



UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Influence of Processing Methods and Fiber Size on Rheological Properties of Hybrid Composite

Report submitted in accordance with partial requirements of the Universiti
Teknikal Malaysia Melaka for the Bachelor of Manufacturing Engineering
(Engineering Materials)

By

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April 2008

DECLARATION

I hereby declare that this report entitled “Influence of Processing Methods and Fiber Size on Rheological Properties of Hybrid Composite” is the result of my own research except as cited in the references.

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APPROVAL

This report submitted to the Faculty of Manufacturing Engineering of UTeM as a partial fulfillment of the requirement for the degree of Bachelor of Manufacturing Engineering (Engineering Materials). The members of the supervisory committee are as follow:

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ABSTRACT

This report is based on the study on the influence of processing methods and fiber size on the rheological properties of hybrid glass/carbon composite. The objective of this study is to investigate the effect of different processing methods, fiber size and processing parameter specifically temperature on the rheological properties of the hybrid composite. Besides that, another aim is to analyze the relationship of the processing methods, fiber size and temperature on the rheological-morphological properties of the hybrid composite. E-glass in both short fiber and powder form as well as charcoal in powder form was incorporated into polypropylene (PP) to form hybrid composite in the study. Processing methods refers to the different mixing techniques used to prepare the hybrid composite mixture prior to rheological measurements while fiber size refers to the reinforcements in particulate form and short fiber with the fiber length of less than 1 mm. Temperature effect was monitored during the rheological measurement. The rheological properties of the hybrid composite were studied using a capillary rheometer. After conducting rheological measurements, the morphology of the hybrid composite for both longitudinal and transverse directions in flow direction was observed under the Scanning Electron Microscope (SEM). Results showed that viscosity decreased while flow rate and shear rate increased with temperature and also in the hybrid composites that employed the processing method of 2+1 as well as those composites utilizing completely particulate reinforcements. All composite system also exhibited the pseudoplastic behaviour based on the rheological measurement results. This was further supported by the good orientation and alignment as well as uniform distribution of the reinforcements in the PP matrix. Thus, hybrid composite which employed the combinations of 2+1 Powder exhibited superior rheological properties compared to the other combinations.

ABSTRAK

Laporan ini adalah berdasarkan kajian tentang kesan kaedah pemprosesan dan saiz gentian ke atas sifat reologi hibrid komposit kaca/karbon. Objektif kajian ini adalah untuk menyelidik kesan daripada kaedah pemprosesan, saiz gentian dan parameter pemprosesan khususnya suhu yang berlainan ke atas sifat reologi hibrid komposit tersebut. Selain itu, objektif lain termasuk menganalisis hubungan antara kaedah pemprosesan, saiz gentian dan suhu ke atas sifat reologi-morfologi hibrid komposit tersebut. Kaca-E dalam bentuk gentian pendek dan serbuk serta arang dalam bentuk serbuk telah ditambah ke dalam polipropilina (PP) untuk membentuk hibrid komposit dalam kajian ini. Kaedah pemprosesan merujuk kepada kepelbagaian teknik pencampuran yang digunakan dalam penyediaan campuran hibrid komposit sebelum pengujian reologi dijalankan. Sementara itu, saiz gentian merujuk kepada penetulang dalam bentuk partikel dan gentian pendek di mana panjang gentian yang digunakan adalah kurang daripada 1 mm. Sifat reologi hibrid komposit dikaji dengan menggunakan reometer kapilari rerambut. Selepas menjalankan kajian pengujian reologi, morfologi hibrid komposit untuk kedua-dua pandangan merentas aliran bahan dan mengikut aliran bahan telah dikaji dengan menggunakan teknik kemikroskopan elektron imbasan. Keputusan menunjukkan kelikatan berkurang manakala kadar alir dan kadar ricih bertambah dengan penambahan suhu serta hibrid komposit yang mengamalkan kaedah pemprosesan jenis 2+1 dan hibrid komposit yang terdiri daripada penetulang jenis zarah. Semua sistem komposit memamerkan kelakuan pseudoplastik berpandukan keputusan ujian reologi yang dijalankan. Keadaan ini disokong dengan orientasi dan susunan serta taburan penetulang yang baik dan sekata dalam matriks PP. Oleh sebab itu, hibrid komposit yang terdiri daripada kombinasi 2+1 Powder memamerkan sifat reologi yang baik berbanding kombinasi yang lain.

