Asian Workshop on Polymer Processing (AWPP 2009)

Penang, Malaysia, Dec 01-04, 2009

Oral Presentation B-201, Dec 13, 2009

By

Assoc. Prof. Dr. Aziz Hassan

Universiti Malaya, Malaysia

THERMAL AND MECHANICAL PROPERTIES OF INJECTION MOULDED SHORT GLASS/SHORT CARBON HYBRID FIBRE REINFORCED POLYAMIDE 6,6 COMPOSITES

AZIZ HASSAN *, **N.M. SALLEH AND ROSIYAH YAHYA**

Dept. of Chemistry, Universiti Malaya,

50603 Kuala Lumpur, Malaysia

Introduction

- Hybrid fibres – to modify / tailor made the properties to suit certain application

- Glass – impact properties

- Carbon – tensile properties

Introduction

- Polyamide – hygroscopic, absorb moisture up to 2.5% w/w
- Plasticisation – affect properties

Objectives

To study the effect of:-

- Hybridisation
- Conditioning

Materials

- Pre-compounded short carbon fibre polyamide 6,6 composites (SC), $V_f = 0.33$
- Pre-compounded short glass fibre polyamide 6,6 composites (SG), $V_f = 0.18$

Experimental

- Pre-compounded composites – physical blended, 0/100, 25/75, 50/50, 75/25 and 100/0 (SG/SC w/w %)

- Injection moulded – Boy 55 tonne injection moulding machine, single gated four cavities, two impacts and two tensile test bars

Experimental

Specimens conditioning:-

- Dry as moulded
- 50% RH
- Wet

Experimental

- TGA – Perkin Elmer, 10°C/min
- DSC – Hyper DSC, Perkin Elmer, 10°C/min
- DMA – Q800 TAI, three point bending, 3°C/min

Experimental

- Tensile – Instron 5569, 10 mm/min
- Impact – Instron Dynatup 9210, charpy, notched (a/D = 0.1, 0.2, 0.3, 0.4)

Results

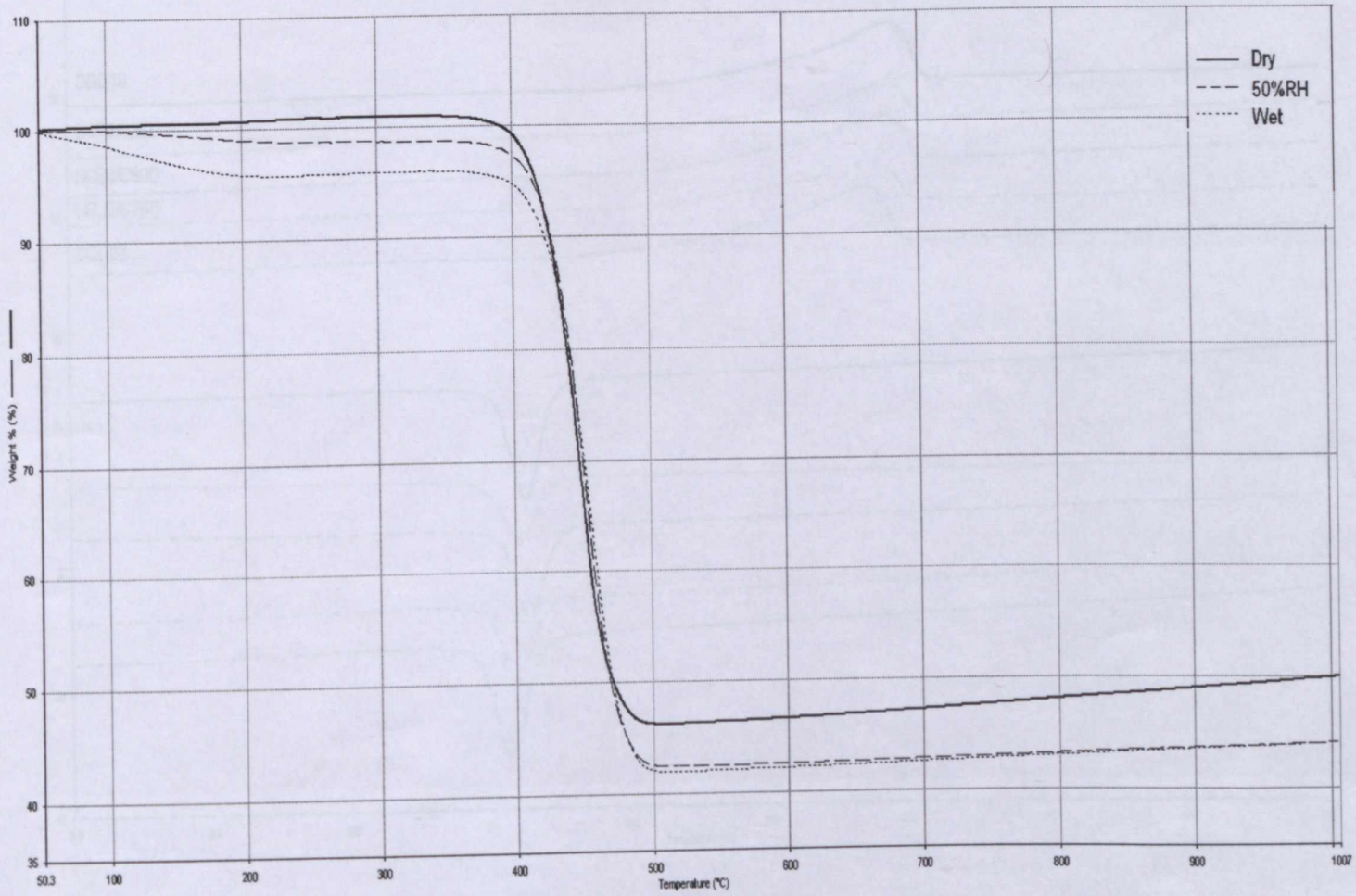

Figure 1: TGA thermographs of glass/carbon hybrid fibre composite (SG50/SC50) under different conditions

