CHAPTER 6: MATERIAL BEHAVIOR

STEADY SHEAR

\[
\begin{align*}
\log \eta & \quad \log \dot{\gamma} \\
\eta_0 & \quad \eta(\dot{\gamma}) = \eta_0 \\
n & = \text{power-law index}
\end{align*}
\]

Zero shear viscosity \( \lim_{\dot{\gamma} \to 0} \eta(\dot{\gamma}) = \eta_0 \)
the critical $\xi_c$ for $\psi_i$ may not be the same as for $\eta$.

$M_c$ - critical molecular weight for entanglement.
Increasing breadth of mw distribution

\[ \log \eta \]

\[ \eta_0 \]

\[ \frac{1}{\zeta} \text{ relaxation time} \]

\[ \log \zeta \]
Effect of Filler

powder added to polymer

slope of -1 indicates yield stress

$\log \gamma$

$\log \sigma$

No increases with filler content

Power-law slope is unaffected
EFFECT OF TEMP

\( T_0 \) decreases sharply with \( T \)

\( \dot{X}_c = \frac{1}{N} \) increases with \( T \)

EFFECT OF PRESSURE

- strongly material dependent
- only important at very high \( P \)
SAOS

$log G'$
$log G''$

$G' = \text{elastic modulus}$
$G'' = \text{viscous modulus}$

Glassy plateau
Entanglement plateau

Soils have constant $G'$
Cox Mentz Rule

\[ \eta(\phi) = \eta^*(\omega) \]

\[
\log \eta \quad \log \eta^* \\
\log \phi \quad \log \omega
\]

\[ WE = \frac{\text{rad}}{s} \]

\[ f = \frac{2\pi \text{rad}}{s} \quad \frac{2\pi \text{rad}}{\omega} \]

2\pi f = \omega

(Caution: not for complex materials)
Entanglement Plateau

$G_0$ (is independent of MW)

$\log G'$

Slope 1

$G''$

Slope 2

Entanglement plateau

Increasing MW

$G''$

Slope 2

$G''$

Not entangled
START UP OF steady shear

$\log \eta^+$

$\log t$

Same shape for $\Psi^+$

increasing shear rate
Cessation of Steady Shear

$\log \eta$ vs $t$

Increasing $\theta$
Elongational Flow

\[ \log \bar{\eta} \]

\[ \frac{3 \eta_0}{\eta_0} \]

\[ \log \dot{\gamma}_0 \]

\[ \log \dot{\gamma}_0 \]

Troutman's Rule: \[ 3 = \frac{\bar{\eta}}{\eta_0} = Tr \]
Elongational Start up increasing \( \dot{\gamma}_0 \)

\[ \log \eta^+ \]

\[ \log t \]

\( 3 \eta^+ \text{ in shear} \)