DEDICATION

For my beloved mother and father.

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TABLE OF CONTENTS

DECLARATION	i
APPROVAL	ii
ABSTRACT	iii
ABSTRAK	iv
DEDICATION	v
ACKNOWLEDGEMENTS	vi
TABLE OF CONTENTS	vii
LIST OF FIGURES	x
LIST OF TABLES	xx
LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURES	xxi
1.0 INTRODUCTION	1
1.1 Background	1
1.2 Problem Statement	2
1.3 Objectives	3
1.4 Scope of Study	3
2.0 LITERATURE REVIEW	5
2.1 Composites	5
2.1.1 Hybrid Composites	6
2.2 Matrices	8
2.2.1 Materials for Matrices	8
2.3 Reinforcement	11
2.3.1 Types of Reinforcement	11
2.3.2 Materials for Reinforcement	12
2.4 Processing Methods	15
2.5 Fiber Size	17
2.5.1 Fiber Length	17

2.6	Rheological Properties	18
2.6.1	Rheology	18
2.6.2	Shear Stress, Shear Rate and Viscosity	18
2.6.3	Arrhenius Equation and Activation Energy	22
2.7	Morphology	24
2.7.1	Rheology-Morphology Relationship	24
3.0	METHODOLOGY	33
3.1	Materials	33
3.1.1	Reinforcement	33
3.1.1.1	E-glass	33
3.1.1.2	Charcoal	34
3.1.2	Matrix	35
3.2	Methods	36
3.2.1	Characterization of Reinforcements	37
3.2.1.1	Determination of Density	37
3.2.1.2	Determination of Fiber Size	37
3.2.2	Composite Processing	38
3.2.3	Rheological Measurement	39
3.2.4	Microscopic Examination	41
3.2.4.1	Sample Preparation	41
3.2.4.2	Microstructure Observation	45
3.3	Flow Chart of Methodology	46
3.4	Gantt Chart	47
3.4.1	Gantt Chart for PSM 1	47
3.4.2	Gantt Chart for PSM 2	48
4.0	RESULTS	49
4.1	Introduction	49
4.2	Characterization of Reinforcements	49
4.2.1	Density	49
4.2.1.1	E-glass Fiber	50

4.2.1.2	E-glass Powder	50
4.2.1.3	Charcoal	50
4.2.2	Fiber Size	51
4.2.2.1	E-glass Fiber	52
4.2.2.2	E-glass Powder	53
4.2.2.3	Charcoal	54
4.3	Rheological Properties	55
4.3.1	Effect of Temperature on Rheological Properties	60
4.3.2	Effect of Processing Methods and Fiber Size on Rheological Properties	64
4.4	Morphological Properties	68
5.0	DISCUSSION	85
5.1	Rheological Properties	85
5.1.1	Effect of Temperature on Rheological Properties	87
5.1.2	Effect of Processing Methods and Fiber Size on Rheological Properties	90
5.2	Relationship between Rheological-Morphological Properties	92
6.0	CONCLUSION AND FUTURE WORK	131
6.1	Conclusion	131
6.2	Future Work	132
	REFERENCES	133

APPENDICES

- A Data for Fiber Size Analysis
- B Raw Data for Rheological Measurement
- C Sample Designation

