Tecnológico de Monterrey

Chemical and Physical Nature of Polymers

Dr. Jaime Bonilla Ríos

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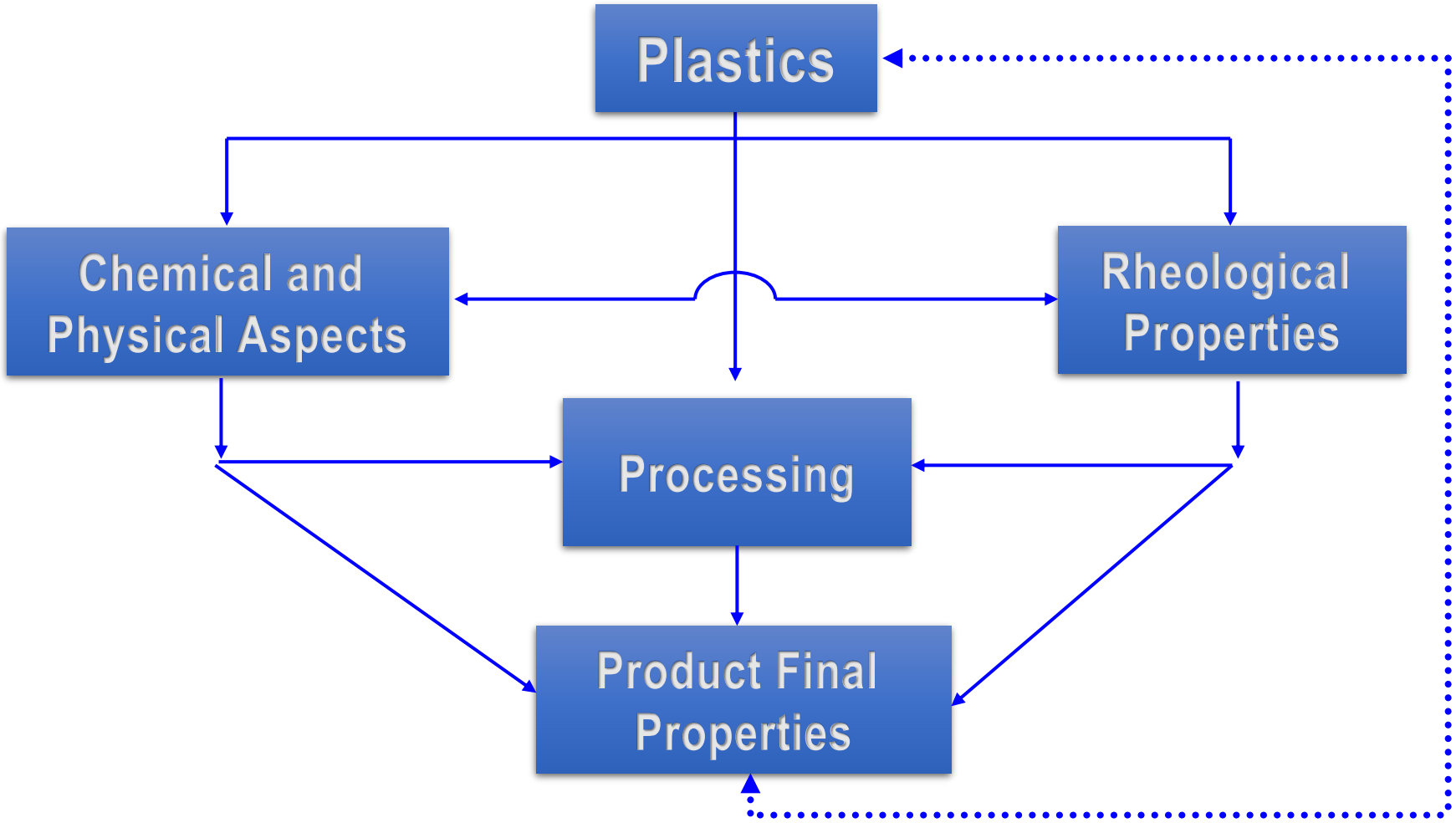
Conceptual map



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Impact of the MWD on the rheological behavior of polymers

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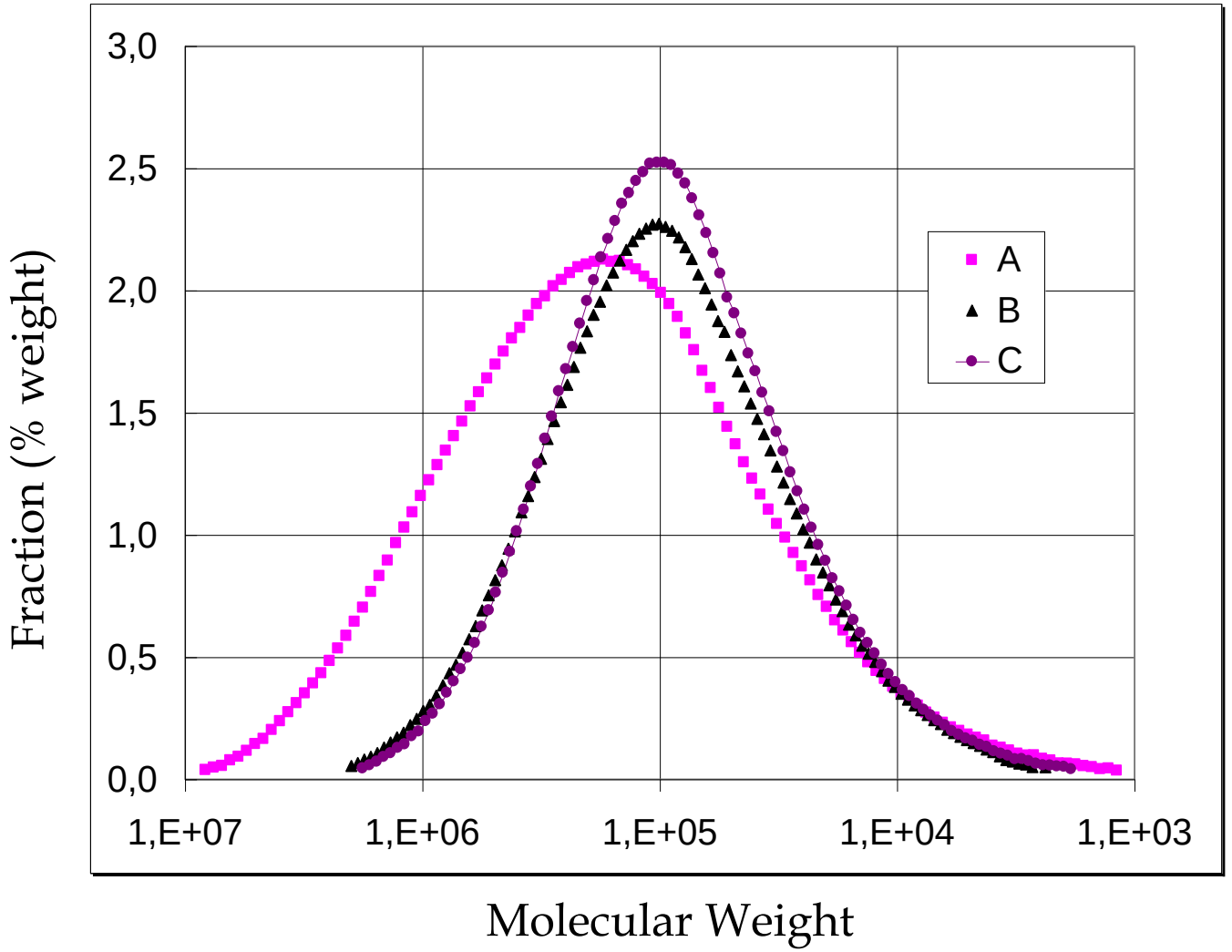
Different molecular weight distribution polypropylene resins



