Bagi pelekatan berlaku semasa pembuatan komposit, penguat dan matrik perlu bersentuhan agar pembasahan berlaku. Tuliskan nota lengkap pembasahan.

(50 marks/markah)

...3/-

2. Write a critical essay on short fiber reinforced thermoplastic composites by taking into consideration of the following aspects:
- (i) microstructure- property relationships
 - (ii) theoretical analysis
 - (iii) strategy to improve the mechanical properties of the composites so as to compete with continuous fiber composites.
 - (iv) energy absorbing mechanisms operating during the fracture process.

Tuliskan satu karangan kritik berhubung dengan komposit termoplastik diperkuatkan gentian pendek dengan mengambil kira aspek:

- (i) hubungan mikrostruktur dan sifat.*
- (ii) analisa teori*
- (iii) strategi untuk meningkatkan sifat mekanik komposit tersebut supaya ia dapat bersaing dengan sifat komposit gentian selanjar.*
- (iv) mekanisme penyerapan tenaga yang beroperasi semasa berlakunya proses rekahan.*

(100 marks/markah)

PART B / BAHAGIAN B

3. [a] How does a silane coupling agent play its role to form adhesion between glass fibers and unsaturated polyester matrix?

Bagaimanakah agen pengkupelan silana berperanan membentuk pelekatan antara gentian kaca dan matrik poliester tak tepu?

(40 marks/markah)

- [b] Describe how to produce and process sheet molding compound (SMC) and bulk molding compound (BMC) to manufacture products from composite materials.

Terangkan bagaimana sebatian pengacuanan kepingan (SMC) dan sebatian pengacuanan pukal (BMC) dihasilkan dan diproses untuk menghasilkan produk-produk daripada bahan komposit.

(60 marks/markah)

4. [a] Describe briefly the concept of load transfer.

Jelaskan konsep pemindahan beban.

(10 marks/markah)

- [b] Single-fiber experiments are used to obtain quantitative information about the strength of interfacial bonding. Figure 1 shows a test setup of a single-fiber experiment. Name the experiment and explain in details this experiment. (Schematic stress distributions and load-displacement plot must be included).

Ujian gentian tunggal digunakan untuk mendapatkan maklumat kuantitatif berkaitan kekuatan ikatan antaramuka. Rajah 1 menunjukkan persediaan suatu ujian gentian tunggal. Namakan ujian tersebut dan jelaskan secara terperinci ujian ini. (Skema taburan tegasan dan plot beban-anjakan mesti diambil-kira).