LIST OF FIGURES

2.1	Classification of various types of composites.	6
2.2	SEM micrograph of glass fibers.	14
2.3	Flow curves, τ_s vs $(d\gamma_s/dt)$, for different types of fluid material.	20
2.4	Power Law plot showing $\log \tau_s$ vs $\log (d\gamma_s/dt)$ for different types of fluid materials.	21
2.5	(a) SEM micrographs taken from fracture surface of glass fiber/carbon fiber/polyamide 6 showing the appearance of carbon fiber. (b) SEM micrographs taken from the fracture surface of glass fiber/carbon fiber/polyamide 6 showing an enlarge portion of the carbon fiber.	25
2.6	SEM micrograph showing the occurrence of carbon and glass fibers pull-outs in the polyamide 6 matrix.	26
2.7	SEM micrograph of tensile fracture surface of an (a) short carbon fiber/polypropylene composite with 25 vol% of carbon fibers (b) short glass fiber/polypropylene composite with 25 vol% of glass fibers.	26
2.8	SEM micrographs of the cross section of polystyrene-sisal composite at a shear rate of 54 s^{-1} at (a) $180 \text{ }^\circ\text{C}$ and (b) $190 \text{ }^\circ\text{C}$.	27
2.9	SEM micrograph of the cut surface of the extrudate of mixture of SBR/nylon-6 fibers, ZnO and stearic acid; shear rate of (a) 1 s^{-1} (b) 100 s^{-1} and temperature $100 \text{ }^\circ\text{C}$.	28
2.10	SEM micrograph of the cut surface of the extrudate of mixture of SBR/nylon-6 fibers, ZnO and stearic acid; shear rate of (a) 1 s^{-1} (b) 100 s^{-1} (c) 500 s^{-1} and temperature $80 \text{ }^\circ\text{C}$.	28
2.11	SEM micrographs of extrudates (a) unfilled polystyrene (b) polystyrene filled with 10% untreated fiber (c) polystyrene filled with 20% untreated fiber (d) polystyrene filled with 30% untreated fiber with fiber length of 6 mm at a shear rate of 54 s^{-1} at $180 \text{ }^\circ\text{C}$.	29

2.12	SEM micrographs of rheometer extrudates of (a) hybrid glass/LCP fibers reinforced toughened nylon composite with 20 wt% LCP (HFRT 20) (b) 20 wt% LCP fibers reinforced toughened nylon composite (LFRT 20) at shear rate of 500 s ⁻¹ .	30
2.13	SEM micrograph of the rheometer extrudate of hybrid glass/LCP fibers reinforced untoughened nylon composite with 20 wt% LCP (HFP 20) at shear rate of 500 s ⁻¹ .	31
3.1	E-glass in woven fiber mat form before blending into short fiber length less than 1 mm.	34
3.2	(a) Charcoal in pieces form before crushing is conducted. (b) Crushed charcoal in powder form before sieving is conducted.	35
3.3	PP used in granule form.	36
3.4	Electronic Densimeter MD-300S.	37
3.5	Haake Rheomix OS Internal Mixer.	39
3.6	Shimadzu CFT-500D Capillary Rheometer.	39
3.7	(a) Capillary die and (b) Piston.	40
3.8	(a) Quickmount 2 Epoxy Resin, (b) Silicome Mold Release and (c) Quickmount 2 Hardener.	42
3.9	(a) Two-piece Plastic Mounting Molds and (b) Sample Clip Holder.	42
3.10	a) Vacuum Drying Oven and (b) Vacuum Pump.	43
3.11	Beta Twin Variable Speed Grinder-Polisher.	44
3.12	(a) Beta Grinder-Polisher and (b) Polycrystalline diamond suspension, 6 μm (left) and 3 μm (right)	44
3.13	Extrudate of hybrid composites after cold mounting process.	45
3.14	Zeiss Evo 50 Scanning Electron Microscope.	45
3.15	Flow chart of methodology	46
4.1	SEM image of E-glass fiber for determination of fiber size.	52
4.2	SEM image of E-glass powder for determination of particle size.	53
4.3	SEM image of charcoal powder for determination of particle size.	54