The characteristic numbers of a molecular weigth distribution (MWD) are:

- Molecular weight average number: Mn

$$Mn = \sum X_i M_i = \frac{1}{\sum \frac{w_i}{M_i}}$$

- Molecular weight average : Mw

$$Mw = \sum w_i M_i$$

- Higher molecular weight average z: Mz

$$Mz = \frac{\sum w_i M_i^2}{\sum w_i M_i}$$

Characteristic numbers of each distribution

	Mn	Mw	Mz	Mz+1	Mw/Mn
A	66650	435093	1488941	2706028	6,53
B	45185	173899	468369	854426	3,85
C	42189	157431	400766	727822	3,73
D	40220	153865	384808	681518	3,83

Why is important to know the molecular weight distribution of the polymers or their “numbers”?

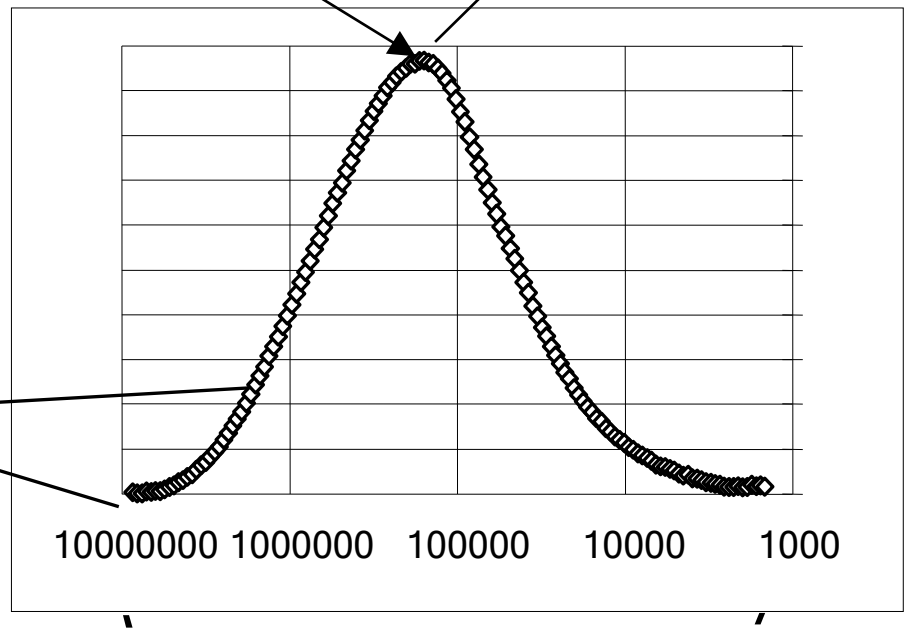
How will this affect the process?

The molecular weight distribution is highly related to the viscosity and elasticity of the polymers

Creep:
short time response
Oscillatory Data
Gx
First normal stress
Zero die length
Steady shear viscosity

Weight average Molecular weight: Mw

Zero Shear Viscosity: η_o



Mz

Relates to the amount of high molecular weight chains.

Mw/Mn

Slope of the viscosity curve, MFI

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Chemical stability of polymers

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Talking about chemical stability, a polymer will be stable if their chains do not break so easily. If the chain present breaks, then…

