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Environmental Stress Relaxation Studies of Polymers: Effect of Temperature on Polyethylene-Xylene and Polyethylene-Toluene Systems

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Synopsis

The method of stress relaxation has been used to study the effect of temperature on the stress decay behavior in the systems of polyethylene–xylene and polyethylene–toluene. The behavior of stress decay in the polyethylene under xylene or toluene at various temperatures was observed and the activation energies of polyethylene–xylene and polyethylene–toluene were obtained.

INTRODUCTION

Stress failure of polymers such as polyethylene under solvent such as the benzene-series hydrocarbons poses a problem of considerable interest.[1,2] It was, therefore, decided to investigate the effect of temperature on the stress decay behavior in polyethylene–xylene and polyethylene–toluene systems.

Stress relaxation experiments, which measure the rate of stress decay of polyethylene under xylene or toluene at various temperatures, have been utilized. The determination can be followed by measuring the stress decay of the polymer as a function of temperature.

EXPERIMENTAL

Materials

Polyethylene, xylene, and toluene used in this work were the same as those described in the previous papers.[1,2]

Apparatus and Procedure

The apparatus used in this work was the same as that described in the previous papers.[1]

Polyethylene films were set in clamps in the inner vessel containing xylene or toluene as solvent at various temperatures, preheated in the unstrained state for 15 min, then extended. The determination was followed by measuring with a balance the residual stress as a function of time in these film samples held at constant extention in a thermostated vessel containing xylene or toluene as a solvent at various temperatures.

RESULTS AND DISCUSSION

The changes, with time, in stress of polyethylene films under xylene or toluene at various temperatures were studied with a 50% elongation.

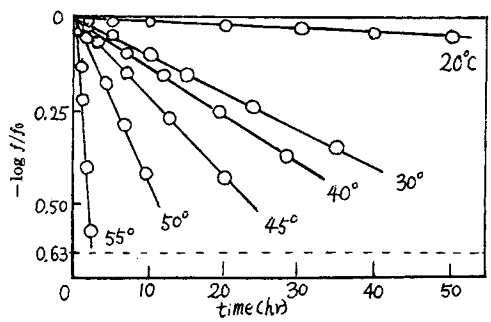


Fig. 1. Stress relaxation of polyethylene-xylene system.

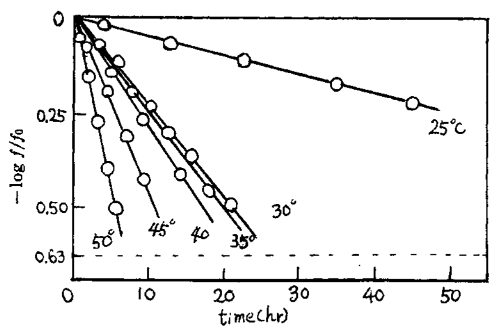


Fig. 2. Stress relaxation of polyethylene-toluene system.

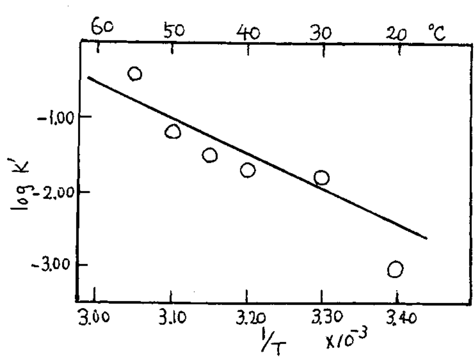


Fig. 3. Temperature dependence of rate constant of polyethylene-xylene system.

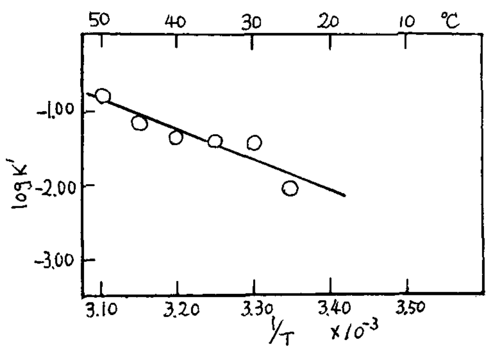
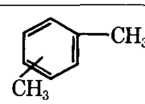
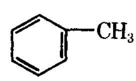
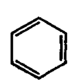


Fig. 4. Temperature dependence of rate constant of polyethylene-toluene system.

Figures 1 and 2 show the relationship of the logarithm of stress versus linear time and its dependence on temperature. When the relaxation time of stress decay shown in Figures 1 and 2 is considered as the reciprocal of a rate constant for solvent cracking and the rate constants are plotted against the temperature, the relationships shown in Figures 3 and 4 are obtained. From these relationships the following activation energy for solvent cracking was obtained: $E_x = 21$ kcal/mole for the polyethylene–xylene system and $E_t = 18$ kcal/mole for the polyethylene–toluene system.

These values are tabulated in Table I for comparison. From these

TABLE I
Activation Energy of Solvation in Polyethylene

Solvent	Formula and structure		Activation energy E, Kcal/mole
Xylene	$C_6H_4(CH_3)_2$		21
Toluene	$C_6H_5CH_3$		18
Benzene[a]	C_6H_6		24

[a] From Nisizawa.[2]

values it is clear that a side chain of the benzene nucleus may be related to the activation energy of solvation in polyethylene.

References

1. M. Nisizawa, *J. Appl. Polym. Sci.*, **13**, 1621 (1969).
2. M. Nisizawa, *J. Appl. Polym. Sci.*, **13**, 2506 (1969).

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