

Environmental Stress Relaxation Studies of Polymers: Effect of Benzene Series Hydrocarbons on Polyethylene

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Synopsis

The method of stress relaxation has been used to study stress decay behavior in the system of polyethylene—benzene series hydrocarbons. The behavior of stress decay in polyethylene under benzene series hydrocarbons was observed and the respective activity forward stress decay of benzene series hydrocarbons was obtained.

INTRODUCTION

Solvent cracking of polyethylene caused by benzene is known to be due to interaction with benzene molecule.^{1,2} Stress failure of polyethylene under benzene series hydrocarbons poses a problem of considerable interest.

Stress relaxation experiments, which measure the rate of stress decay of the polyethylene—benzene series hydrocarbons system, have been utilized. If the polymers fail, then similar rates of stress decay should be obtained for benzene series hydrocarbons.

The benzene series hydrocarbons used in this study were benzene, toluene, and xylene. All of these can cause failure of stressed polyethylene.

EXPERIMENTAL

Materials

Polyethylene used in this work was limited to a commercial polyethylene film having a density of 0.922 g/cc, a melt index of 2, and thickness of 0.0024 cm.

Benzene, toluene, and xylene used were commercial materials.

Apparatus and Procedure

The apparatus used in this work was shown in Figure 1.

Polyethylene film (1) was set in the clamps (2, 3) in the inner vessel containing benzene series hydrocarbons (4), 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 this film sample

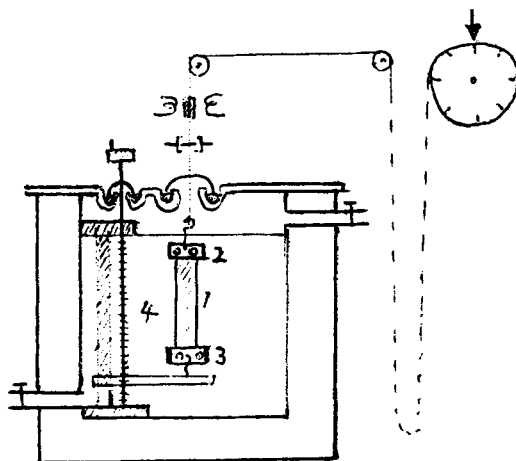


Fig. 1. Schematic diagram of stress relaxation apparatus. (1) Sample; (2,3) clamps and (4) solvent.

(1) held at constant extension in a thermostated vessel containing benzene series hydrocarbons (4).

RESULTS AND DISCUSSION

The changes in stress of polyethylene film with time under benzene series hydrocarbons were studied with a 50% elongation at 30°C. The results are shown in Figure 2. From these results the relaxation of polyethylene under benzene series hydrocarbons was found to be approximately the equation $f/f_0 = e^{-t/\tau}$, where τ is relaxation time. The relaxation time, τ

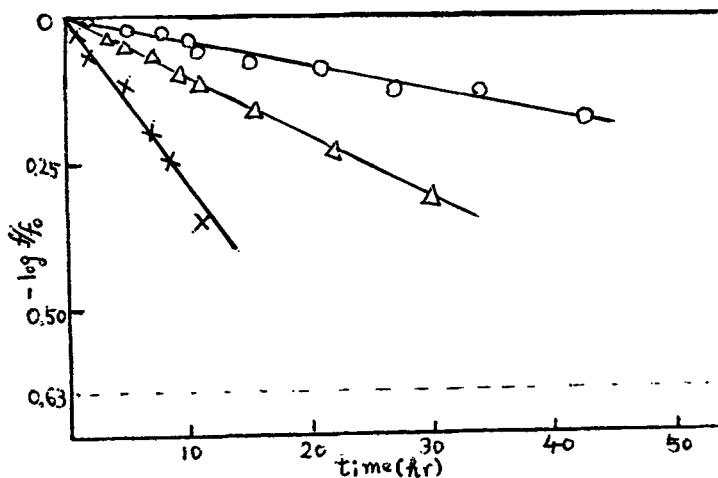

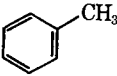
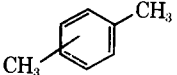


Fig. 2. Stress relaxation of polyethylene under benzene series hydrocarbons (O: benzene Δ : xylene, and X: toluene).

is the time value at which the residual stress reached $1/e$ (equals 0.368) of its value at zero time and it was obtained from the slope of log stress plotted against time. If the relaxation time, τ can be considered as the reciprocal of a rate constant for solvent cracking, the rate constant, $1/\tau$ can indicate an activity forward stress decay of benzene series hydrocarbons. These values were tabulated in Table I for comparison.

TABLE I
Activity of solvation in polyethylene
($1/\tau$ at 30°C)

Solvents	Formula and structure	Relaxation time, τ (hr)	Activity, $1/\tau$ (1/hr)
Benzene	C_6H_6 	160	6.3×10^{-3}
Toluene	$C_6H_5CH_3$ 	24	4.2×10^{-2}
Xylene	$C_6H_4(CH_3)_2$ 	63	1.6×10^{-2}

From these it is clear that solvation tends to decrease the relaxation time, and that dependency increases with increasing activity of solvation in the system of polyethylene—benzene series hydrocarbons.

In the present system a side chain of benzene nucleus may be related to the solvation reaction in the system of polyethylene—benzene series hydrocarbons.

References

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