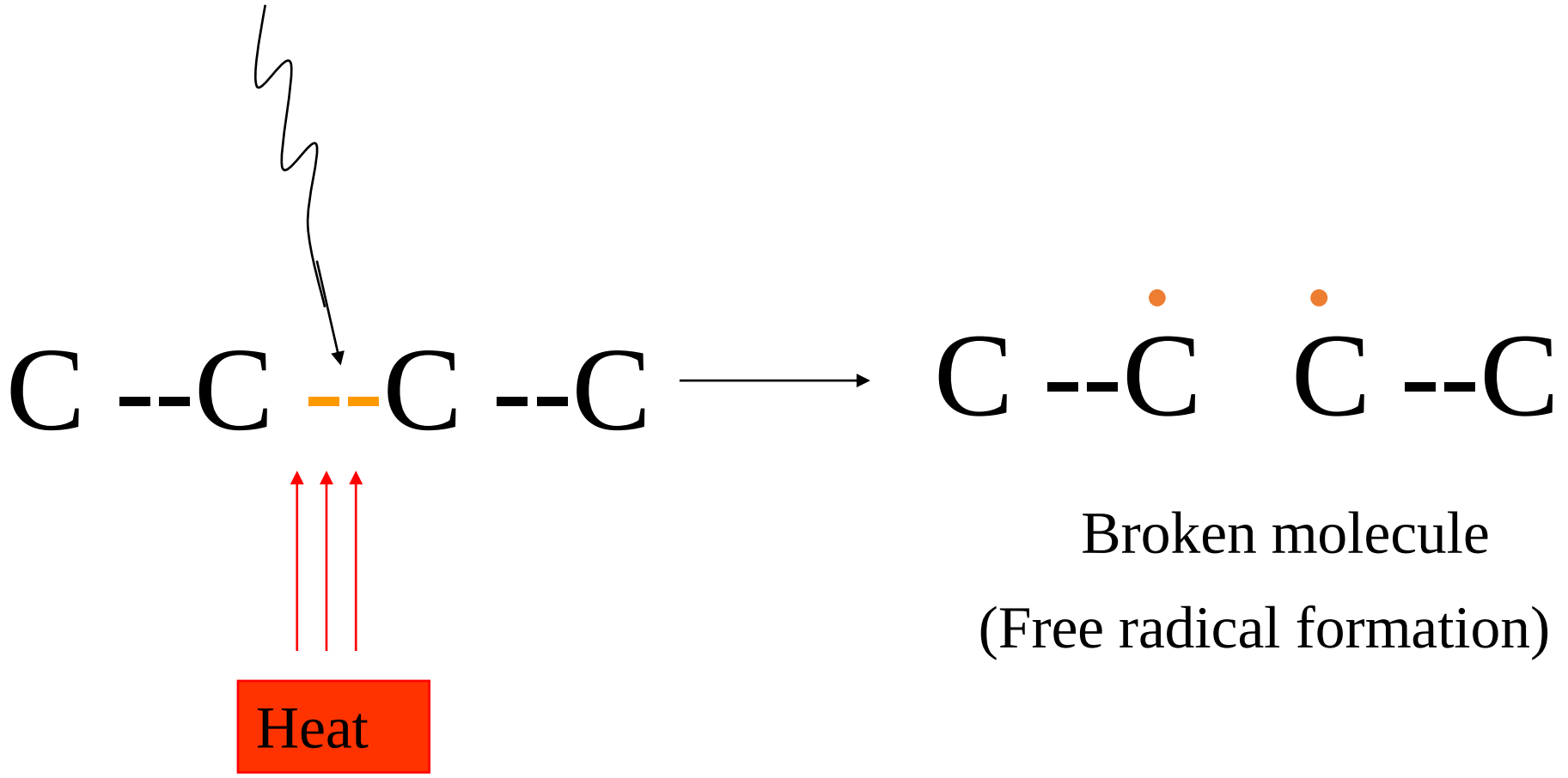
Let’s see the factors that affect polymer stability and cause degradation.

Chemical instabilities examples

Inherent to the nature of the chemical bond in the polymers and that eventually will affect their physical and mechanical properties.

Thermal and light stability (environmental stability)