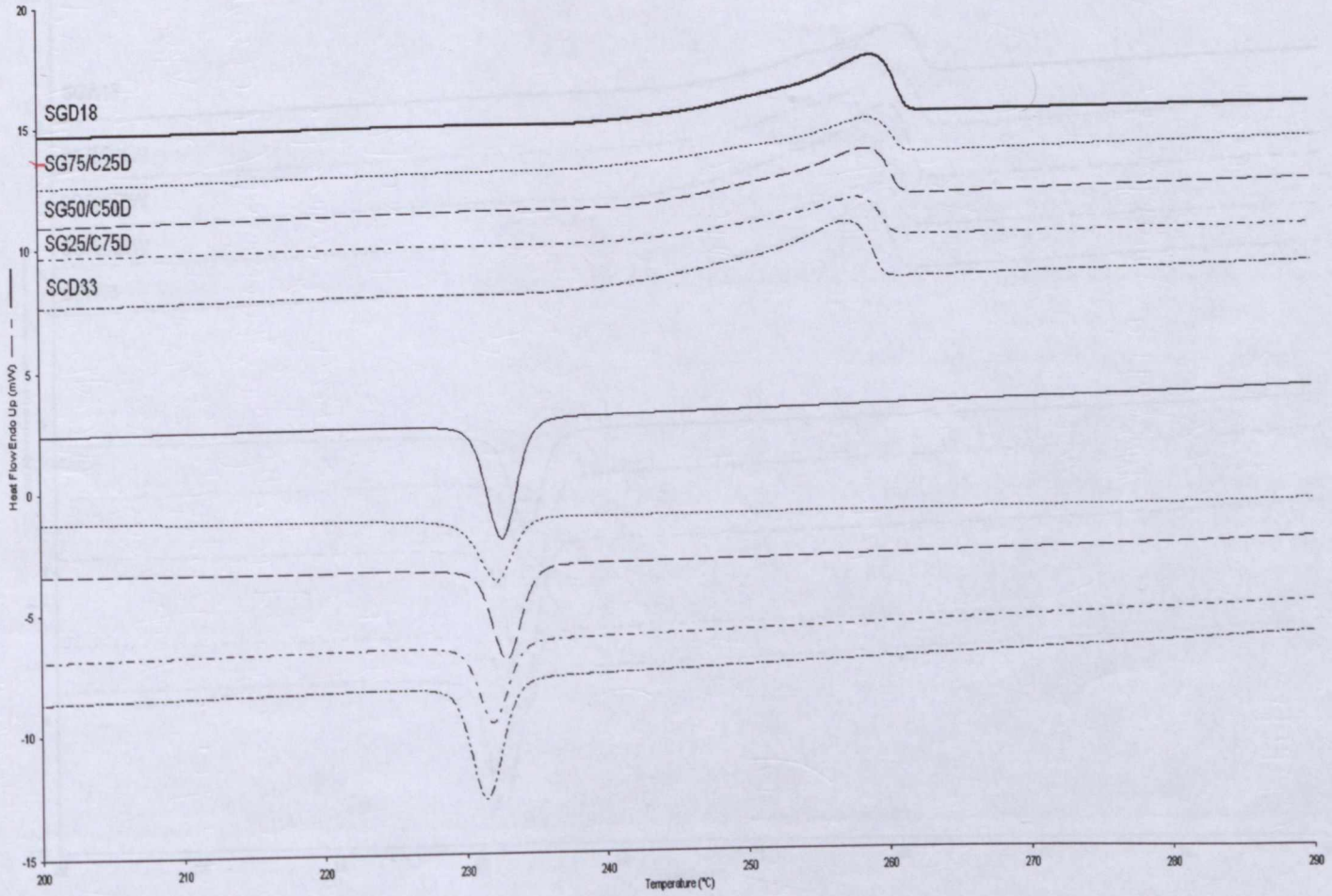

Figure 2: DSC results of hybrid fibre composites with different carbon fibre content under dry condition

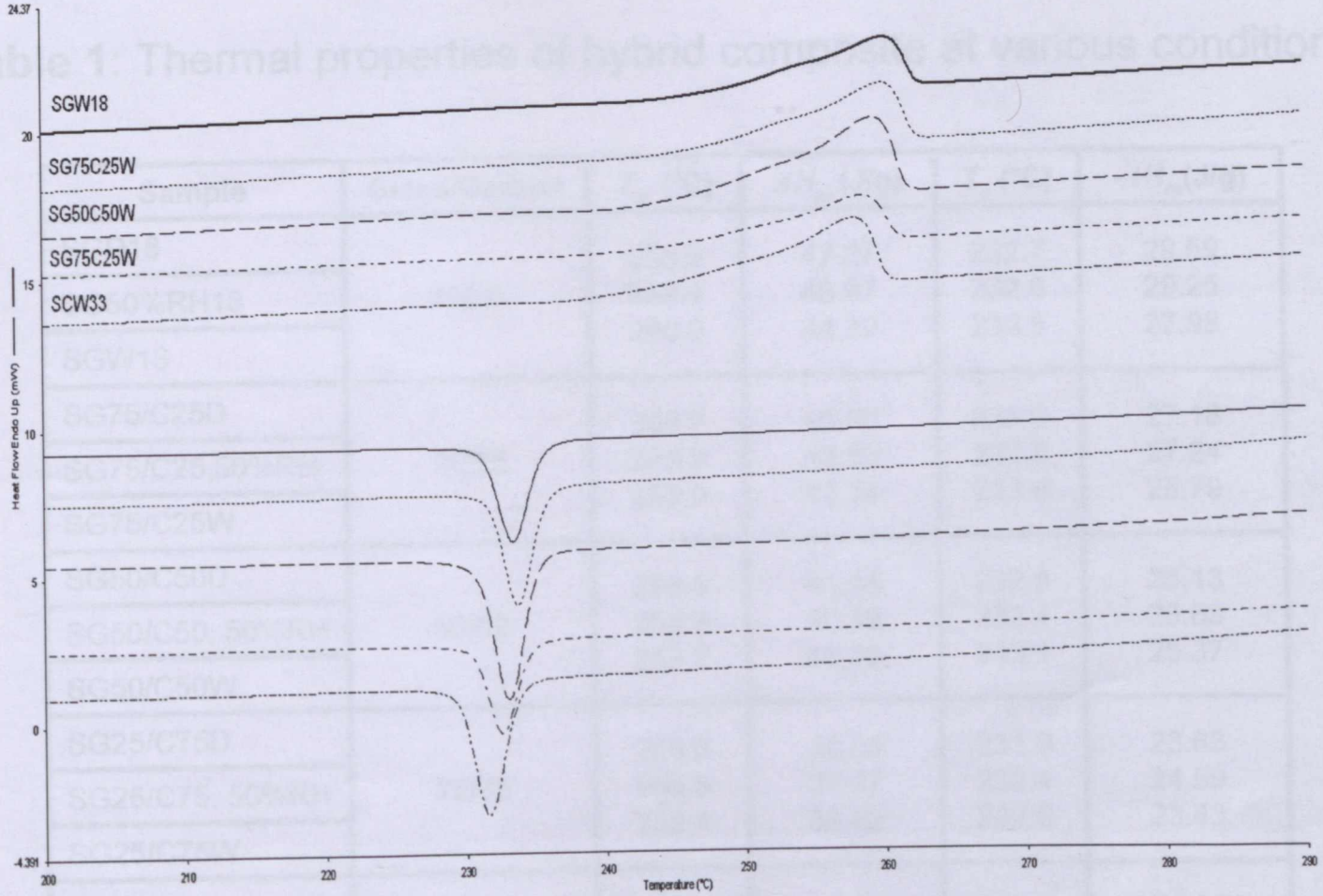

Figure 3: DSC results of hybrid fibre composites with different carbon fibre content under wet condition