4.4	(a) Graph of viscosity – shear rate of composite for different processing methods and fiber size at temperature 180 °C. (b) Magnification of the plot area highlighted by an oval shape in (a).	56
4.5	(a) Graph of viscosity – shear rate of composite for different processing methods and fiber size at temperature 190 °C. (b) Magnification of the plot area highlighted by an oval shape in (a).	57
4.6	(a) Graph of viscosity – shear rate of composite for different processing methods and fiber size at temperature 200 °C. (b) Magnification of the plot area highlighted by an oval shape in (a).	58
4.7	(a) Graph of viscosity – shear rate of composite for different processing methods and fiber size at temperature 210 °C. (b) Magnification of the plot area highlighted by an oval shape in (a).	59
4.8	Graph of viscosity of composite at different temperature.	60
4.9	(a) Graph of flow rate of composite at different temperature. (b) Magnification of the plot area highlighted by an oval shape in (a).	61
4.10	(a) Graph of shear rate of composite at different temperature. (b) Magnification of the plot area highlighted by an oval shape in (a).	62
4.11	(a) Graph of viscosity – shear rate of composite at different temperature. (b) Magnification of the plot area highlighted by an oval shape in (a).	63
4.12	Graph of viscosity of composite for different processing methods and fiber size.	64
4.13	(a) Graph of flow rate of composite for different processing methods and fiber size. (b) Magnification of the plot area highlighted by an oval shape in (a).	65
4.14	(a) Graph of shear rate of composite for different processing methods and fiber size. (b) Magnification of the plot area highlighted by an oval shape in (a).	66
4.15	(a) Graph of viscosity – shear rate of composite for different processing methods and fiber size. (b) Magnification of the plot area highlighted by an oval shape in (a).	67

4.16	Micrographs of hybrid glass/carbon composite employing 2+1 Fiber at temperature of 180 °C along longitudinal direction at (a) wall (b) core.	69
4.17	Micrographs of hybrid glass/carbon composite employing 2+1 Fiber at temperature of 180 °C along transverse direction at (a) wall (b) core.	69
4.18	Micrographs of hybrid glass/carbon composite employing 3 Fiber at temperature of 180 °C along longitudinal direction at (a) wall (b) core.	70
4.19	Micrographs of hybrid glass/carbon composite employing 3 Fiber at temperature of 180 °C along transverse direction at (a) wall (b) core.	70
4.20	Micrographs of hybrid glass/carbon composite employing 2+1 Powder at temperature of 180 °C along longitudinal direction at (a) wall (b) core.	71
4.21	Micrographs of hybrid glass/carbon composite employing 2+1 Powder at temperature of 180 °C along transverse direction at (a) wall (b) core.	71
4.22	Micrographs of hybrid glass/carbon composite employing 3 Powder at temperature of 180 °C along longitudinal direction at (a) wall (b) core.	72
4.23	Micrographs of hybrid glass/carbon composite employing 3 Powder at temperature of 180 °C along transverse direction at (a) wall (b) core.	72
4.24	Micrographs of hybrid glass/carbon composite employing 2+1 Fiber at temperature of 190 °C along longitudinal direction at (a) wall (b) core.	73
4.25	Micrographs of hybrid glass/carbon composite employing 2+1 Fiber at temperature of 190 °C along transverse direction at (a) wall (b) core.	73
4.26	Micrographs of hybrid glass/carbon composite employing 3 Fiber at temperature of 190 °C along longitudinal direction at (a) wall (b) core.	74