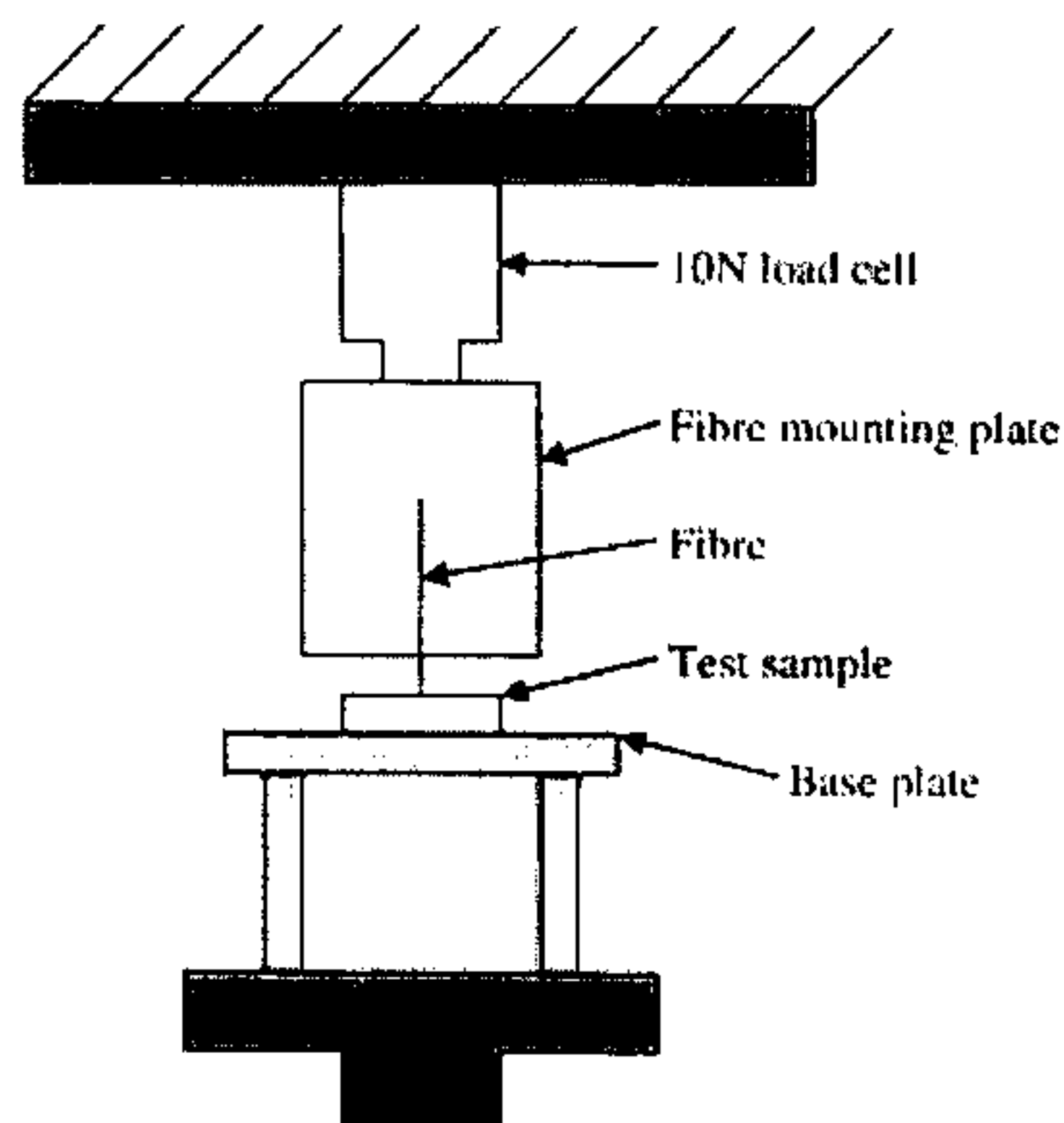


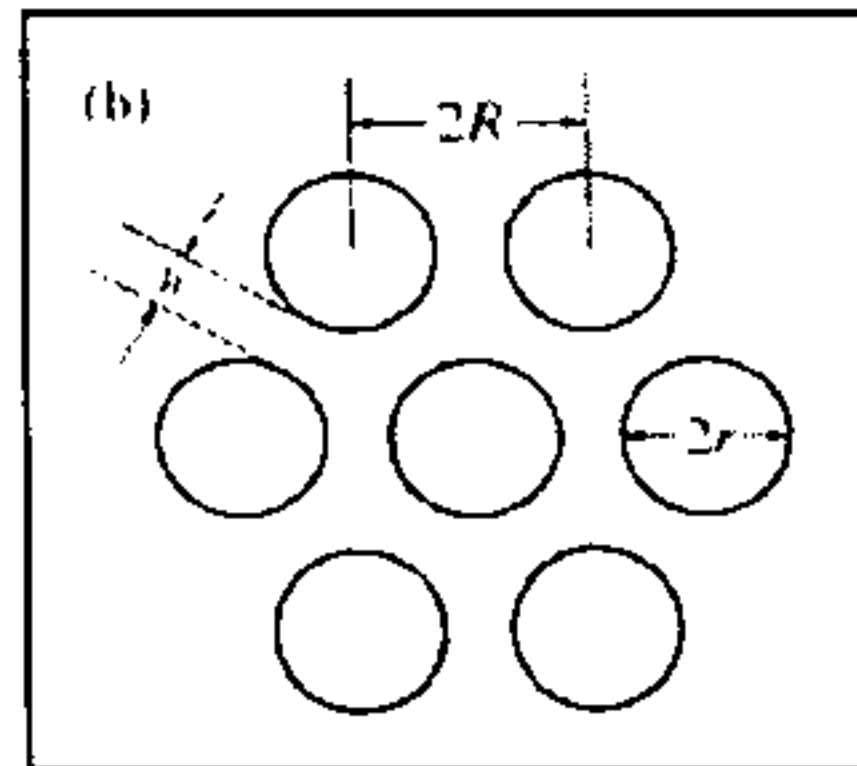
Figure 1 - A test setup of a single-fiber experiment

