Polymers Engineering
Group #5

INFOGRAPHY

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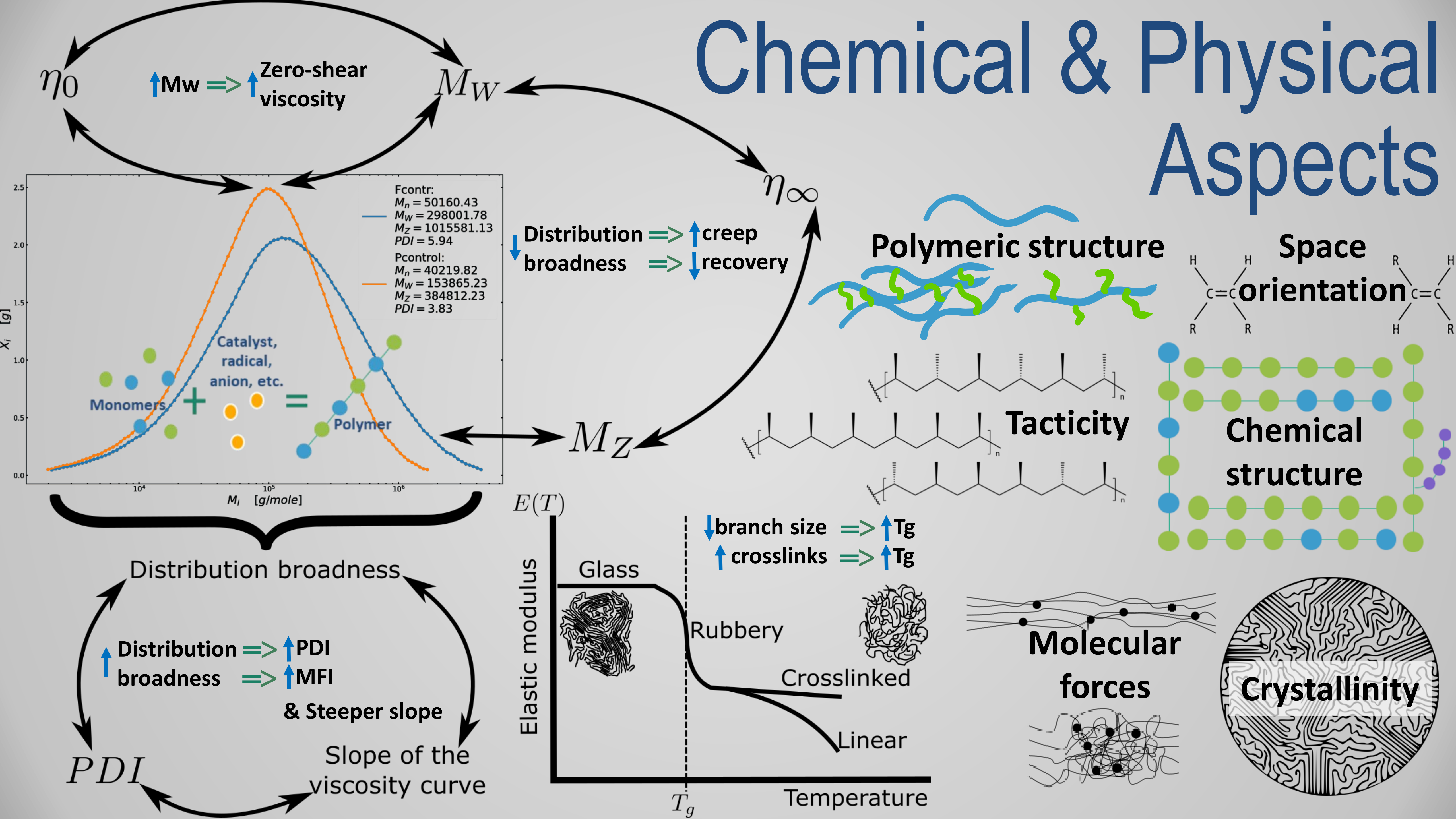