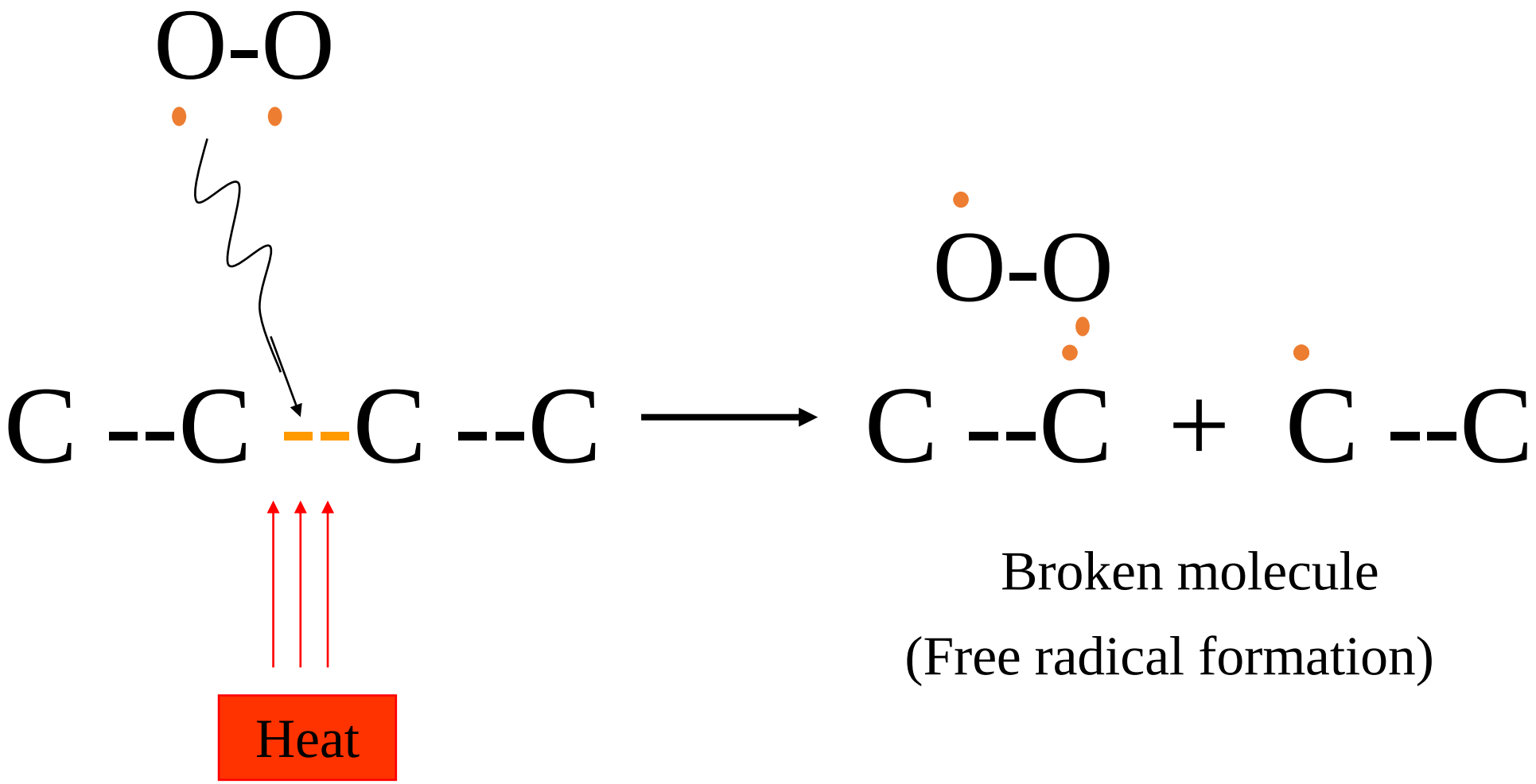
Ultraviolet light



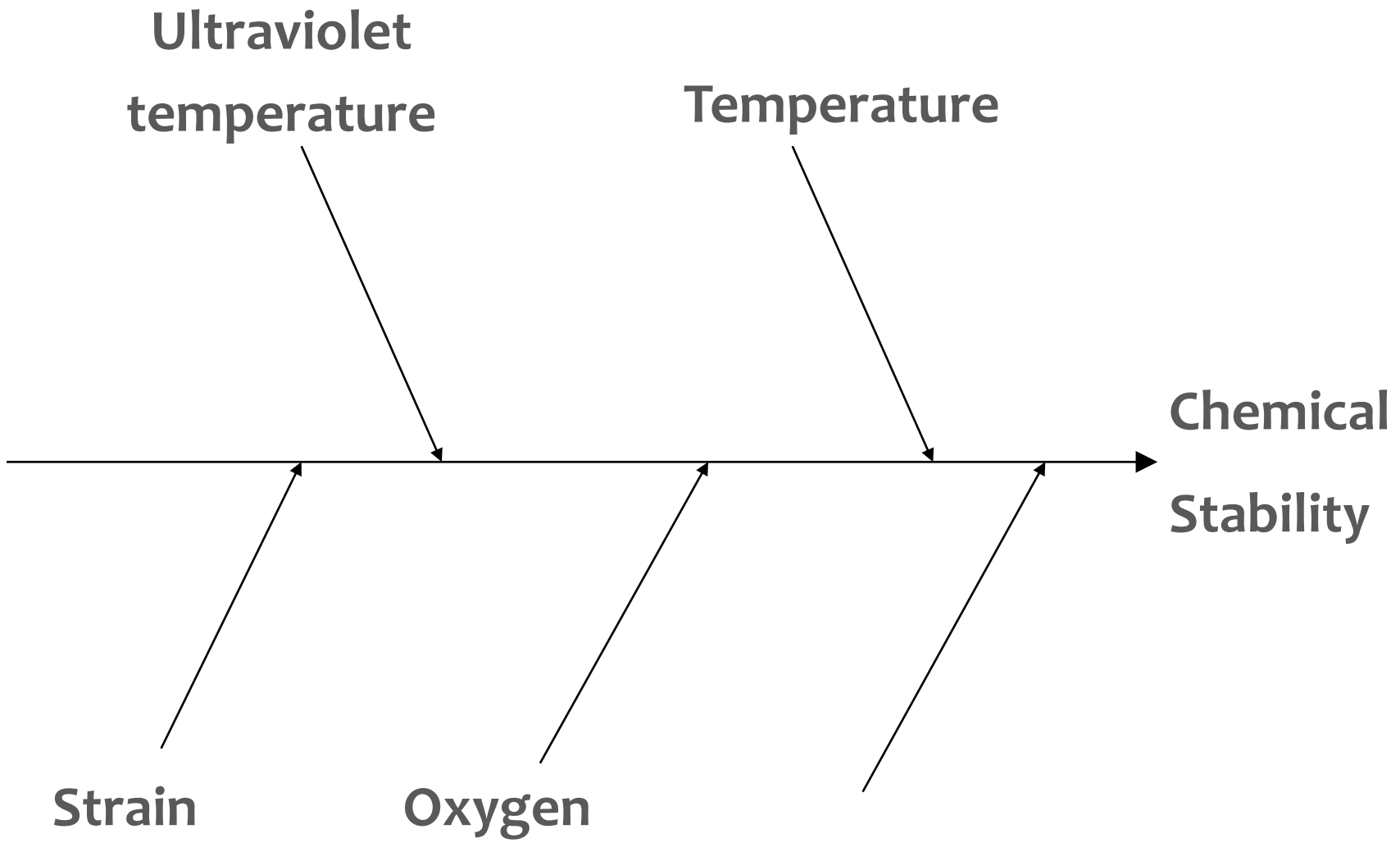
Broken molecule

(Free radical formation)

Chemical stability in presence of Oxygen and Heat
(for example in an injection molding process)



