Constant force applied

Extension measured over gauge length

Heating element

Thermocouple

Constant force applied
Variability of Creep-Rupture Lifetimes

Histogram of lifetimes of 500 HDPE tubes subjected to 4 MPa at 80°C.

Log-normal cumulative probability plot.
Polymer Fracture
- Rate and Temperature Dependence

- Bond rupture as a 1st-order rate process

\[ \frac{du}{dt} = -Kn \rightarrow \frac{du}{u} = -Kdt \rightarrow n = n_0 e^{-Kt} \]

mean time to rupture

\[ \langle t \rangle = \frac{\int n \cdot u \cdot dt}{\int n \cdot u \cdot dt} = \frac{1}{K} \]

- Thermally activated, stress-aided process

\[ K = \frac{kT}{\Delta H} \exp \left( \frac{-\Delta G^+ - \Delta H^+}{kT} \right) \]

\[ = \frac{kT}{\Delta H} \exp \left( \frac{\Delta S^+}{k} \exp \left( \frac{-\Delta H^+ - \Delta S^+}{kT} \right) \right) \]

- Assume (!) \( \tau = \langle t \rangle, \sigma = 0 \)

\[ \tau = \tau_0 \exp \left( \frac{U - \Delta G^+}{kT} \right) \]

(Shurkov's Eqn)
Fig. 5. Time and temperature dependence of the lifetime of solids on stress.
1. Silver chloride (Reference 4)
2. Aluminum (Reference 5)
3. Plexiglas (Reference 6)