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NOTE

Heat Distortion Temperatures of Plastic Compositions by Means of a Torsional Test Using Small Quantities of Material

The standard A.S.T.M. method of test for heat distortion temperature (HDT) of plastics[1] requires a relatively large size specimen, 5 × 0.5 × 0.125 to 0.5 in., approximately 15 g. It is common that during the initial stages of a research investigation on a new polymeric system only a limited amount of material is available for testing. In order to overcome this difficulty an alternate test method was sought for determining HDT. One method that was investigated for this purpose was the standard test for stiffness properties of plastics by torsional measurements.[2] This procedure requires small specimens, 2.5 × 0.25 × 0.060 to 0.10 in., approximately 1 g., and in addition torsional testing apparatus is generally available in most laboratories conducting research and development investigations on polymeric materials. In this note the utility of the torsional method in determining the HDT of various thermosetting and thermoplastic polymeric compositions is demonstrated.

HDT's[1] for eighteen polymeric materials are given in Table I for two fiber stresses, namely, 264 and 66 psi, hereafter designated HDT_{264} and HDT_{66}, respectively. The

TABLE I
Heat Distortion Temperature and Moduli of Torsion for Various Polymeric Materials

Polymeric material	Heat distortion, temperature, °C.		Modulus of Torsion, psi × 10^{-4} at heat distortion temperature		Heat distortion, temperature, °C., from torsional modulus	
	264 psi	66 psi	264 psi	66 psi	10 × 10^4 psi	3 × 10^4 psi
Araldite 6005[a,h]	102	107	13	5.5	104	108
Araldite 6005[b]	135	142	15	2.9	136	140
Epon 828[c]	113	—	11	—	113	117
Epon 562[d]	66	—	9.5	—	66	72
Poly(methyl methacrylate)	73	75	9.0	7.5	72	79
Poly(styrene)	87	91	24	6.0	90	92
Poly(vinyl chloride)[e]	81	84	5.5	3.0	79	83
Poly(vinyl chloride)[f]	64	70	8.5	2.3	63	68
Poly(vinyl chloride-*co*-acetate)[g]						
95:5[f]	61	63	4.0	1.3	60	61
95:5	77	81	9.0	1.5	76	79
93:7	73	76	9.0	2.5	72	75
87:13	69	71	9.0	5.0	69	72
Poly(vinyl chloride-*co*-vinyl caproate)[g]						
96:4	68	71	5.0	2.0	66	69
91:9	53	58	5.0	1.3	50	54
86:14	43	48	12	4.6	44	48
Poly(vinyl chloride-*co*-vinyl pelargonate)[g]						
96:4	60	65	17	5.0	63	66
92:8	51	55	3.5	0.4	47	50
89:11	38	42	17	6.8	41	44

[a] Commercial epoxy resin (from Ciba Products Corp., Kimberton, Pa.) cured with triethylene tetramine.
[b] Commercial epoxy resin (from Ciba Products Corp., Kimberton, Pa.) cured with *m*-phenylene diamine.
[c] Commercial epoxy resin (from Shell Chem. Co., 500 Fifth Ave., New York) cured with diethylenetriamine.
[d] Commercial epoxy resin (from Shell Chem. Co., 500 Fifth Ave., New York) cured with hexahydrophthalic anhydride.
[e] Vinyl chloride compositions stabilized with 1 part basic lead carbonate except where noted.
[f] Vinyl chloride compositions stabilized with 4 parts of an organotin compound.
[g] Vinyl chloride compositions are given in molar quantities.
[h] Mention of a specific commercial product does not constitute an endorsement by the United States Department of Agriculture.

torsional modulus-temperature curve for each material reported was determined in the usual manner[2] except that a 2°/min. heating rate was employed. Moduli of torsion at the corresponding standard values of HDT's were simply obtained from the torsional modulus-temperature curves. The torsional moduli are given in Table I. Examination of the data shows that the moduli of all polymeric compositions fall in a very narrow range: 3.5×10^4 to 24×10^4 psi and 0.4×10^4 to 7.5×10^4 psi for specimens HDT_{264} and HDT_{66}, respectively. The average values of each range, namely, 10×10^4 psi and 3×10^4 for HDT_{264} and HDT_{66}, respectively, can arbitrarily be selected to define the HDT of a specimen as determined by the torsional measurements. Listed in the last two columns of the table are the HDT's of the various plastic compositions investigated.

It is apparent that the HDT obtained in this manner is in very good agreement with the data obtained using the standard heat distortion test.[1] It should be pointed out that the use of the torsional test cannot be applied to compositions containing large amounts of crystallinity. Similar behavior has been reported[3] for crystalline specimens subjected to the standard test. However, in spite of this limitation it would appear that the torsional test provides a simple means for determining HDT's on small samples while simultaneously providing information about the entire temperature range in which the plastic composition might be employed. In addition, the state of cure in a plastic composition can be determined quickly and simply by following the changes in its torsional modulus at a single temperature (i.e., room temperature).

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References

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