4.27	Micrographs of hybrid glass/carbon composite employing 3 Fiber at temperature of 190 °C along transverse direction at (a) wall (b) core.	74
4.28	Micrographs of hybrid glass/carbon composite employing 2+1 Powder at temperature of 190 °C along longitudinal direction at (a) wall (b) core.	75
4.29	Micrographs of hybrid glass/carbon composite employing 2+1 Powder at temperature of 190 °C along transverse direction at (a) wall (b) core.	75
4.30	Micrographs of hybrid glass/carbon composite employing 3 Powder at temperature of 190 °C along longitudinal direction at (a) wall (b) core.	76
4.31	Micrographs of hybrid glass/carbon composite employing 3 Powder at temperature of 190 °C along transverse direction at (a) wall (b) core.	76
4.32	Micrographs of hybrid glass/carbon composite employing 2+1 Fiber at temperature of 200 °C along longitudinal direction at (a) wall (b) core.	77
4.33	Micrographs of hybrid glass/carbon composite employing 2+1 Fiber at temperature of 200 °C along transverse direction at (a) wall (b) core.	77
4.34	Micrographs of hybrid glass/carbon composite employing 3 Fiber at temperature of 200 °C along longitudinal direction at (a) wall (b) core.	78
4.35	Micrographs of hybrid glass/carbon composite employing 3 Fiber at temperature of 200 °C along transverse direction at (a) wall (b) core.	78
4.36	Micrographs of hybrid glass/carbon composite employing 2+1 Powder at temperature of 200 °C along longitudinal direction at (a) wall (b) core.	79
4.37	Micrographs of hybrid glass/carbon composite employing 2+1 Powder at temperature of 200 °C along transverse direction at (a) wall (b) core.	79

4.38	Micrographs of hybrid glass/carbon composite employing 3 Powder at temperature of 200 °C along longitudinal direction at (a) wall (b) core.	80
4.39	Micrographs of hybrid glass/carbon composite employing 3 Powder at temperature of 200 °C along transverse direction at (a) wall (b) core.	80
4.40	Micrographs of hybrid glass/carbon composite employing 2+1 Fiber at temperature of 210 °C along longitudinal direction at (a) wall (b) core.	81
4.41	Micrographs of hybrid glass/carbon composite employing 2+1 Fiber at temperature of 210 °C along transverse direction at (a) wall (b) core.	81
4.42	Micrographs of hybrid glass/carbon composite employing 3 Fiber at temperature of 210 °C along longitudinal direction at (a) wall (b) core.	82
4.43	Micrographs of hybrid glass/carbon composite employing 3 Fiber at temperature of 210 °C along transverse direction at (a) wall (b) core.	82
4.44	Micrographs of hybrid glass/carbon composite employing 2+1 Powder at temperature of 210 °C along longitudinal direction at (a) wall (b) core.	83
4.45	Micrographs of hybrid glass/carbon composite employing 2+1 Powder at temperature of 210 °C along transverse direction at (a) wall (b) core.	83
4.46	Micrographs of hybrid glass/carbon composite employing 3 Powder at temperature of 210 °C along longitudinal direction at (a) wall (b) core.	84
4.47	Micrographs of hybrid glass/carbon composite employing 3 Powder at temperature of 210 °C along transverse direction at (a) wall (b) core.	84
5.1	Graph of \ln viscosity versus reciprocal of absolute temperature (Arrhenius plots).	89

5.2	Graph of viscosity – shear rate of hybrid glass/carbon composite employing combinations of 2+1 Fiber for transverse direction at wall area.	93
5.3	Graph of viscosity – shear rate of hybrid glass/carbon composite employing combinations of 2+1 Fiber for transverse direction at core area.	94
5.4	Graph of viscosity – shear rate of hybrid glass/carbon composite employing combinations of 3 Fiber for transverse direction at wall area.	95
5.5	Graph of viscosity – shear rate of hybrid glass/carbon composite employing combinations of 3 Fiber for transverse direction at core area.	96
5.6	Graph of viscosity – shear rate of hybrid glass/carbon composite employing combinations of 2+1 Powder for transverse direction at wall area.	97
5.7	Graph of viscosity – shear rate of hybrid glass/carbon composite employing combinations of 2+1 Powder for transverse direction at core area.	98
5.8	Graph of viscosity – shear rate of hybrid glass/carbon composite employing combinations of 3 Powder for transverse direction at wall area.	99
5.9	Graph of viscosity – shear rate of hybrid glass/carbon composite employing combinations of 3 Powder for transverse direction at core area.	100
5.10	Graph of viscosity – shear rate of hybrid glass/carbon composite employing combinations of 2+1 Fiber for longitudinal direction at wall area.	101
5.11	Graph of viscosity – shear rate of hybrid glass/carbon composite employing combinations of 2+1 Fiber for longitudinal direction at core area.	102