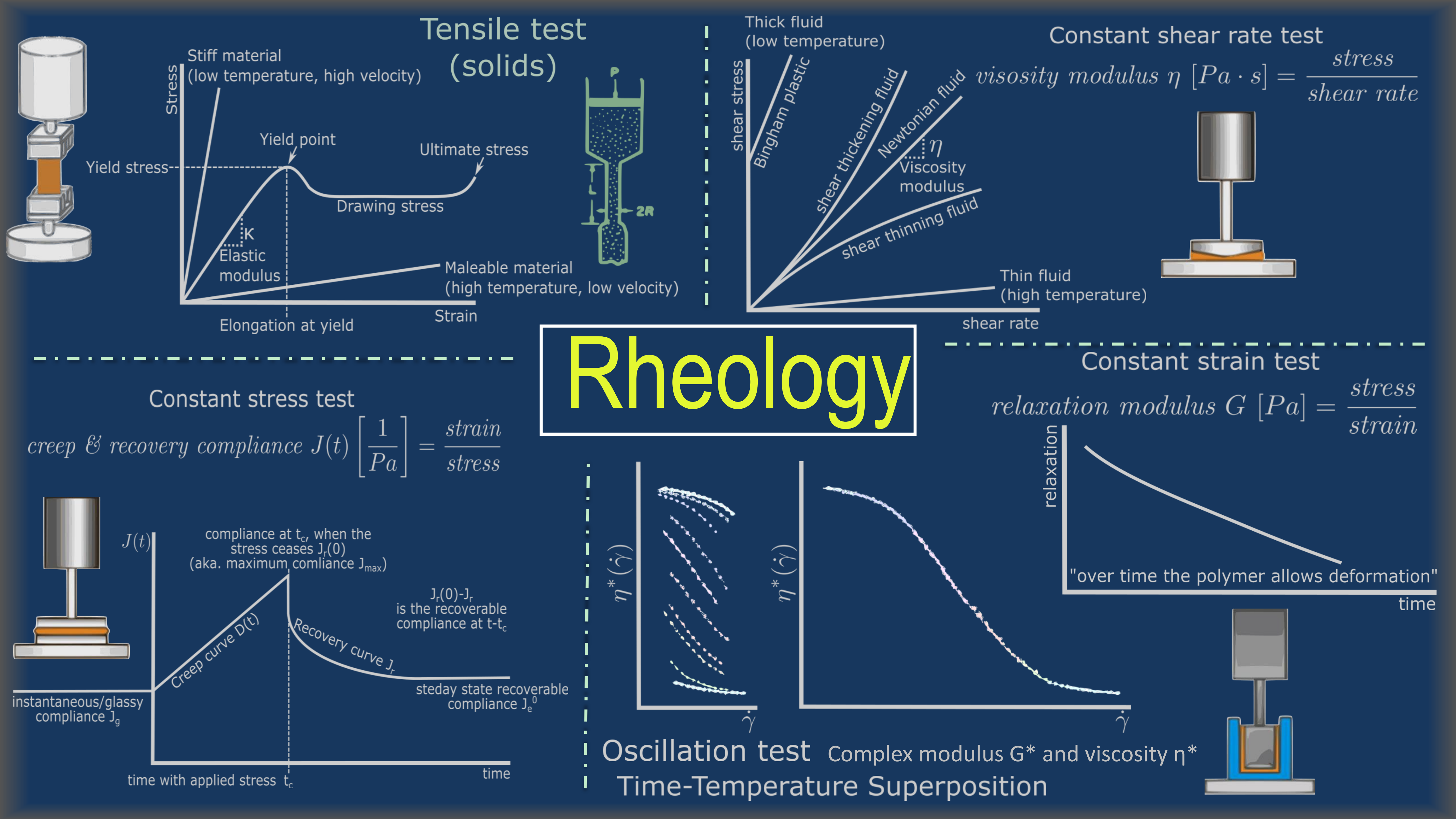
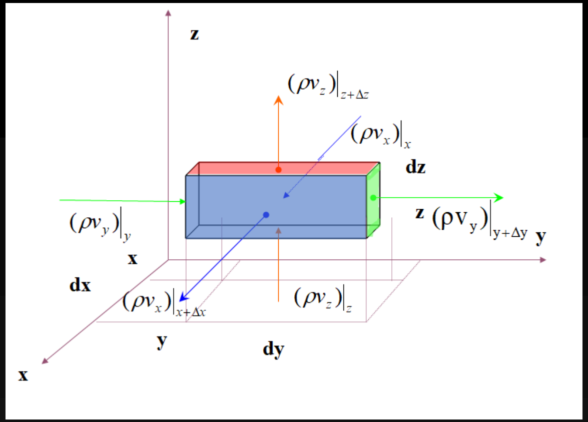
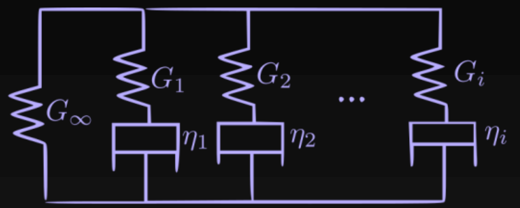

