Introduction to Polymer Viscoelasticity

Second Edition

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Viscoelastic Models

The phenomenological theory of linear viscoelasticity developed in Chapter 2 is completely independent of the existence of models. It is desirable to consider the representation of linear viscoelastic processes by certain model systems in order to gain greater insight into relaxation behavior. In this chapter we consider two broad classes of models. The first consists of the so-called "mechanical analogues." These are combinations of elements, usually springs and dashpots, that more or less faithfully reproduce the viscoelastic response of real systems. The second group is composed of the molecular theories. Here a fairly reasonable representation of a polymer molecule is assumed and the motion of such a molecule in a viscous medium is deduced. In this case the viscoelastic behavior is predicted on the basis of molecular parameters. It will be demonstrated that the two classes of models are equivalent in many respects.

A. MECHANICAL ELEMENTS

We return to the tensile elongation experiment described in the Introduction and Chapter 2. The simplest mechanical model that has some of the gross physical behavior exhibited by bodies subject to uniaxial elongation is a pure Hookean spring (Figure 7-1a). This body is purely elastic and all inertial effects are neglected. Thus if the Hookean spring is subjected to an instantaneous stress σ_0, it will respond instantaneously with a strain ε_0, σ_0 and ε_0 being related by the equation

$$\sigma_0 = E\varepsilon_0 \tag{7-1}$$