This Week's Citation Classic

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Boyer R F. The relation of transition temperatures to chemical structure in high polymers. *Rubber Chem. Technol.* **36**:1303-421, 1963.
[Plastics Department, Dow Chemical Company, Midland, MI]

This paper presents a systematic study of the literature on multiple transitions in non-biological polymers, based on 1-1,000 Hz mechanical loss spectra, dilatometry, specific heat and other techniques, and using a relative temperature scale, T/T_g, to clarify common features of many spectra. [The *SCI®* indicates that this paper has been cited over 320 times since 1963.]

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"A 1960 main lecture at the Cordon Polymer Conference by the late Karl Wolf of Heidelberg treated the torsion pendulum mechanical loss spectra of many amorphous and semicrystalline organic polymers. These 1-10 Hz spectra consisted of two to four energy absorption peaks from -160 to + 200°C. Each peak signified some type of solid-state motion of the polymer main chain, or side chain, or both. Dozens of slides were shown, each with several spectra but with no obvious general pattern.

"I awoke the next morning with the clear vision that a horizontal shift of each spectrum either way along the temperature scale until the glass temperatures, T_g, coincided revealed some remarkable similarities in the spectra of different polymers. It was then obvious to employ a relative temperature scale, T/T_g, for plotting the location of loss peaks.

"At an invited IUPAC lecture in Montreal in 1961, we presented our views on the generalized spectra of polymers and classification scheme for such spectra. Interest was gratifying. Cordon Kline invited me to present this lecture to his polymer and rubber group at the National Bureau of Standards. Staff member Norman Bekkedahl was on the editorial advisory board of *Rubber Chemistry and Technology* whose editor, G.E.P. Smith, soon invited me to submit a detailed article for the 1963 *Rubber Reviews* issue. My progress writing outside of normal working hours at Dow Chemical Company was slow and Smith finally had to declare an absolute deadline.

"The rest is history. We sent out over 500 reprints. The article was mimeographed for classroom use. A translation into Chinese was made. It appears to still be in use.

"Several factors may have contributed to its success: 1. Timeliness in bringing some order from chaos, as, for example, in listing criteria for T_g. 2. Worldwide circulation of *Rubber Chemistry and Technology*. 3. Intercorrelation of dynamic mechanical methods with thermal methods such as expansivity and specific heat. 4. New concepts such as reduced temperature scales, and a new liquid state transition, T_{ll}, which is currently quite controversial. 5. A three-year period of gestation and writing, and extensive consultation with international experts in the field. The net result was an organized review of the literature in a preselected field, interspersed with daring concepts, generalizations, insights, and predictions which provided a convenient departure for future research and which may have inspired the preparation of at least two books. I credit this article in large part for one of my most coveted honors, the Swineburne Award, from the Plastics Institute of Great Britain in 1972. Three lengthy sequels to the article have since appeared, one emphasizing semi-crystalline polymers in 1975;[1] one emphasizing the glass transition in 1977;[2] and one on the liquid state of amorphous polymers in 1980."[3]

1. **Boyer R F.** Glassy transitions in semicrystalline polymers. *J. Polym. Sci. C* **50**:189-242, 1975.
2. ....., Transitions and relaxations. (Bikales N M, ed.) *Encyclopedia of polymer science and technology—plastics, resins, rubbers, fibers: supplement.* New York: Interscience, 1977. Vol. 2. p. 745-839.
3. ....., Dynamics and thermodynamics of the liquid state ($T>T_g$) of amorphous polymers. *J. Macromol. Sci.—Phys.* **B18**:461-553, 1980.