Table 1: Thermal properties of hybrid composite at various conditions

Sample	Glass/Carbon	T_m (°C)	ΔH_m (J/g)	T_c (°C)	$-\Delta H_m$ (J/g)
SGD18	100/0	258.9	47.37	232.7	29.59
SG50%RH18		259.4	48.97	232.6	29.25
SGW18		260.0	44.39	233.5	27.98
SG75/C25D	75/25	258.7	45.35	232.3	27.18
SG75/C25,50%RH		259.2	42.89	232.9	27.24
SG75/C25W		259.9	42.14	233.8	25.79
SG50/C50D	50/50	258.5	41.14	232.9	25.13
SG50/C50, 50%RH		258.9	40.49	232.4	25.63
SG50/C50W		259.2	40.25	233.1	25.37
SG25/C75D	25/75	258.0	38.05	231.9	23.63
SG25/C75, 50%RH		258.5	37.47	232.4	24.59
SG25/C75W		258.4	36.62	232.6	23.43
SCD33	0/100	257.1	34.58	231.4	21.95
SC50%RH33		257.5	35.20	231.5	21.85
SCW33		257.8	34.29	231.6	21.47

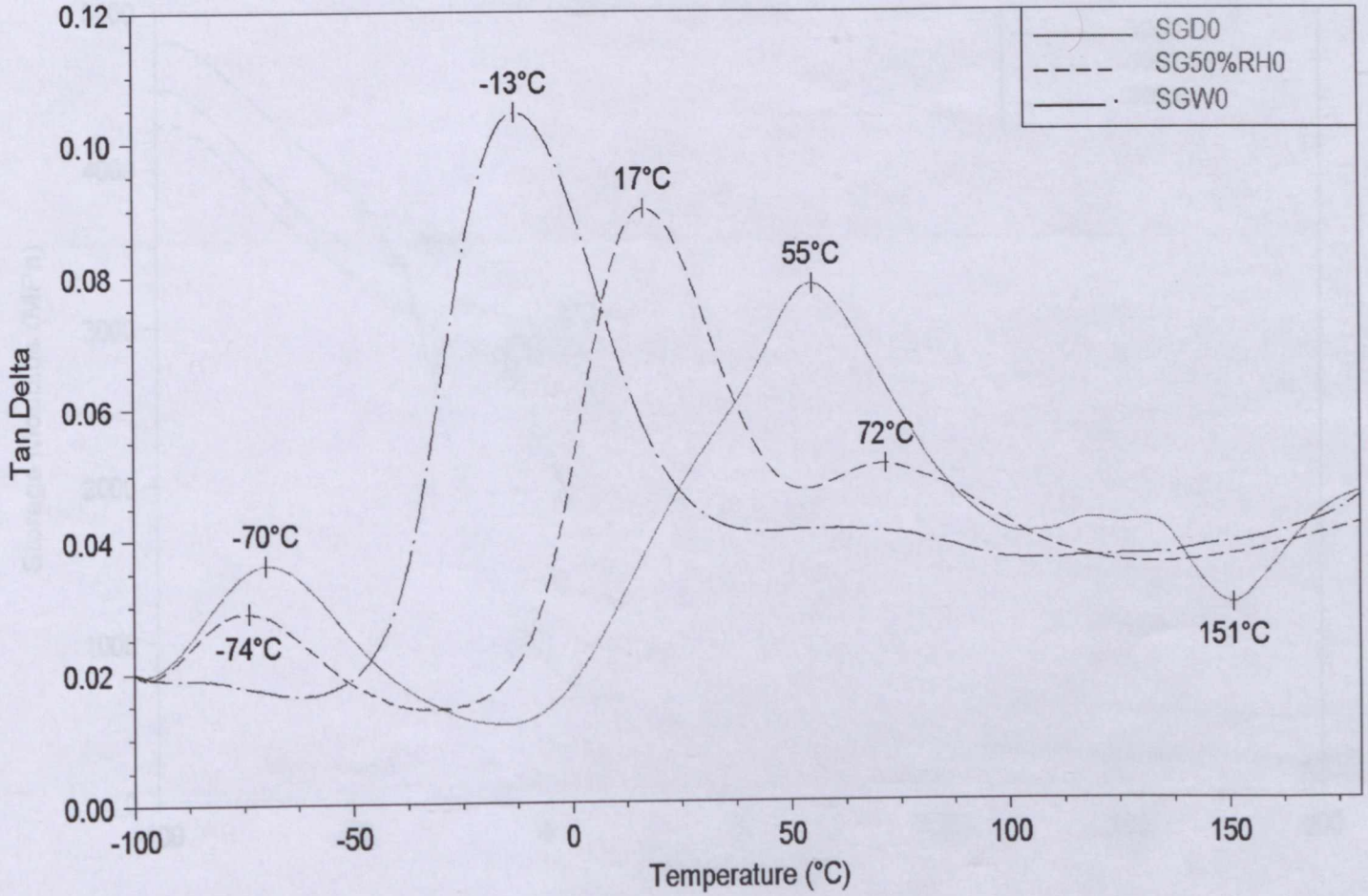

Figure 4: The tan delta–temperature behaviour of unreinforced polyamide 6,6 matrix under different conditions