Chemical & Physical Aspects
η_0
↑Mw => ↑Zero-shear viscosity
M_W
η_∞
Fcontr:
$M_n = 50160.43$
$M_W = 298001.78$
$M_Z = 1015581.13$
$PDI = 5.94$
Pcontrol:
$M_n = 40219.82$
$M_W = 153865.23$
$M_Z = 384812.23$
$PDI = 3.83$
x_i [g]
M_i [g/mole]
Monomers
Catalyst, radical, anion, etc.
Polymer
↓Distribution broadness => ↑creep
=> ↓recovery
M_Z
Distribution broadness
↑Distribution broadness => ↑PDI
=> ↑MFI
& Steeper slope
PDI
Slope of the viscosity curve
$E(T)$
Elastic modulus
Glass
Rubbery
Crosslinked
Linear
T_g
Temperature
↓branch size => ↑Tg
↑crosslinks => ↑Tg
Polymeric structure
Space orientation
Tacticity
Chemical structure
Molecular forces
Crystallinity



Tensile test (solids)
Stiff material (low temperature, high velocity)
Stress
Yield point
Ultimate stress
Yield stress
Drawing stress
K
Elastic modulus
Maleable material (high temperature, low velocity)
Strain
Elongation at yield
P
L
2R
Thick fluid (low temperature)
shear stress
Bingham plastic
shear thickening fluid
Newtonian fluid
η
Viscosity modulus
shear thinning fluid
Thin fluid (high temperature)
shear rate
Constant shear rate test
$visosity\ modulus\ \eta\ [Pa \cdot s] = \frac{stress}{shear\ rate}$
Rheology
Constant stress test
$creep\ \&\ recovery\ compliance\ J(t) \left[\frac{1}{Pa}\right] = \frac{strain}{stress}$
$J(t)$
compliance at t_c, when the stress ceases $J_r(0)$ (aka. maximum comliance J_{max})
Creep curve D(t)
Recovery curve J_r
$J_r(0)$-J_r is the recoverable compliance at t-t_c
instantaneous/glassy compliance J_g
steday state recoverable compliance J_e^0
time with applied stress t_c
time
Constant strain test
$relaxation\ modulus\ G\ [Pa] = \frac{stress}{strain}$
relaxation
"over time the polymer allows deformation"
time
$\eta^*(\dot{\gamma})$
$\dot{\gamma}$
$\eta^*(\dot{\gamma})$
$\dot{\gamma}$
Oscillation test
Complex modulus G* and viscosity η*
Time-Temperature Superposition

Viscoelastic models





Generalized Maxwell model

$$G(t) = G_\infty + \sum_{i=1}^{n} G_i e^{-\frac{G_i}{\eta_i}t}$$

G_∞ is the relaxation modulus at $t=\infty$
G_i is the relaxation modulus of the ith spring
η_i is the viscosity of the dashpot for the ith series
n is the number of spring–dashpot series
τ_i is the relaxation time for a single spring–dashpot series

Linear Infinitesimal Viscoelasticity (LIVE)
"non-zero normal stress with increasing shear rate"

Kinematic tensors

Cauchy & Finger Strain Tensors
Non-Linear behavior
(Stress is a function of shear rate)

Memory function

Damping function

Constitutive Models

PTT model
(PanThienTanner)

$H(\lambda)$ *in Pa*
Discrete relaxation spectra
a distribution moduli for
the Generalized Maxwell model

$$G_g = \int H(\lambda) d ln\lambda$$
instantaneous modulus

$$\eta_0 = \int H(\lambda)\lambda \cdot d ln\lambda$$
zero shear viscosity

$$J_e{}^0 = \frac{\int H(\lambda)\lambda^2 d ln\lambda}{\left(\int H(\lambda)\lambda \cdot d ln\lambda\right)^2}$$
steady state recoverable compliance

