Thermal expansion of aramid fibres

S. ROJSTACZER, D. COHN, G. MAROM
Casali Institute of Applied Chemistry, School of Applied Science and Technology, The Hebrew University of Jerusalem, 91904 Jerusalem, Israel

Thermal expansion behaviour is a useful parameter in materials science research reflecting physio-chemical properties of the material. In addition, its knowledge is indisputably essential for engineering design. Surprisingly enough, specific information pertinent to aramid fibres is scarce, inconsistent and at times, conflicting.

As an example let us examine some thermal expansivity values measured by Strife and Prewo [1] for unidirectional Kevlar fibre-reinforced epoxy composites. The reported axial value at 25° C for a fibre volume fraction of 50% was $-2.1\times10^{-6}\,°\mathrm{C}^{-1}$. This value exhibited poor agreement with that of $-0.43\times10^{-6}\,°\mathrm{C}^{-1}$ calculated by Shapery's equations [2], incorporating an axial coefficient of thermal expansion of the fibre of $-2.0\times10^{-6}\,°\mathrm{C}^{-1}$, obtained from the Kevlar data manual [3]. The authors already suspected that the axial fibre expansion coefficient was more negative than this reported value, hitherto accepted in the literature (e.g. see [4]).

This suspicion has been confirmed by our results obtained in a study of the thermal expansion of aramid fibres and their composites. In view of their importance and significance we present them here in a preliminary publication. Our measurements were carried out with Kevlar 49 fibres using a Mettler TMA 40/TC 10 thermomechanical analyser.

Fig. 1 presents the axial dilatation of the fibre from 20 to 150° C. It shows two regimes with a slope change at around 90° C, producing a coefficient of $-5.7\times10^{-6}\,°\mathrm{C}^{-1}$ for the temperature range of 20 to 80° C and a coefficient of $-6.3\times10^{-6}\,°\mathrm{C}^{-1}$ for the temperature range of 100 to 150° C. Table I displays side by side some measured and calculated axial coefficients for unidirectional Kevlar/epoxy composites of three fibre loadings in the temperature range 20 to 80° C. It is seen that the agreement is excellent. Regarding Strife and Prewo's results a coefficient of $-5.7\times10^{-6}\,°\mathrm{C}^{-1}$ will result in a value of $-4.0\times10^{-6}\,°\mathrm{C}^{-1}$ compared with their measured value of $-2.1\times10^{-6}\,°\mathrm{C}^{-1}$.

A comprehensive account of our study will be prepared for publication in the near future.

TABLE I Axial thermal expansion coefficients of unidirectional Kevlar epoxy composites at 20 to 80° C

Nominal fibre content (%)	Coefficient ($10^{-6}\,°\mathrm{C}^{-1}$)	
	Calculated	Measured
50	−3.66	−3.80
60	−4.33	−4.47
70	−4.80	−4.61

References

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2. R. A. SHAPERY, *ibid.* 2 (1968) 380.
3. Kevlar 49 Data Manual, E.I. DuPont de Nemours & Co.
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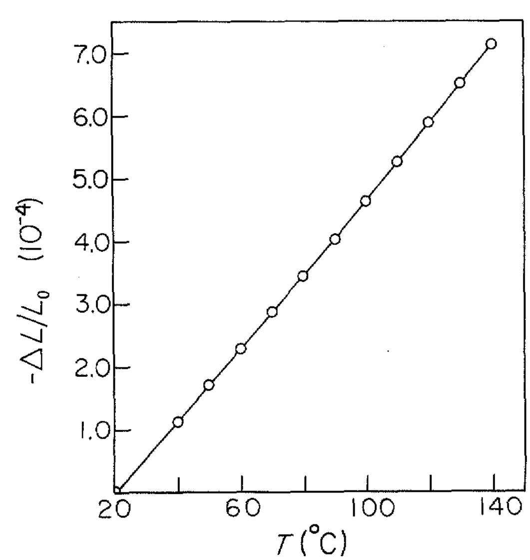

Figure 1 Dilatation behaviour of Kevlar 49 fibres in the temperature range 20 to 150° C.

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