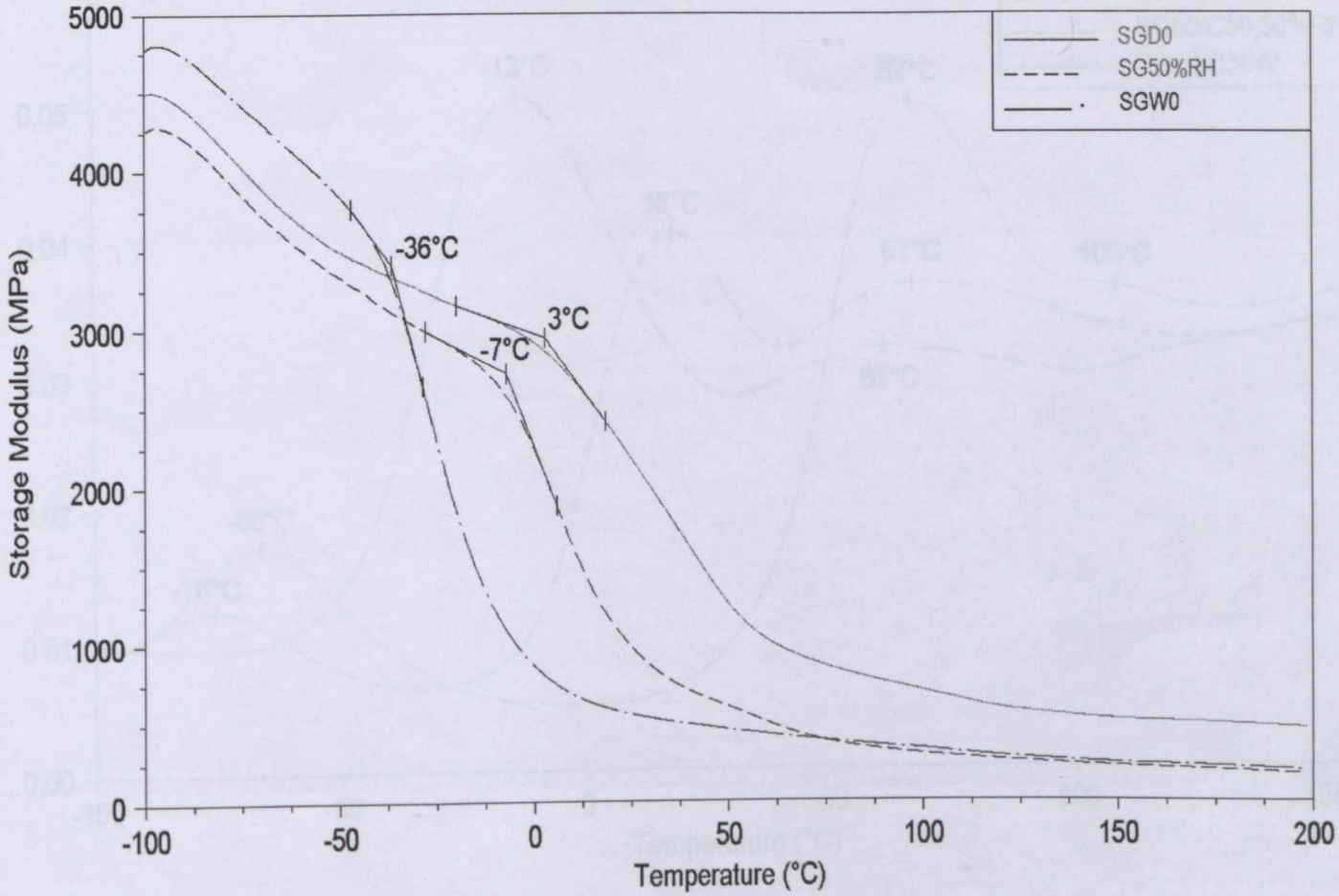

Figure 5: The storage modulus–temperature behaviour of unreinforced polyamide 6,6 matrix under different conditions

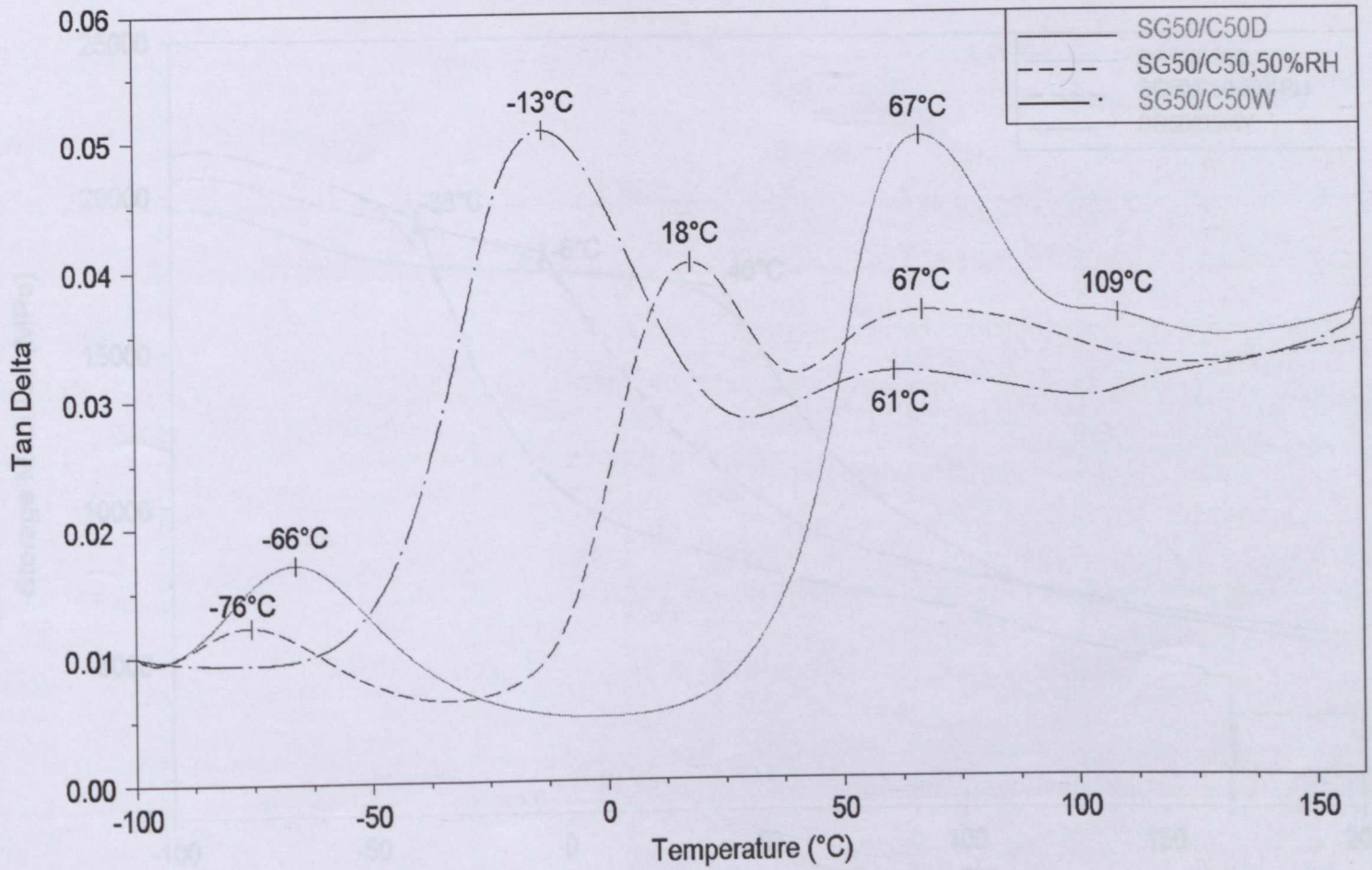

Figure 6: The tan delta–temperature behaviour of injection-moulded (SG50/C50) hybrid fibre composites under different conditions

