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THE MODULUS OF POLYETHYLENE

by

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The Modulus of Polyethylene

In a previous article in this journal, we simultaneously measured shear modulus, density, and crystallinity for linear polyethylenes as a function of temperature in samples subjected to various annealing procedures.

At sufficiently high temperatures, the degree of amorphicity becomes appreciable and the modulus becomes lower than 7×10^8 dynes/cm^2. Under these conditions one can interpret the modulus as a rubber elasticity modulus. In the sample, under these conditions, the crystallites have a dual role: they act as crosslinks and also as filler particles. An equation has been proposed for the shear modulus:

$$1.\quad G = \frac{(1-Q)dkT}{\bar{r}\,m}(1+2.5Q+14.1Q^2)$$

In equation (1) Q is the fractional crystallinity, d is the density, m is the molecular mass of the repeating link in the chain (CH_2 in this case,) k is Boltzmann's constant, T is the absolute temperature, and $\bar{r}$ is the average number of CH_2 units in an amorphous sequence of the polymer chain connecting two crystallites. The term in parenthesis on the right hand side is a correction for the "filler effect."

Data obtained in reference (1) on Q, d and G at various temperatures enable us to compute $\bar{r}$, a quantity which should be of use in characterizing crystalline polymers.

We believe that it is permissible to apply equation (1) based on rubber elasticity theory for values of G less than 7×10^8 dynes/cm^2 and for values of $\bar{r}$ equal to or greater than ten. This is suggested by our systematic studies of highly crosslinked polymers[3].

Table I shows the data for T, d, Q, and G for sample (No. 491 $\bar{M}_v = 2.8 \times 10^5$) of reference (1) together with the values of $\bar{r}$ computed by equation (1).

It would, of course, be of great interest if other physical methods for measuring $\bar{r}$ could be developed.

Table I

Linear Polyethylene

Temperature °C	Density	Crystallinity	Modulus (dynes/cm^2)	$\bar{r}$
115	0.918	0.76	6.53×10^8	10.0
120	0.912	0.70	4.95×10^8	14.9
125	0.903	0.67	3.37×10^8	22.6
130	0.892	0.51	7.8×10^7	70.6
133	0.795	0.30	6.9×10^7	95.8

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