Rajah 1 - Persediaan bagi suatu ujian gentian tunggal

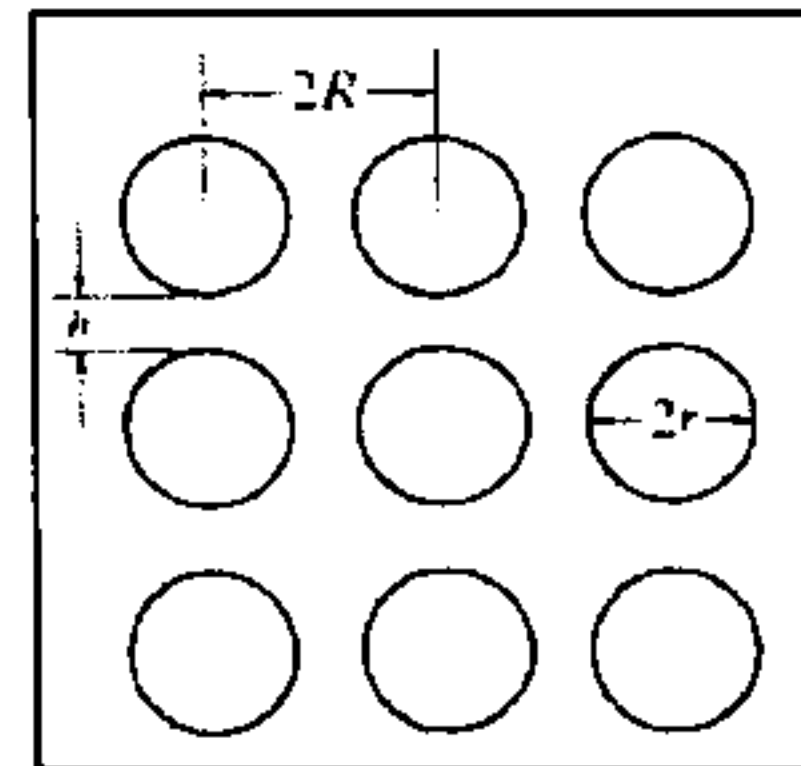
(50 marks/markah)

- [c] Prove that for hexagonal and square packing arrangements, fiber volume fraction are given as:

Buktikan bagi penyusunan heksagonal dan segi empat sama, pecahan isipadu gentian diungkapkan sebagai:



$$V_f = \left(\frac{\pi}{2\sqrt{3}} \right) \left(\frac{r}{R} \right)^2$$



$$V_f = \left(\frac{\pi}{4} \right) \left(\frac{r}{R} \right)^2$$

Determine the maximum fiber volume fractions for both arrangements.

Kirakan pecahan isipadu gentian maksima bagi kedua-dua penyusunan di atas.

(40 marks/markah)

5. [a] Write a short note on ultrasonic testing and representation of data.

Tuliskan nota pendek tentang ujian ultrasonik dan perwakilan data.

(50 marks/markah)

- [b] A cantilever beam is made of a unidirectional continuous composite containing 40 vol. % of standard carbon fiber (density = 1.64 g/cm^3) in a nylon 66 matrix (density = 1.14 g/m^3). Calculate the composite density.

Suatu rasuk penyokong diperbuat daripada komposit selanjar terarah unidireksional berasaskan 40% isipadu gentian karbon (ketumpatan = 1.64 g/cm^3) dan matrix nilon 66 (ketumpatan = 1.14 g/m^3). Kirakan ketumpatan komposit.

(20 marks/markah)

- [c] SEM micrographs of fracture surfaces of glass fiber reinforced polypropylene composites with and without a coupling agent are shown in Figure 2. These micrographs were obtained at low and high magnifications.