Cause-effect

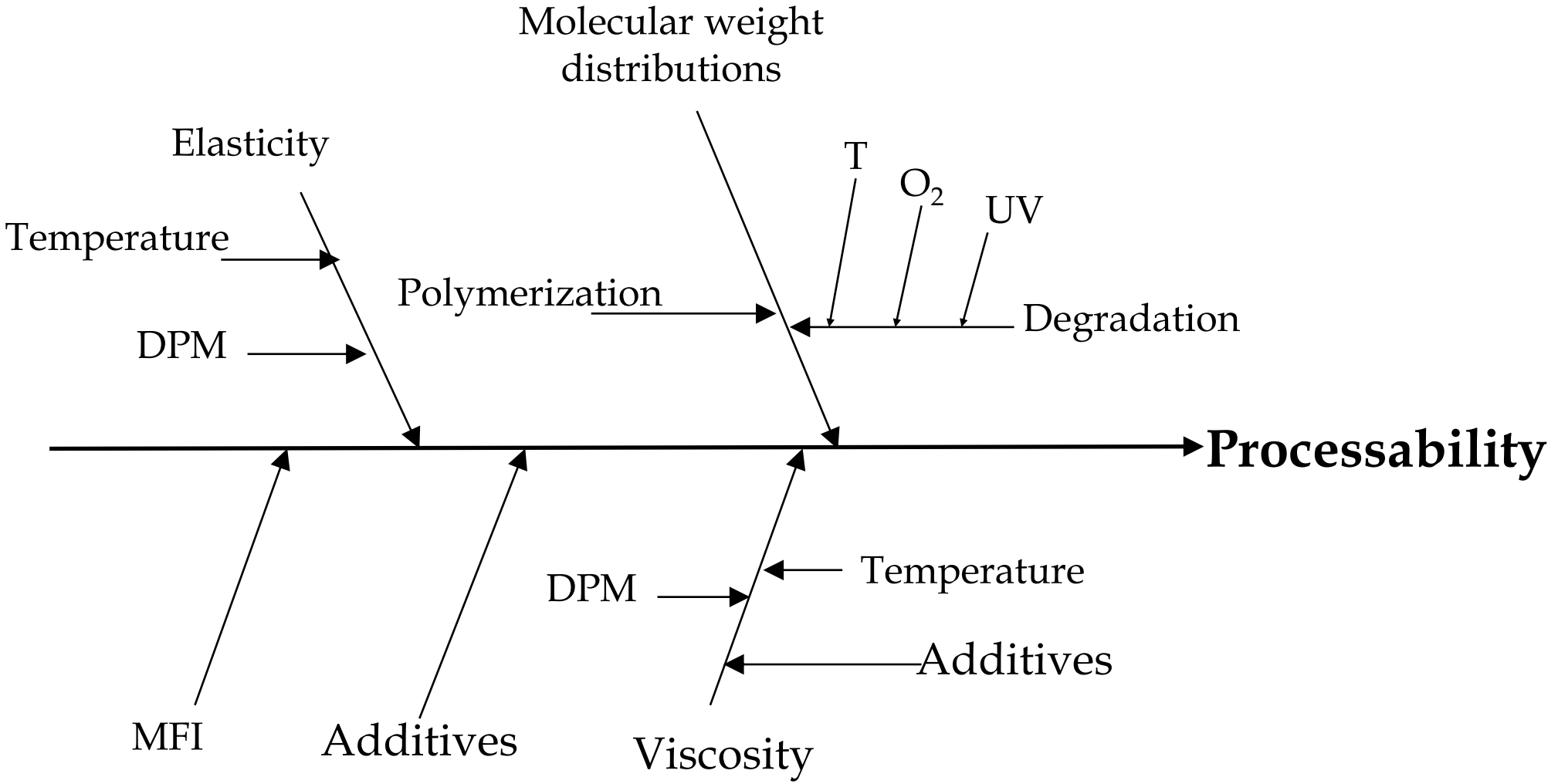


How to stop or minimize the chains rupture?

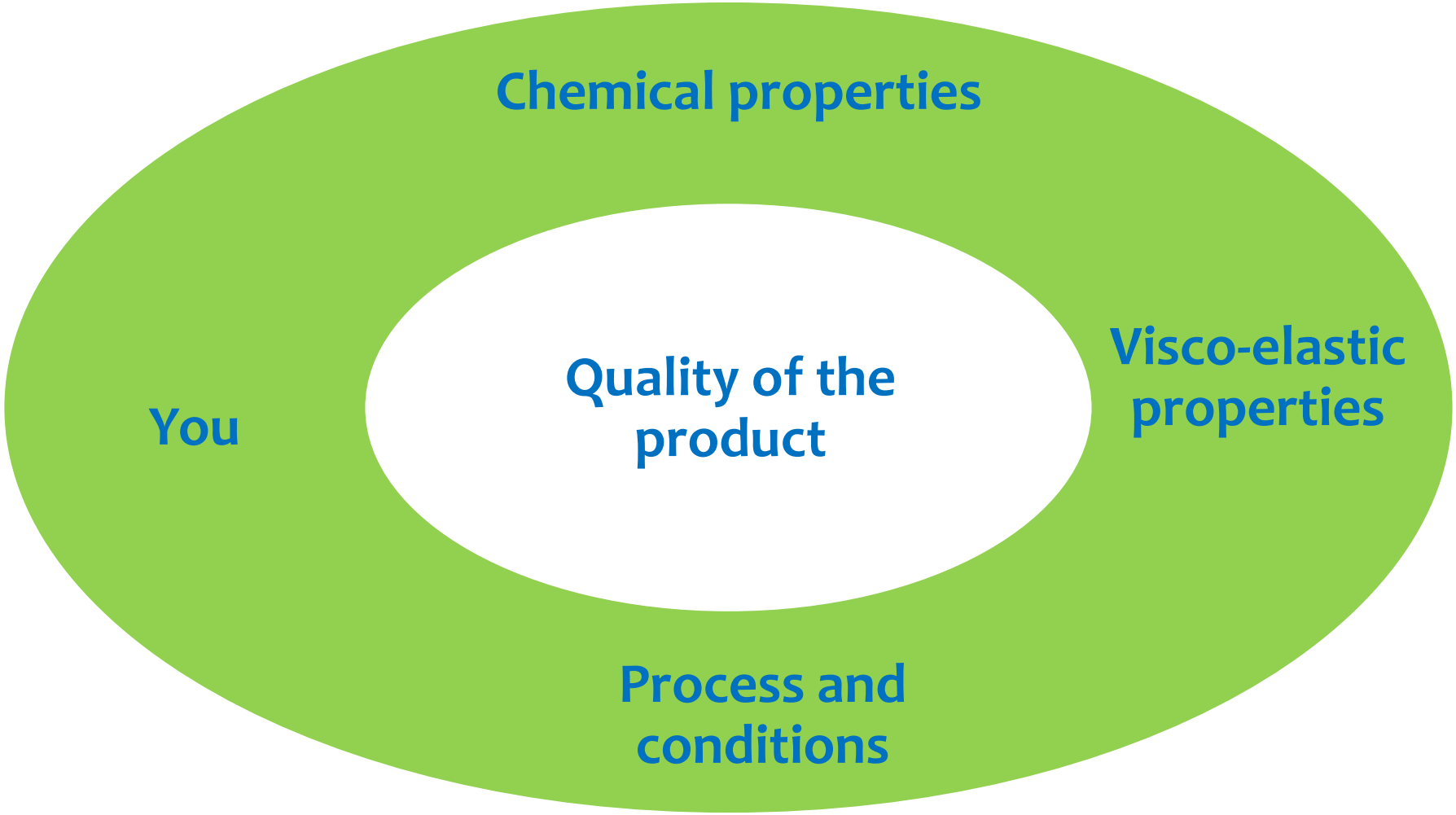
- Additives (free radical scavengers):
  - Thermal stabilizers
  - UV stabilizers
  - Antioxidant stabilizers
- Do not heat too much
- Do not heat too many times
  - (if you recycle then more additives might be required, but then…)

This information need to be added to the cause- effect diagram of the polymer processability, then…

Polymer processability cause- effect diagram



Then…


Chemical properties
Quality of the product
Visco-elastic properties
You
Process and conditions

➲ http://www.pslc.ws/macrog/maindir.htm

Activity 6

- Go to the Blackboard platform/Course Resources and read the article of Melt and Blown spun fibers.