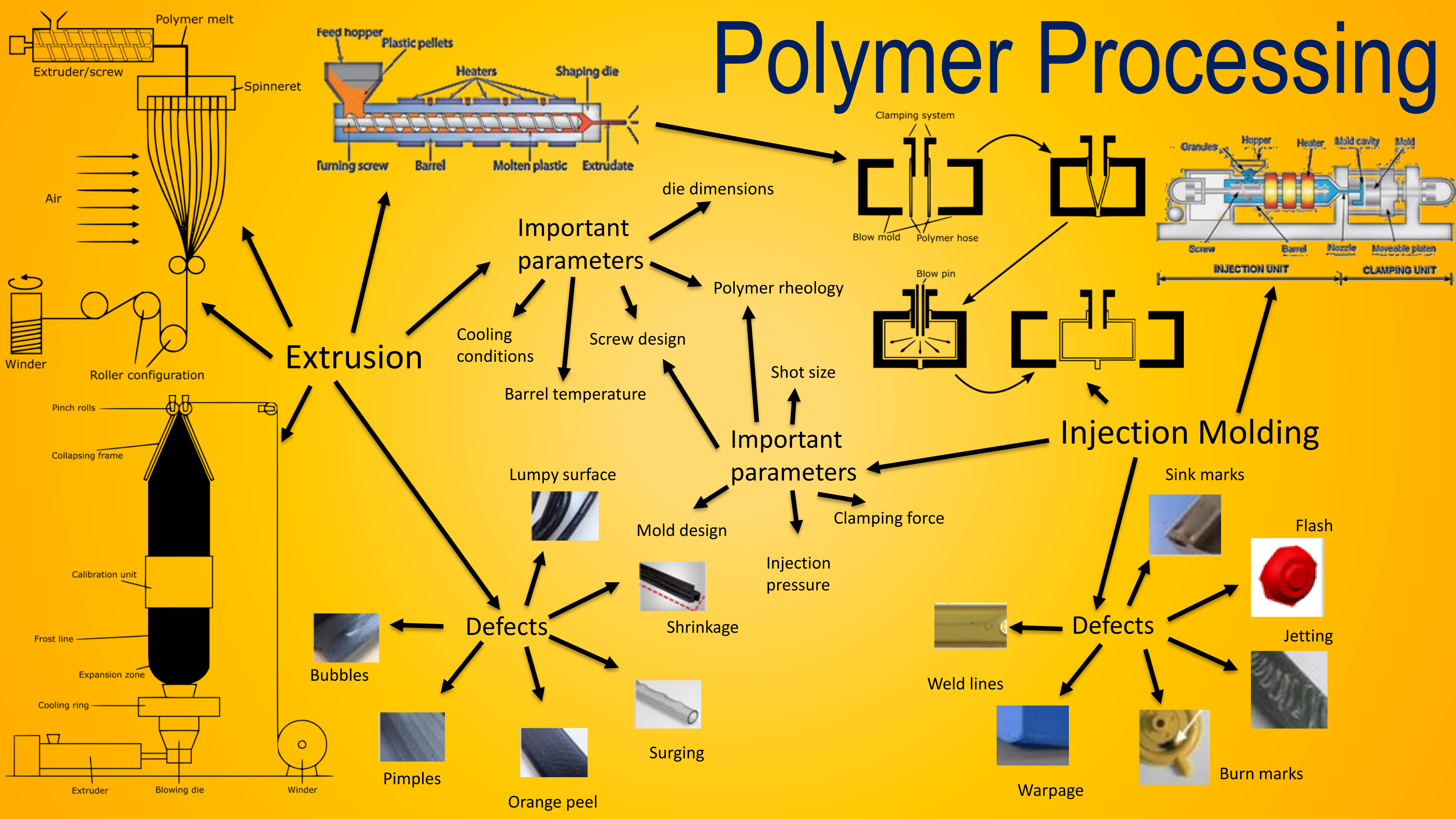
Wagner model

$$\eta(t=\infty,\dot{\gamma}_o) = f_1 \sum_{1=1}^{n} \frac{a_i}{{\alpha_i}^2} + f_2 \sum_{1=1}^{n} \frac{a_i}{{\beta_i}^2}$$

$$\alpha_i = \frac{1 + n_1\lambda_i\dot{\gamma}_o}{\lambda_i} \qquad f_2 = 1 - f_1 \qquad \beta_i = \frac{1 + n_2\lambda_i\dot{\gamma}_o}{\lambda_i}$$

with the fitted parameters, estimate:

Recovery compliance
Stress growth
Elongational viscosity
Creep compliance
First normal stress difference



Polymer Processing
Polymer melt
Extruder/screw
Spinneret
Air
Winder
Roller configuration
Feed hopper
Plastic pellets
Heaters
Shaping die
Turning screw
Barrel
Molten plastic
Extrudate
Clamping system
Blow mold
Polymer hose
Blow pin
Granules
Hopper
Heater
Mold cavity
Mold
Screw
Barrel
Nozzle
Moveable platen
INJECTION UNIT
CLAMPING UNIT
Extrusion
Important parameters
die dimensions
Polymer rheology
Cooling conditions
Screw design
Barrel temperature
Pinch rolls
Collapsing frame
Calibration unit
Frost line
Expansion zone
Cooling ring
Extruder
Blowing die
Winder
Injection Molding
Important parameters
Shot size
Mold design
Clamping force
Injection pressure
Lumpy surface
Defects
Shrinkage
Bubbles
Pimples
Orange peel
Surging
Sink marks
Flash
Jetting
Defects
Weld lines
Warpage
Burn marks

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