5.12	Graph of viscosity – shear rate of hybrid glass/carbon composite employing combinations of 3 Fiber for longitudinal direction at wall area.	103
5.13	Graph of viscosity – shear rate of hybrid glass/carbon composite employing combinations of 3 Fiber for longitudinal direction at core area.	104
5.14	Graph of viscosity – shear rate of hybrid glass/carbon composite employing combinations of 2+1 Powder for longitudinal direction at wall area.	105
5.15	Graph of viscosity – shear rate of hybrid glass/carbon composite employing combinations of 2+1 Powder for longitudinal direction at core area.	106
5.16	Graph of viscosity – shear rate of hybrid glass/carbon composite employing combinations of 3 Powder for longitudinal direction at wall area.	107
5.17	Graph of viscosity – shear rate of hybrid glass/carbon composite employing combinations of 3 Powder for longitudinal direction at core area.	108
5.18	Voids with rough surfaces due to incomplete melting of materials.	109
5.19	Odd fibers entrapped in voids with rough surfaces believed to be fibers detached from polishing cloth.	110
5.20	Flocked fibers on polishing cloth under observation of Scanning Electron Microscope at magnification of 700X.	110
5.21	Voids with smooth surfaces due to expansion of gas bubbles.	111
5.22	Graph of viscosity – shear rate of hybrid glass/carbon composite for different combinations of processing methods and fiber size at temperature of 180 °C for transverse direction at wall area.	113
5.23	Graph of viscosity – shear rate of hybrid glass/carbon composite for different combinations of processing methods and fiber size at temperature of 180 °C for transverse direction at core area.	114

5.24	Graph of viscosity – shear rate of hybrid glass/carbon composite for different combinations of processing methods and fiber size at temperature of 180 °C for longitudinal direction at wall area.	115
5.25	Graph of viscosity – shear rate of hybrid glass/carbon composite for different combinations of processing methods and fiber size at temperature of 180 °C for longitudinal direction at core area.	116
5.26	Graph of viscosity – shear rate of hybrid glass/carbon composite for different combinations of processing methods and fiber size at temperature of 190 °C for transverse direction at wall area.	117
5.27	Graph of viscosity – shear rate of hybrid glass/carbon composite for different combinations of processing methods and fiber size at temperature of 190 °C for transverse direction at core area.	118
5.28	Graph of viscosity – shear rate of hybrid glass/carbon composite for different combinations of processing methods and fiber size at temperature of 190 °C for longitudinal direction at wall area.	119
5.29	Graph of viscosity – shear rate of hybrid glass/carbon composite for different combinations of processing methods and fiber size at temperature of 190 °C for longitudinal direction at core area.	120
5.30	Graph of viscosity – shear rate of hybrid glass/carbon composite for different combinations of processing methods and fiber size at temperature of 200 °C for transverse direction at wall area.	121
5.31	Graph of viscosity – shear rate of hybrid glass/carbon composite for different combinations of processing methods and fiber size at temperature of 200 °C for transverse direction at core area.	122
5.32	Graph of viscosity – shear rate of hybrid glass/carbon composite for different combinations of processing methods and fiber size at temperature of 200 °C for longitudinal direction at wall area.	123
5.33	Graph of viscosity – shear rate of hybrid glass/carbon composite for different combinations of processing methods and fiber size at temperature of 200 °C for longitudinal direction at core area.	124