- Find the melting point of the High Density Polyethylene (HDPE) and the Polypropylene (PP). Bring the information you find on this regard to the classroom so we can discuss about it.

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Thermal Behavior of Polymers

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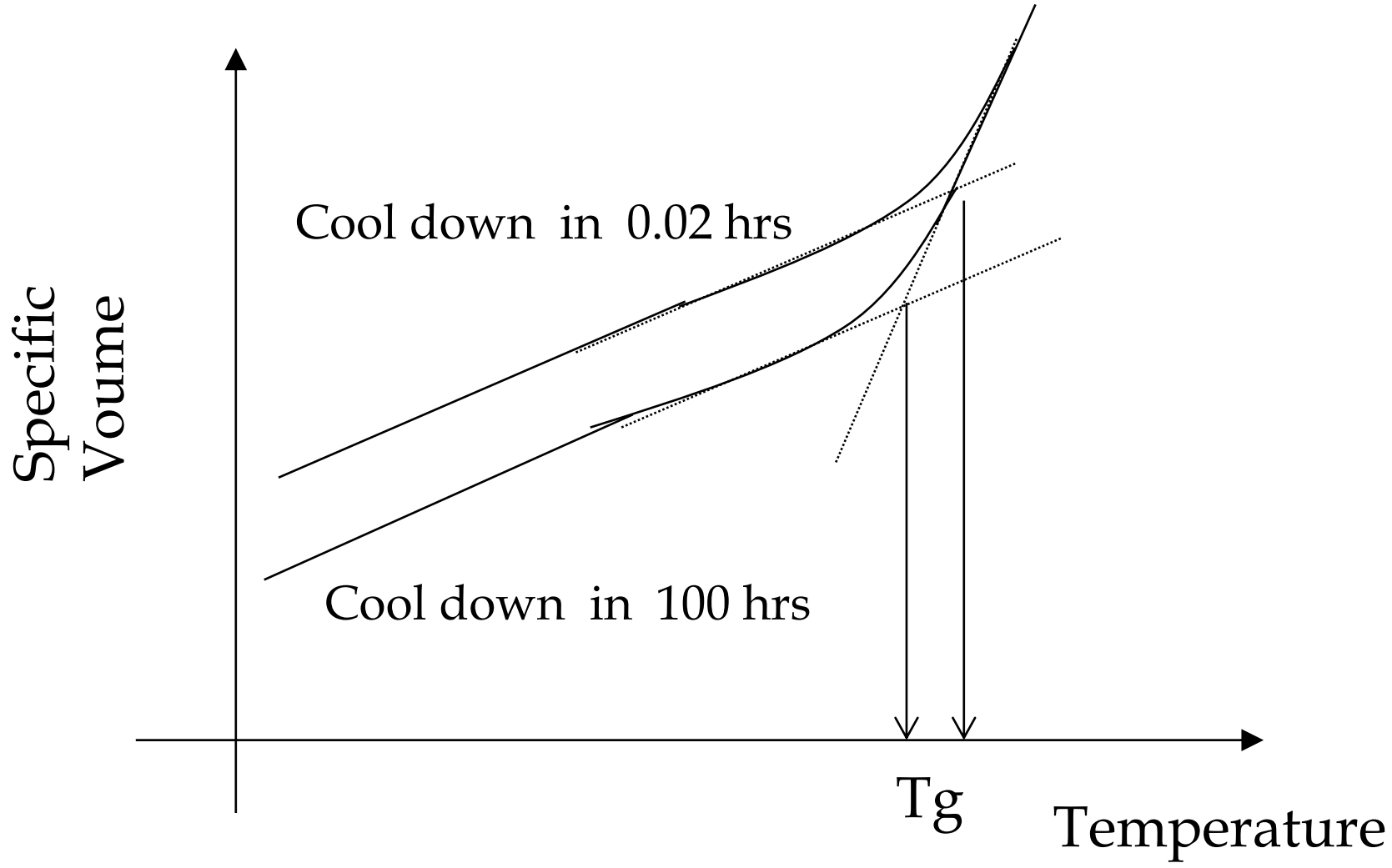
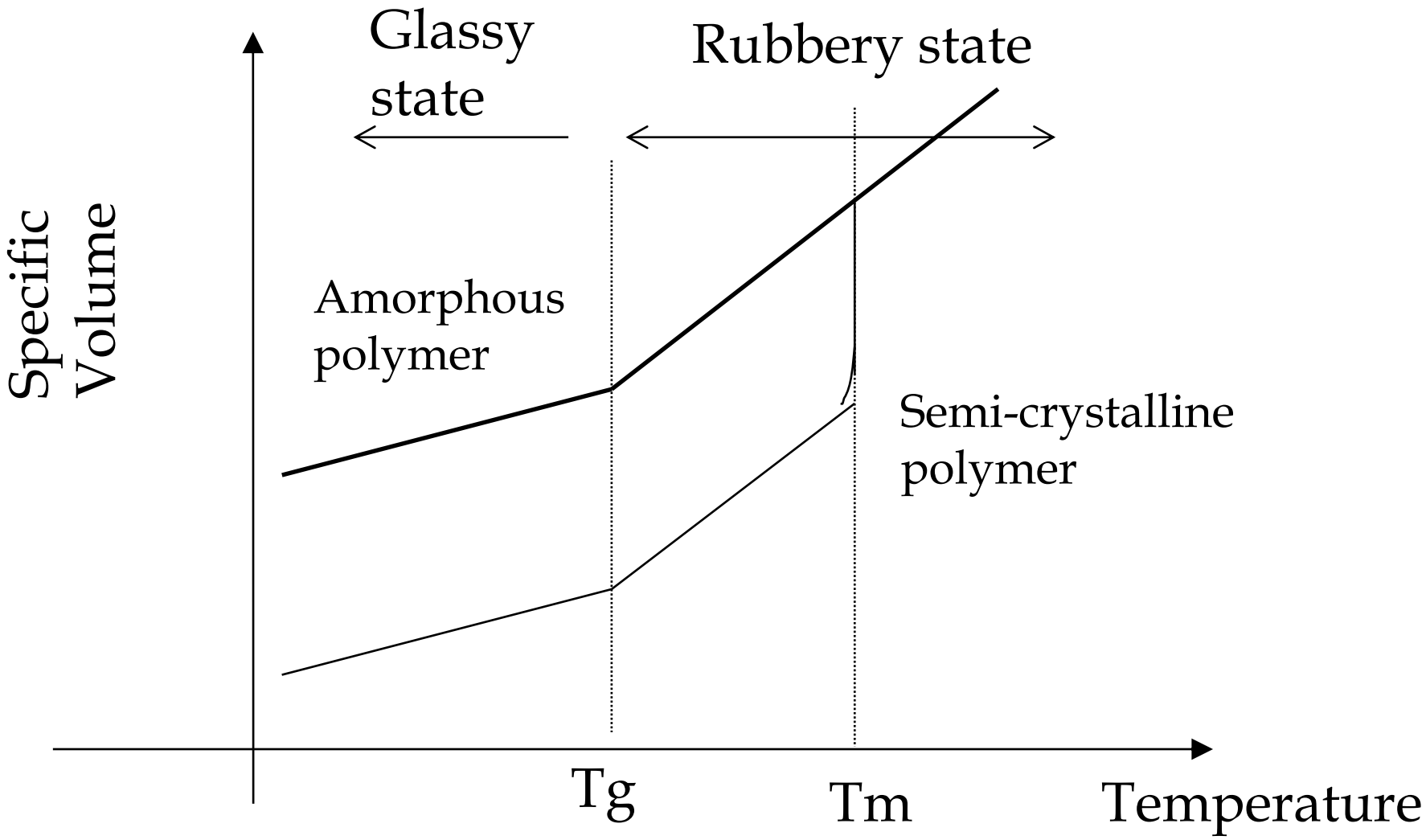
Glass Transition