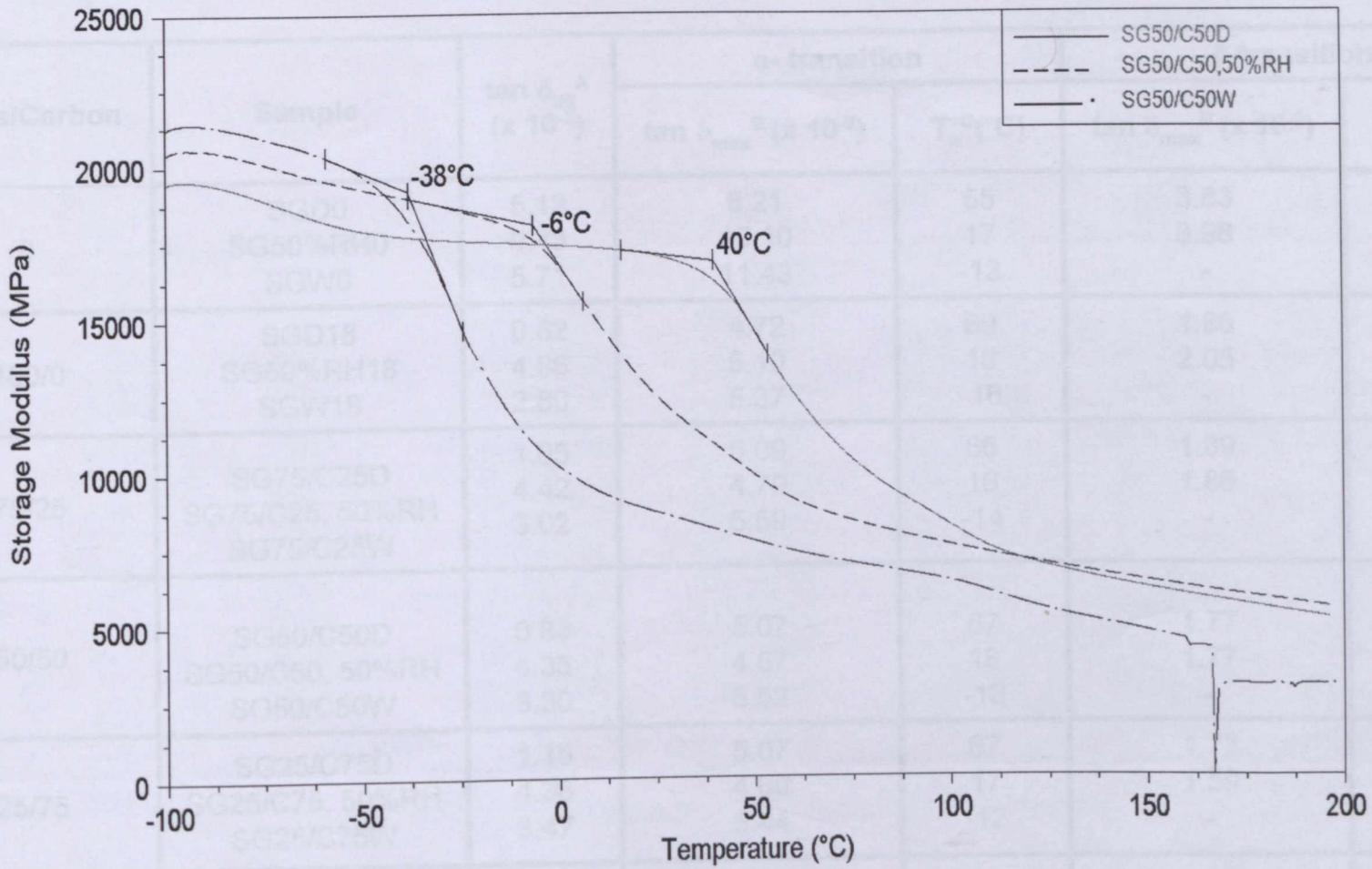

Figure 7: The storage modulus–temperature behaviour of injection-moulded (SG50/C50) hybrid fibre composites under different conditions

Table 2: Thermomechanical data of hybrid composite at various conditions

Glass/Carbon	Sample	tan δ_{25} [A] (x 10^{-2})	α- transition		β-transition	
			tan δ_{max} [B] (x 10^{-2})	T_α [C](°C)	tan δ_{max} [B] (x 10^{-2})	T_β [D] (°C)
0	SGD0	5.12	8.21	55	3.83	-70
	SG50%RH0	9.43	10.10	17	3.98	-74
	SGW0	5.71	11.43	-13	-	-
100/0	SGD18	0.82	4.72	69	1.88	-64
	SG50%RH18	4.86	5.10	18	2.05	-76
	SGW18	2.80	5.37	-16	-	-
75/25	SG75/C25D	1.05	5.09	66	1.89	-66
	SG75/C25, 50%RH	4.42	4.79	16	1.86	-77
	SG75/C25W	3.02	5.59	-14	-	-
50/50	SG50/C50D	0.83	5.07	67	1.77	-66
	SG50/C50, 50%RH	4.35	4.57	18	1.77	-76
	SG50/C50W	3.30	5.52	-13	-	-
25/75	SG25/C75D	1.15	5.07	67	1.72	-66
	SG25/C75, 50%RH	4.36	4.60	17	1.59	-74
	SG25/C75W	3.47	5.44	-12	-	-
0/100	SCD33	1.10	4.83	69	1.66	-66
	SC50%RH33	4.17	4.65	19	1.58	-76
	SCW33	3.98	5.44	-11	-	-