5.34	Graph of viscosity – shear rate of hybrid glass/carbon composite for different combinations of processing methods and fiber size at temperature of 210 °C for transverse direction at wall area	125
5.35	Graph of viscosity – shear rate of hybrid glass/carbon composite for different combinations of processing methods and fiber size at temperature of 210 °C for transverse direction at core area	126
5.36	Graph of viscosity – shear rate of hybrid glass/carbon composite for different combinations of processing methods and fiber size at temperature of 210 °C for longitudinal direction at wall area.	127
5.37	Graph of viscosity – shear rate of hybrid glass/carbon composite for different combinations of processing methods and fiber size at temperature of 210 °C for longitudinal direction at core area	128

LIST OF TABLES

3.1	Properties of E-glass at 20 °C.	34
3.2	Chemical and physical composition of charcoal.	35
3.3	Properties of charcoal.	35
3.4	Physical properties of PP used.	36
3.5	Gantt Chart for PSM 1.	47
3.6	Gantt Chart for PSM 2.	48
4.1	Density measurement of E-glass fiber	50
4.2	Density measurement of charcoal.	51
5.1	Values of the power law index (n) for hybrid glass carbon/carbon composites for different processing methods and fiber size at various temperatures.	86
5.2	Activation energy of hybrid glass-carbon composites.	88
5.3	Summary on the hybrid composite morphology	130

LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURES

τ	-	Interfacial shear strength or the matrix shear strength
μm	-	Micron or Micrometer
π	-	Pi
$\hat{\sigma}_{\text{Tr}}$	-	Tensile stress in fiber
Δt	-	Time Taken from S_1 to S_2 or Time Taken for D_r
%	-	Percentage
&	-	And
=	-	Equal
$^{\circ}\text{C}$	-	Degree Celsius
$^{\circ}\text{C}^{-1}$	-	Reciprocal of Degree Celsius
$1/T$	-	Reciprocal of Temperature
2+1	-	2+1 Processing Method
3	-	3 Processing Method
A	-	Pre-exponential factor or Prefactor
A_r	-	Cross Sectional Area
CaCO_3	-	Calcium Carbonate
cm^2	-	Centimeter Square
cm^3	-	Centimeter Cube
CMC	-	Ceramic-Matrix Composite
cmHg	-	Centimeter Mercury
D	-	Diameter of fiber
D	-	Diameter of Orifice
D_r	-	Distance
$d\gamma_s/dt$	-	Shear Rate
E	-	Activation Energy
E_a	-	Activation Energy
<i>et al.</i>	-	Et Alia (And Others)

g	-	Gram
GPa	-	Giga Pascal
HDPE	-	High Density Polyethylene
HFP 20	-	Hybrid Glass/LCP Fibers Reinforced Untoughened Nylon Composite with 20 wt% LCP
HFRT 20	-	Hybrid Glass/LCP Fibers Reinforced Toughened Nylon Composite with 20 wt% LCP
K	-	Constant
k	-	Rate constant of chemical reaction
K ⁻¹	-	Reciprocal of Kelvin
kg	-	Kilogram
kgf	-	Kilogram Force
kJ	-	Kilo Joule
kV	-	Kilo Volt
l _c	-	Critical Fiber Length
L	-	Die Length
LCP	-	Liquid Crystalline Polymer
LFRT 20	-	20 wt% LCP Fibers Reinforced Toughened Nylon Composite
log	-	Logarithm of 10
M	-	Malaysia
min	-	Minute
mm	-	Millimeter
MMC	-	Metal-Matrix Composite
mol	-	mol
n	-	Flow Index
O ₂	-	Oxygen
P	-	Pressure
Pa	-	Pascal
PA	-	Polyamide
PDMS	-	Polydimethylsiloxane
PE	-	Polyethylene