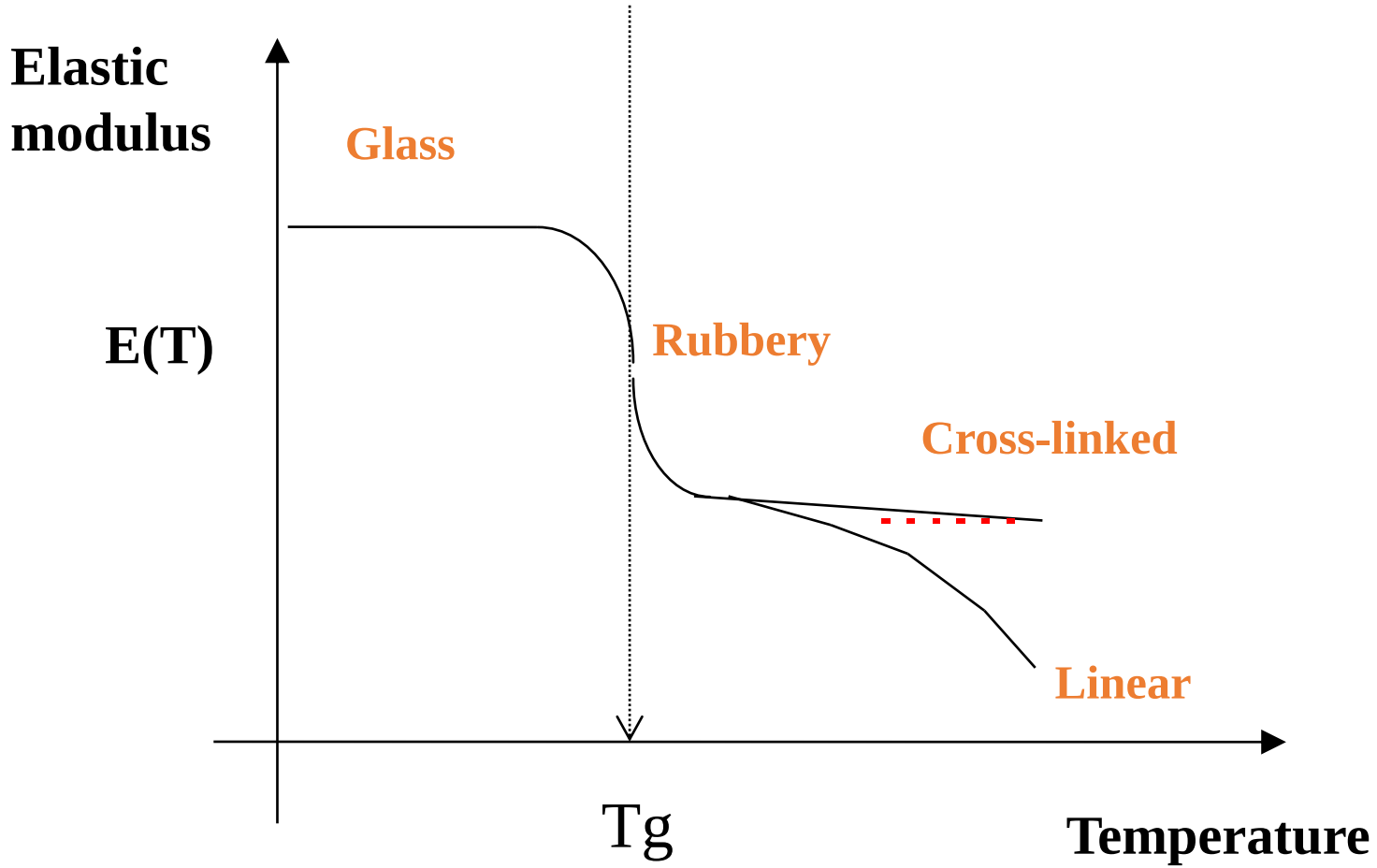
Transitions when a polymer is cooled down(PVA)



