Polymer Processing
Topics

1. Introduction
   - what is polymer processing?
   - role of chemical engineers in polymer processing industry
   - why rheology?
2. Introduction to extrusion
   - why statistical process control in polymer processing?
3. Introduction to injection molding
   - why design of experiments in polymer processing?
4. Fundamentals of polymers
   - material properties
   - mechanical properties
5. Rheology
   - flow field
   - rheological properties
6. Constitutive equations
   - Mid Exam
7. Statistical process control
   - process capabilities
   - 6 sigma process control
8. Design of experiments
   - method of orthogonal arrays
   - Taguchi method
9. Extrusion process
   - mixing
   - single screw extrusion
   - twin screw extrusion
10. Injection molding process
    - CAE (Computer Aided Engineering)
    - typical problems in injection molding
    - new technologies
11. Others
    - other processes
    - role of chemical engineers in polymer processing industry
      - Final Exam

essment:
- Mid Exam (20%), Final Exam (35%), HW (25%), Quiz & Reading (20%)
Questions!

- What is polymer?
Questions!

• What is polymer?
• What is polymer processing?
Questions!

- What is polymer?
- What is polymer processing?
- What is polymer industry?
Questions!

- What is polymer?
- What is polymer processing?
- What is polymer industry?
- What is industry?
Questions!

• What is polymer?
• What is polymer processing?
• What is polymer industry?
• What is industry?
• What is the role of chemical engineers in polymer industry?
Questions!

• What is polymer?
Polymer

- A long molecule consisting of many small units (monomers) joined end to end.
Radical groups

Table 1.7. Polymer radical group structure (23).

<table>
<thead>
<tr>
<th>Radical group name</th>
<th>Formula</th>
<th>Structure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methyl</td>
<td>− CH₃</td>
<td>− C−H</td>
</tr>
<tr>
<td>Ethyl</td>
<td>− CH₂CH₃</td>
<td>− C−C−H</td>
</tr>
<tr>
<td>Propyl</td>
<td>− CH₃CH₂CH₃</td>
<td>− C−C−C−H</td>
</tr>
<tr>
<td>Hydroxyl</td>
<td>− OH</td>
<td>− O−H</td>
</tr>
<tr>
<td>Carboxyl</td>
<td>− COOH</td>
<td>− C=O−H</td>
</tr>
<tr>
<td>Acetyl</td>
<td>− COCH₃</td>
<td>− C−C−H</td>
</tr>
<tr>
<td>Aldehyde</td>
<td>− CHO</td>
<td>− C=O</td>
</tr>
<tr>
<td>Amino</td>
<td>− NH₂</td>
<td>− N−H</td>
</tr>
</tbody>
</table>
### Vinyl structure

**Table 1.8. Monomers based on the ethylenic or vinyl structure.**

<table>
<thead>
<tr>
<th>When [A] is:</th>
<th>Monomer is:</th>
</tr>
</thead>
<tbody>
<tr>
<td>−H</td>
<td>Ethylene</td>
</tr>
<tr>
<td>−Cl</td>
<td>Vinyl chloride</td>
</tr>
<tr>
<td>−F</td>
<td>Vinyl fluoride</td>
</tr>
<tr>
<td>H</td>
<td></td>
</tr>
<tr>
<td>−C−H</td>
<td>Propylene</td>
</tr>
<tr>
<td>H</td>
<td></td>
</tr>
<tr>
<td>−C−O−C−H</td>
<td>Methyl acrylate</td>
</tr>
<tr>
<td>H</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Styrene</td>
</tr>
</tbody>
</table>

---

*Polymer Processing*
More...

PE, PP, PVC, PS, PVA ...

Polyethylene terephthalate (PET)
Styrene–acrylonitrile (SAN)

PMMA, PA, PU, PC, SBR, EVOH, ABS ...

Polymer Processing
Polyethylene

Fig. 1.1. Side branched polyethylene.

Fig. 1.2. Illustration of the molecular structure of cross-linked polyethylene in the liquid state. The spaces between the sketched net are filled with other parts of the network.
Polyethylene

10 um

Polymer Processing
ABS
(Acrylonitrile- Butadiene- Styrene)
Components

• G- ABS
• San
• Anti- oxydent
• Lubricant
• Colorant
• Others
  – Light stabilizer, acid scavenger, filler, frame retardant, coupling agent...
What is good resin?

• Design
  – Overall performance
  – Processing, material (chemistry, morphology)

• Production
  – Uniformity, appearance

• marketing
Questions!

• What is polymer processing?
Polymer processing

• Extrusion
  – Compounding, sheet, pipe ...
• Injection molding
• Blow molding
• Thermoforming
• Film blowing
• Fiber spinning
• etc
Figure 2.1 The main components of a single screw extruder
Pipe extrusion

Figure 1.3 Double ‘H’ Plastics Co. with 14 complete pipe/profile lines with Welex extruders and Gonair/Gatto coolers.

Polymer Processing
Sheet extrusion

Figure 9.1 Sheet line using a stand of three cooling rolls.
Injection molding

Figure 1.1 Schematic of a typical injection-molding machine
Blow molding

Fig. 1.17. Schematic view of the blow molding process. (Reprinted with permission from W. A. Holmes Walker, Polymer Conversion, Halsted Press, London, 1975.)
Thermoforming

(a)
Film blowing

Nip Rolls

Collapsing Frame

Bubble

Resin Pellets

Air Ring

Hopper

Die

Extruder

Idler Roll

Layflat

Roll of Film

Polymer Processing
Statistics

Polymer Processing
Questions!

- What is polymer industry?
Polymer industry

1PMZNFS1SPDFTTJOH

Future for you

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3. LG화학, ABSreme, 대형, 신규, 출시
4. 유화제품, 중국 수출, 팀, 박람회
5. LG화학, 호주, 공장, 설립

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1. LG 에디지 발생 도어

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Polymer industry
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Polymer industry

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Questions!

• What is industry?
Industry (Innovation)

innovation

knowledge <-> money

research

Competitiveness, customer oriented

Polymer Processing
Questions!

- What is the role of chemical engineers in polymer industry?
Role of chemical engineers

• R&D
• Production
• T/s
• Sales & marketing
• Management
• CEO/CTO
Young chemical engineers...

- Knowledge – problem solving
- Passion
- Creativity
- Dream/vision
- Leadership
What is the problem?