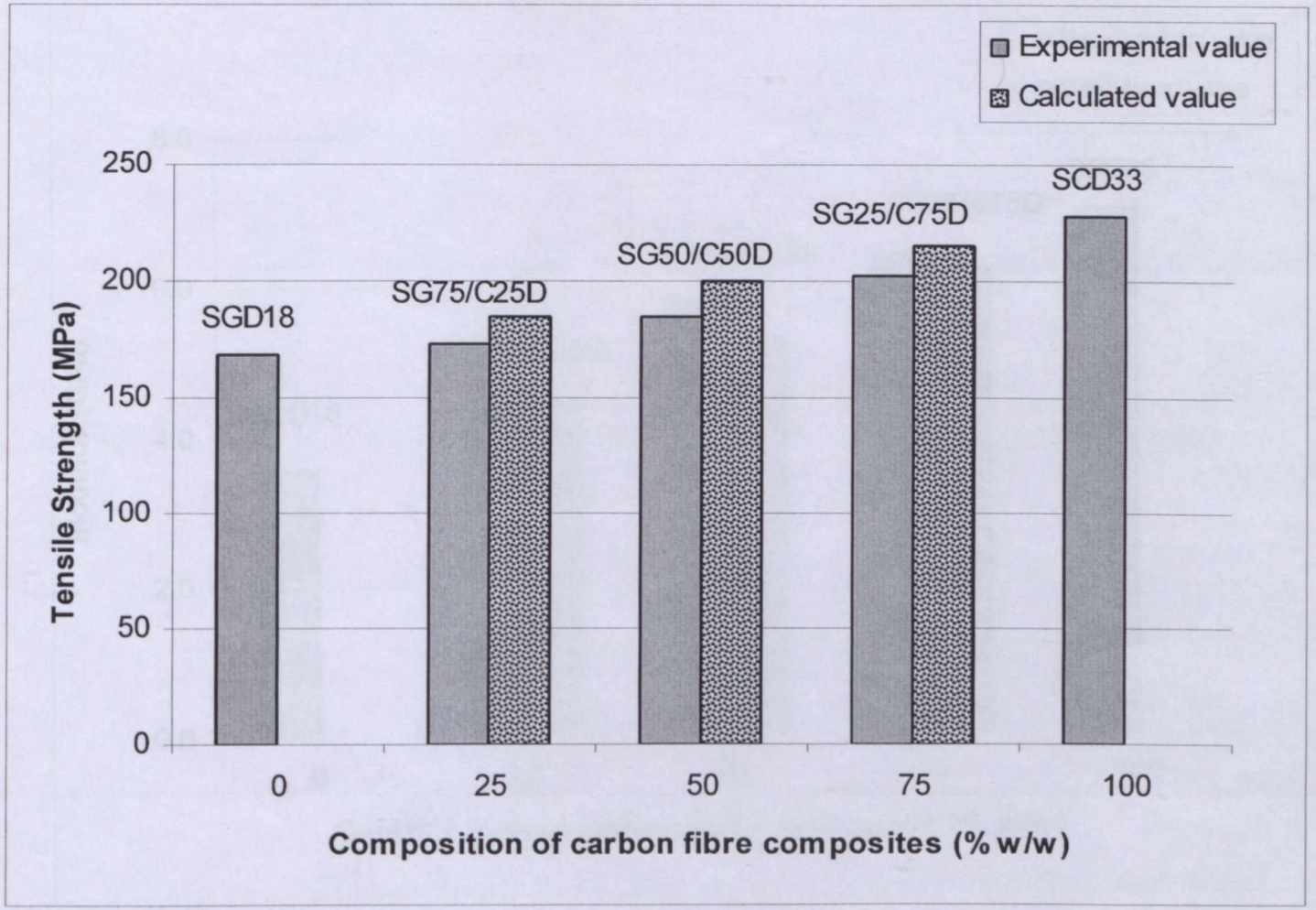

Figure 8: Tensile strength of composites subjected to dry condition

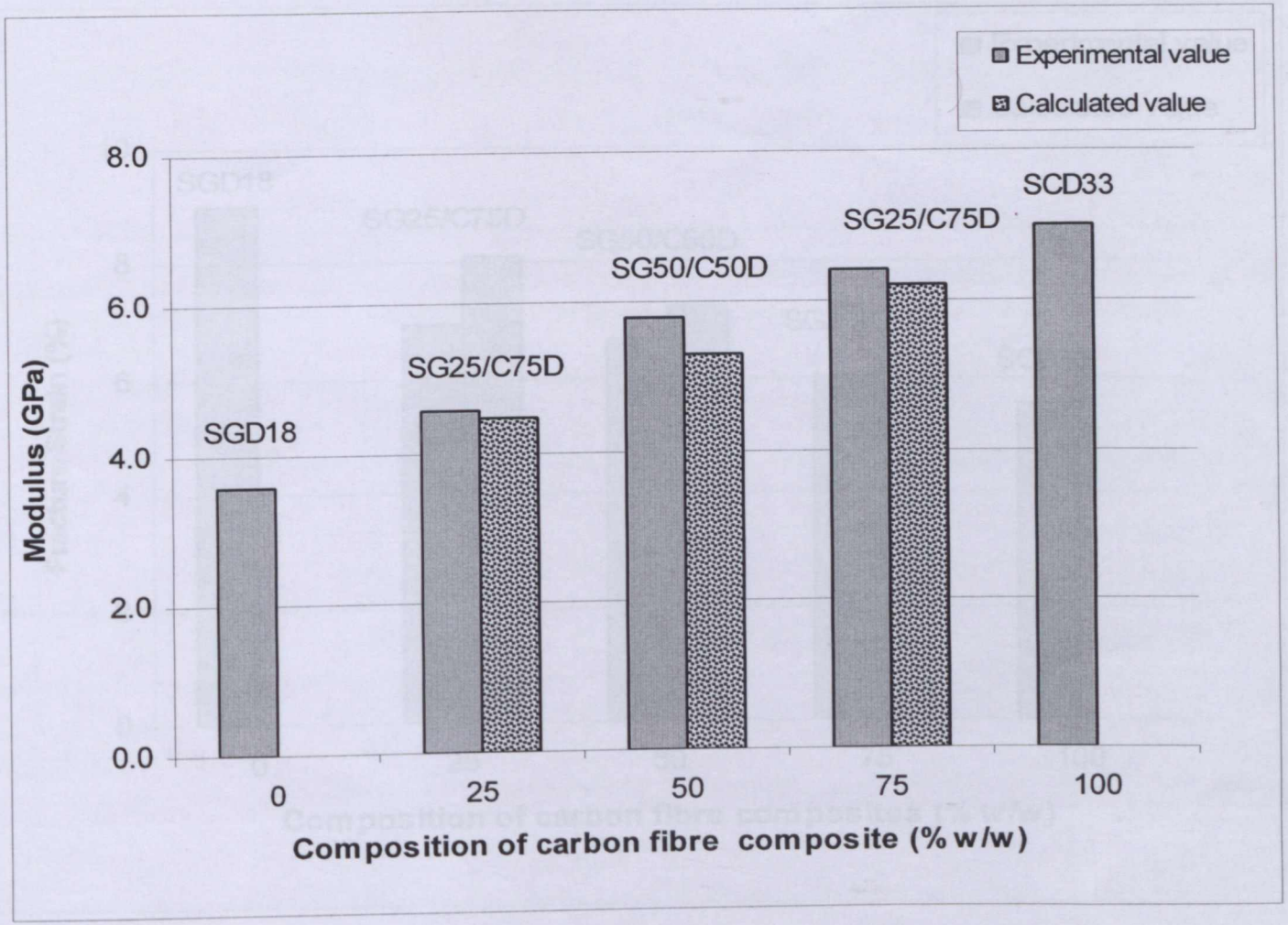

Figure 9: Tensile modulus of composites subjected to dry condition

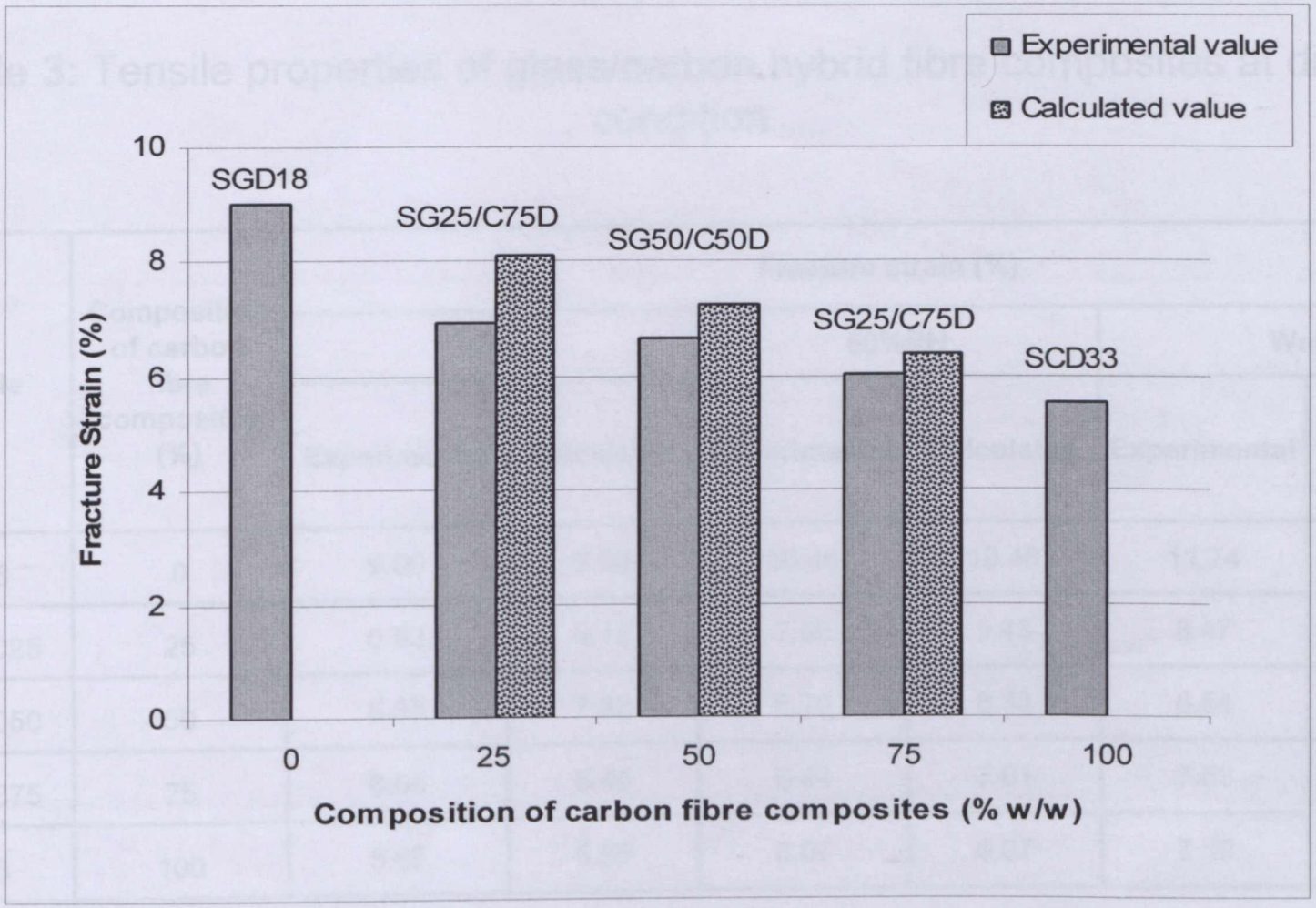

Figure 10: Fracture strain of composites subjected to dry condition

Table 3: Tensile properties of glass/carbon hybrid fibre composites at different condition

Sample	Composition of carbon fibre composites (%)	Fracture strain (%)					
		Dry		50%RH		Wet	
		Experimental	Calculated	Experimental	Calculated	Experimental	Calculated
SG18	0	9.00	9.00	10.46	10.46	11.74	11.74
SG75/C25	25	6.93	8.12	7.69	9.43	8.47	10.79
SG50/C50	50	6.65	7.32	6.70	8.33	8.54	9.51
SG25/C75	75	6.05	6.40	6.41	7.01	7.59	8.33
SC33	100	5.55	5.55	6.07	6.07	7.19	7.19