Transitions when a polymer is cooled down



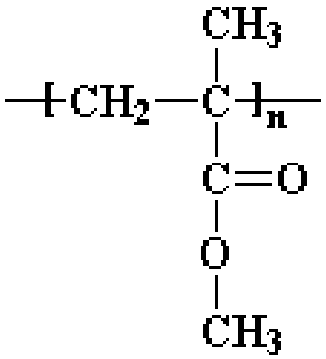
Elastic modulus vs. temperature



Examples

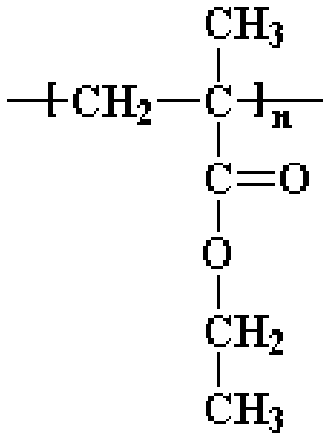
Polymer	Tg (°C)
Polypropylene	-23
PVC	81
Polystyrene	100
Polycarbonate	150
Polyethylene	-133 to -3

Influence of branching size on Tg



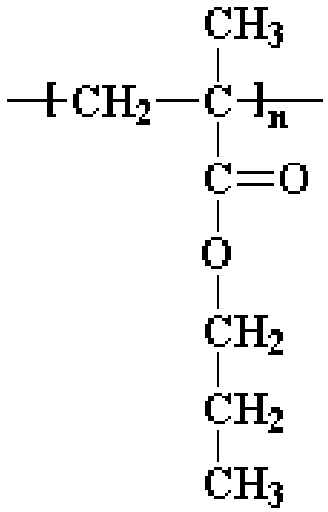
Poly(methyl methacrylate)

T_g = 100-120 °C



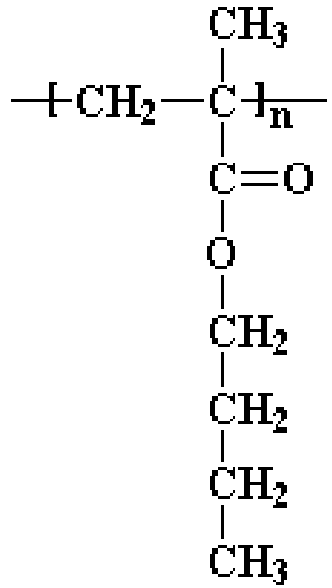
Poly(ethyl methacrylate)

T_g = 65 °C



Poly(propyl methacrylate)

T_g = 35 °C



Poly(butyl methacrylate)

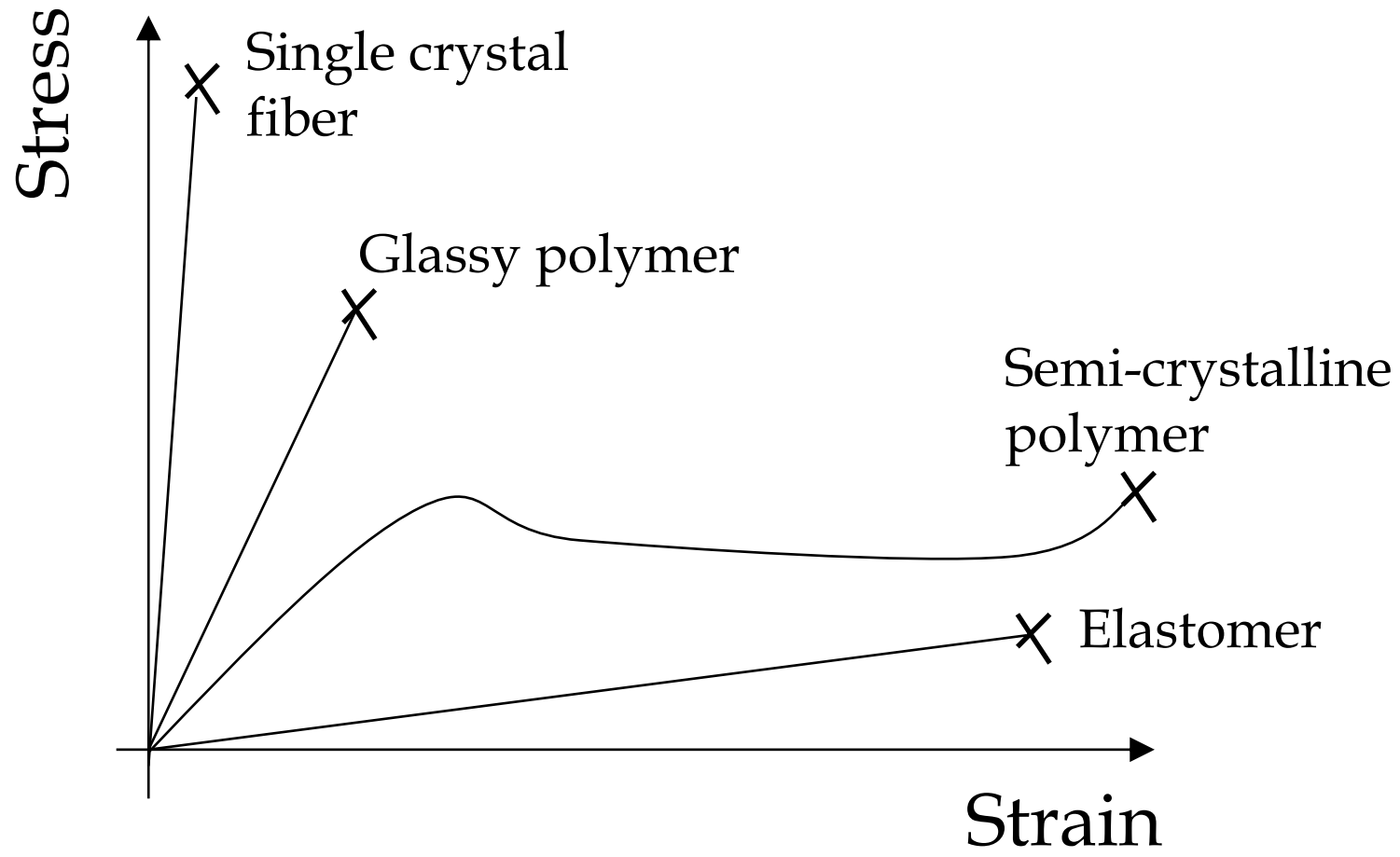
T_g = 20 °C

Tg modification

- Tg is at linear function of the copolymer composition. If two materials with different values of Tg are mixed, even a polymer with a “solvent” or with a compatible polymer, Tg will be an average of each component. A very important application is the plastification.

- A plasticizer is a non-volatile solvent that remains in the system.

Typical stress-strain curves for different types of polymers



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