NOTE

Effect of Humidity on the Tensile Properties of Filled and Unfilled Epoxy Polymer

It is often observed that there is a deleterious influence of humidity on the mechanical properties of polymers and adhesive joints. We wish to report our observation of a system in which the presence of high humidity appears to enhance the mechanical properties of the polymer.

The tensile properties of samples of Epon 828 crosslinked with a stoichiometric amount of hexamethylenediamine (HMDA) and of a similar system filled with 14.3% TiO_2 (by weight) were measured after samples had been conditioned for 100 hr. at 15% relative humidity and 93% relative humidity. The results of these measurements are shown in Table I.

TABLE I

Tensile Properties of Filled and Unfilled Crosslinked Epoxy Polymer[a]

	Unfilled		Filled	
Relative humidity, %	15	93	15	93
Tensile strength, lbs./in.^{2}	2,990	4,420	6,248	8,750
Ultimate elongation, %	5.5	7.0	8.7	18.3
Young's modulus, dynes/cm.^{2}	6.38×10^9	7.89×10^9	8.1×10^9	9.8×10^9

[a] Strain rate: 1000%/min.

Ultimate tensile strengths of samples conditioned at the higher relative humidity were greater than those of samples conditioned at lower humidity by 47% in the case of the unfilled system and 40% in the case of the filled system. Ultimate elongation is also increased by higher concentration of water vapor by 27 and 110% for unfilled and filled materials, respectively. These results can be explained either in terms of the theories advanced for the tensile strength of rubber by Bueche,[1] and Taylor and Darin,[2] or in terms of Griffith's flaw theory,[3] or a combination of both. Consistent with the first theory, the water may be considered as creating increased mobility in the polymer network, thus affording the opportunity for the network of chains to orient more fully in the direction of stress during tensile drawing. Consistent with the flaw theory, the water may be considered to be filling internal fractures, possibly through hydrogen bonding to the chain network, thus increasing the tensile strengths of the systems.

The increase in Young's Modulus for both the filled and unfilled systems (21 and 24%, respectively) with exposure to higher humidity suggests an increase in the elastic (or potential) energy of both systems due to the increased amounts of water present.

References

1. Bueche, F., *J. Polymer Sci.*, **24**, 189 (1957).
2. Taylor, G. R., and S. R. Darin, *J. Polymer Sci.*, **17**, 511 (1955).
3. Griffith, A. A., *Phil. Trans. Roy. Soc., London*, **A221**, 163 (1920).

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