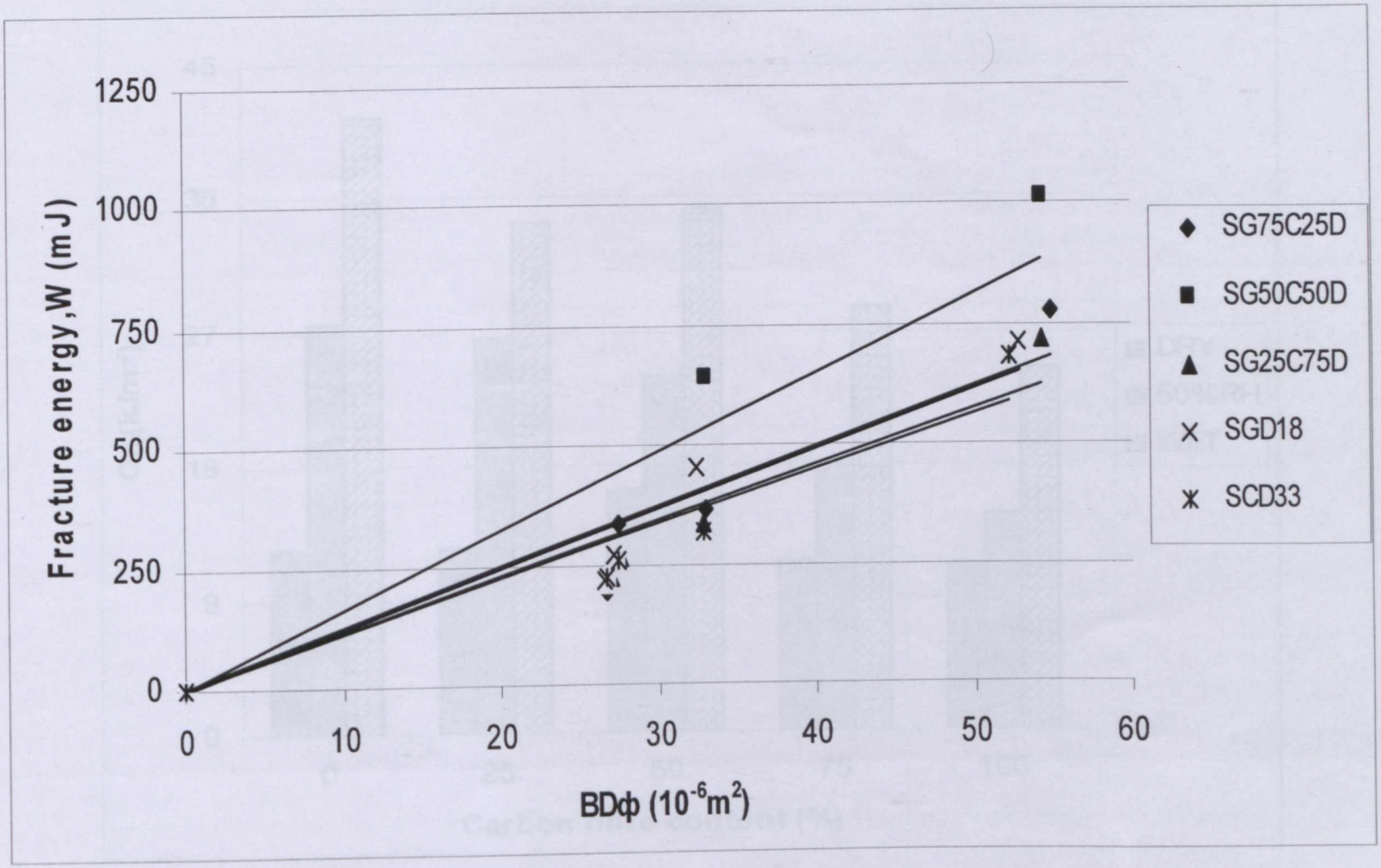

Figure 11: Variation of fracture energy with specimen geometry function of hybrid fibre composites under dry condition

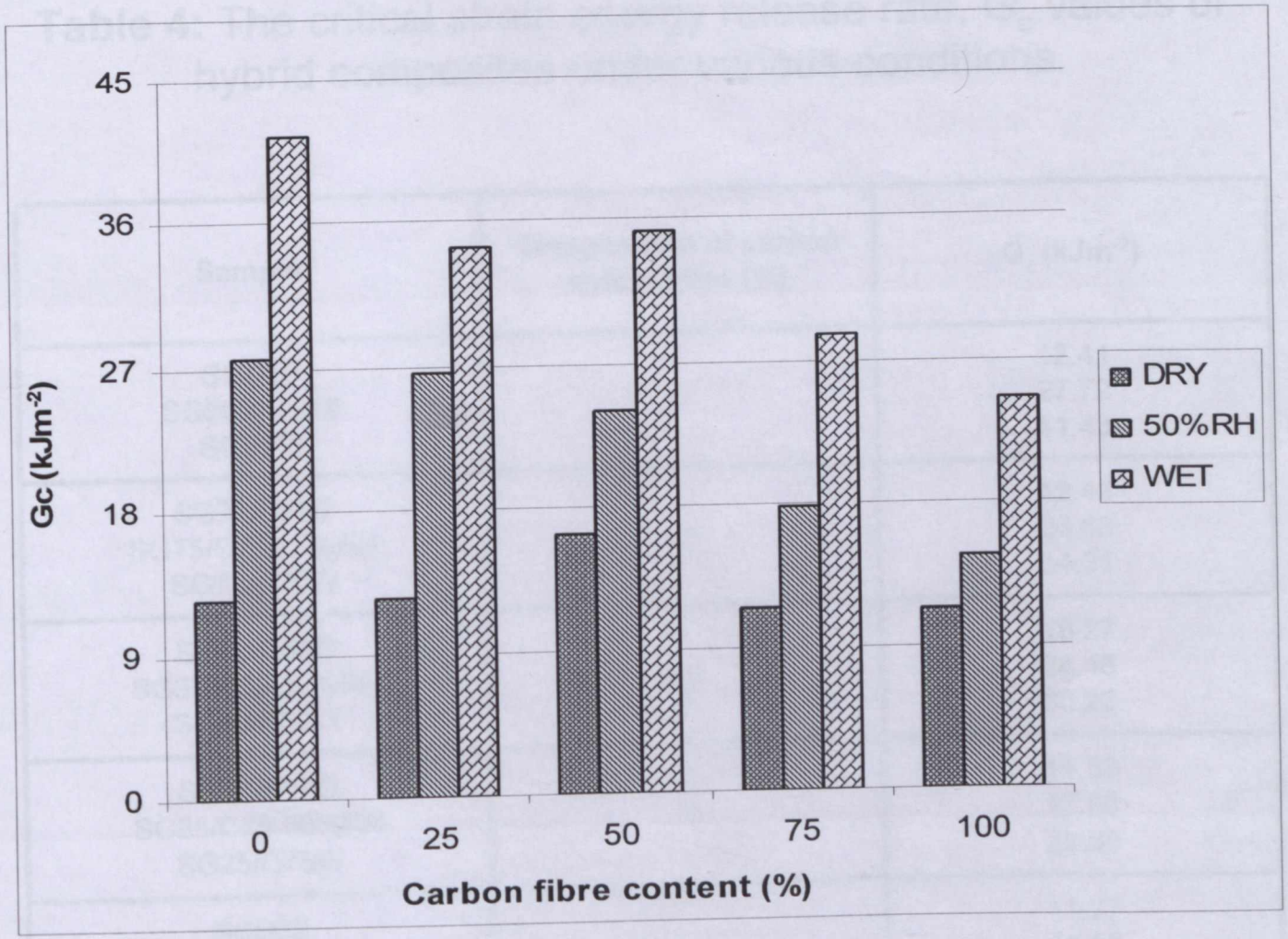

Figure 12: G_c values of hybrid fibre composites under dry, 50% RH and wet condition

Table 4: The critical strain energy release rate, G_c values of hybrid composites under various conditions.

Sample	Composition of carbon composites (%)	G_c (kJm^{-2})
SGD18 SG50%RH18 SGW18	0	12.41 27.72 41.43
SG75/C25D SG75/C25,50%RH SG75/C25W	25	12.45 26.68 34.31
SG50/C50D SG50/C50,50%RH SG50/C50W	50	16.27 24.16 35.22
SG25/C75D SG25/C75,50%RH SG25/C75W	75	11.53 17.86 28.68
SCD33 SC50%RH33 SCW33	100	11.27 14.57 24.55

Conclusion

Effect of hybridisation:-

- No sensible change in matrix properties from DSC results
- Positive effect on E, G_c
- Negative effect on UTS

Conclusion

Effect of moisture absorption:-

- Plasticisation effect – shown in mechanical and dynamic mechanical properties

Thank you