Mikrograf SEM permukaan patah bagi komposit polipropilena diperkuat gentian kaca dengan kehadiran dan tanpa kehadiran agen pengkupel ditunjukkan pada Rajah 2. Mikrograf ini diperolehi pada pembesaran yang rendah dan tinggi.

- (i) State the differences between the composites in terms of fracture surface morphologies.

Nyatakan perbezaan morfologi permukaan patah bagi komposit tersebut.

(25 marks/markah)

- (ii) Suggest a coupling agent that can be used to improve the fiber-matrix adhesion in glass fiber reinforced polypropylene composite.

Cadangkan satu agen pengkupelan yang boleh digunakan untuk mempertingkatkan lekatan di antara gentian dan matrik untuk komposit polipropilena diperkuat gentian kaca.

(5 marks/markah)

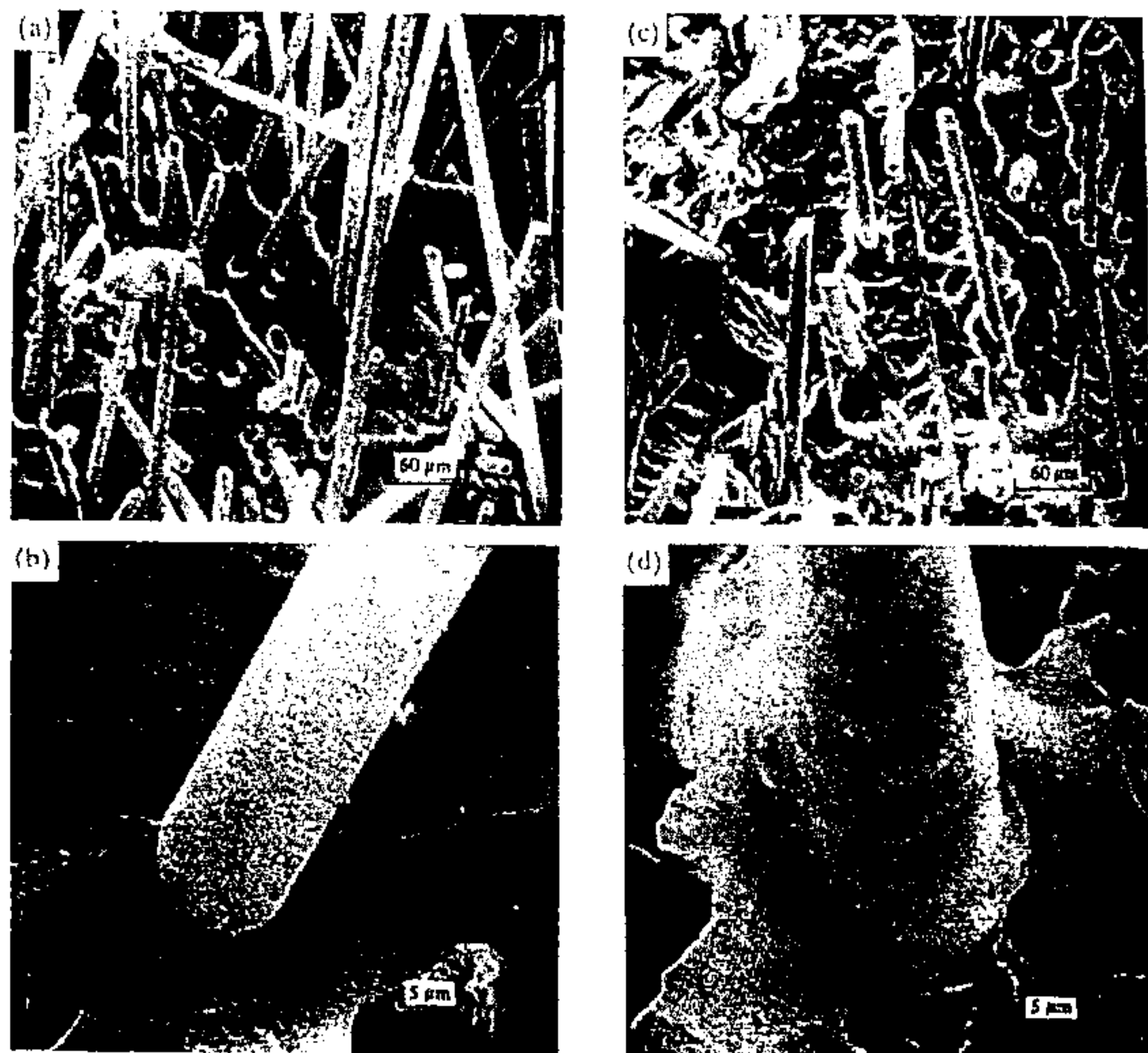


Figure 1 - SEM micrographs of fracture surfaces of polypropylene-glass fibers composites. (a) and (b) without a coupling agent. (c) and (d) with a coupling agent

Rajah 1 - Mikrograf SEM permukaan patah bagi komposit polipropilena diperkuat gentian kaca. (a) dan (b) tanpa kehadiran agen pengkupelan. (c) dan (d) dengan kehadiran agen pengkupelan

6. Write short notes on the following topics:

Tuliskan nota-nota ringkas bagi tajuk-tajuk yang berikut:

- (a) Hand lay-up method

Kaedah 'hand lay-up'

(30 marks/markah)

- (b) Pultrusion

Pultrusi

(40 marks/markah)

- (c) Resin transfer molding

Pengacuanan pindah resin

(30 marks/markah)

7. Two composite formulations based on the combination of epoxy resin and non-continuous glass fibres have been produced using fibres with two different aspect ratios i.e. 5 and 50. Determine:
- the values of tensile modulus of the composites in the direction; parallel E_L and perpendicular, E_T to the fibre alignment using Halpin-Tsai semi-empirical model.
 - Using the values obtained from above; determine the elastic modulus of the composites, E_R which is given by the empirical equation:

$$E_R = \frac{3}{8}E_L + \frac{5}{8}E_T$$

Describe the efficiency of the aspect ratios in enhancing the modulus of both composites as compared to modulus of continuous and uniaxially aligned epoxy/glass fibre composites obtained by the rule of mixture. What conclusion can be drawn from the obtained results? Please state clearly any assumption made.

Given:

Poisson ratio of epoxy resin = 0.38

Poisson ratio of glass fibres = 0.22

Density of epoxy resin = 1300 kg/m³

Density of glass fibers = 2540 kg/m³

Weight fraction of matrix = 0.6

Diameter of fibre = 12 micron

Shear modulus of epoxy resin at room temperature = 1.15 GPa

Ratio of tensile modulus of constituent materials = 25

Dua formulasi komposit dihasilkan daripada gabungan resin epoksi dan gentian kaca tak selanjar yang mempunyai nisbah aspek yang berlainan iaitu 5 dan 50. Tentukan:

- (i) nilai modulus komposit dalam arah selari, E_L , dan dalam arah bertentangan, E_T dengan penjajaran gentian dengan menggunakan model semi-empirik Halpin-Tsai.
- (ii) Berdasarkan nilai yang diperolehi di atas tentukan modulus elastik komposit, E_R yang diberikan oleh persamaan empirik:

$$E_R = \frac{3}{8} E_L + \frac{5}{8} E_T$$

Terangkan keberkesanan nisbah aspek tersebut dalam meningkatkan modulus kedua-dua komposit tersebut berbanding dengan modulus komposit epoksi/gentian kaca yang selanjar dan terjajar yang ditentukan menggunakan model hukum campuran. Apakah kesimpulan yang dapat dibuat daripada keputusan-keputusan yang diperolehi? Nyatakan segala anggapan yang dibuat.

Diberi:

Nisbah poisson resin epoksi = 0.38

Nisbah poisson resin gentian kaca = 0.22

Ketumpatan resin epoksi = 1300 kg/m³

Ketumpatan gentian kaca = 2540 kg/m³

Pecahan berat matrik = 0.6

Garispusat gentian = 12 mikron

Modulus ricih resin epoksi pada suhu bilik = 1.15 GPa

Nisbah modulus tensil bahan jujuk = 25

(100 marks/markah)