Chapter 1
The Scope of Polymer Chemistry

- Introduction
- Definitions
- Different Types of Polymers
- Historical Overview

Introductions

- **Available Materials Before the beginning of World War II**

  For construction: Steel, Glass, Wood, Stone, Brick, Concrete
  For fabric: Cotton, Wool, Jute(□ㅏ), other agricultural products

- **After World War II:**

  New Materials: new fiber, plastics, elastomers, adhesives, resins…..

  Theses are polymers.

More than 50% of all chemists and chemical engineers are involved with polymer

Definitions

- **Monomer: any substance that can be converted into a polymer.**

Examples

Ethylene

Amino acid

Dimers, Trimers, and Oligomers

Oligomer: Low-molecular weight polymerization products, for example, dimers, trimers, tetramers, and so on-cyclic or linear

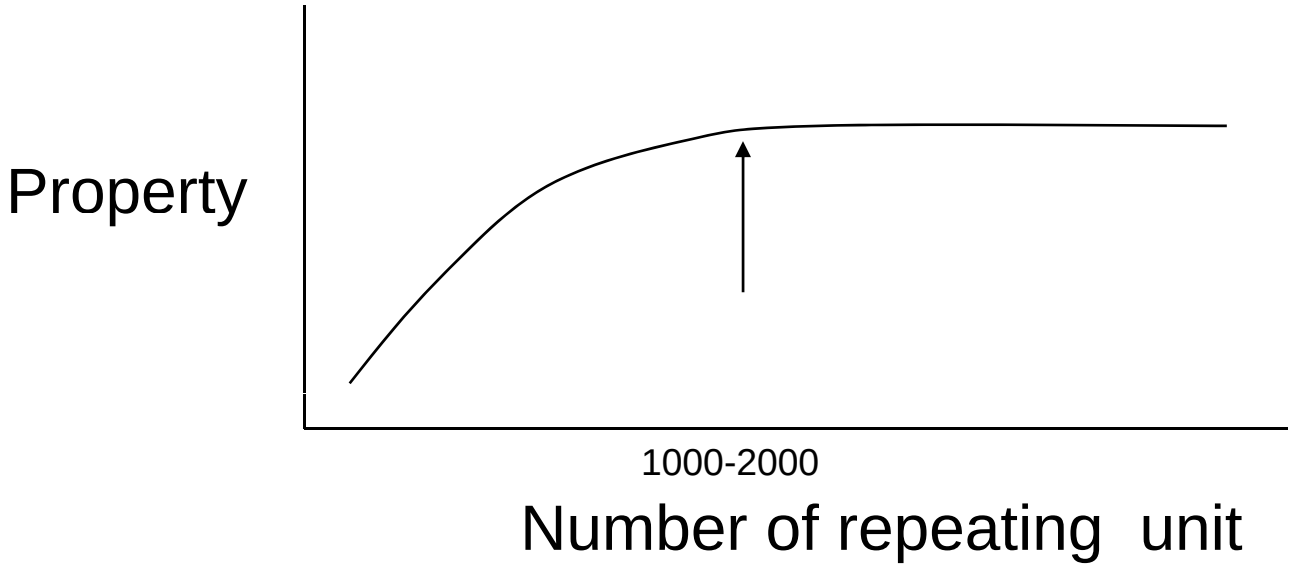
Polymers

Broad Definition: high-molecular-weight substance

Low polymer: molecular weight < 10,000 to 20,000
repeating units < 1000 to 2000

High polymer: molecular weight > 10,000 to 20,000
repeating units > 1000 to 2000

Why?



Linear Polymers

- Linear polymer consists of a long chain of skeletal atoms to which are attached the substituent groups.

Branched Polymers

→ linear polymers with branches

Cross linked Polymers

in which chemical

→ linkages exist

between the chains

Star Polymers

have arms (3 or more) radiating from a common core

Dendritic Polymers (Dendrimer)

Two method for the preparation of dendrimers

1. core first 2. arm first

Cyclolinear Polymers

→ linking together of ring systems

Ladder Polymers

consists of linesr molecules in which two

→ skeletal strands are linked together in a regular sequence by crosslinking units

Cyclometrix Polymers

Ring systems are linked together to form a three dimensional matrix of connecting units

Copolymers

a polymer made from two or more different monomers

- Random copolymer
- Alternating copolymer
- Block copolymer
- Terpolymer: contains three different monomeric units. Random or block

Graft copolymers

Telechelic polymers: bears functioanal groups

Average molecular weights and distributions

Number average molecular weight

Weight average molecular weight

N_i = number of molecules of molecular weight M_i

X_i = number(mole) fraction of molecules having molecular weight M_i

w_i = weight of molecules having molecular weight M_i

W_i = weight fraction of molecules having molecular weight M_i

Molecular weight Distribution: Polydispersity = M_n/M_w

Example for MW

w_i (g)	M_i (g/mol)	N_i (mol)	n_iM_i (g)	$n_i^2M_i^2$ (g^2mol)
1,000	1.0×10^3	1.0	1,000	1.0×10^6
1,000	1.0×10^6	0.001	1,000	1.0×10^9
total		1.001	2,000	1.001×10^9

Mn ~ 2000 g/mol
Mw ~ 500,000 g/mol

Polymer morphology

the study of the solid-state structure and behavior of polymers chapter 17, 19, 20, 21

thermoplastics

any material that softens when it is heated.

T_g: glass transition temperature

T_m: melting temperature

T_{lc}: quasi melting temperature

Liquid crystals ?

Example of a compound that shows no liquid crystal phase

Ice Cube

Solid crystalline water
3 degrees of order

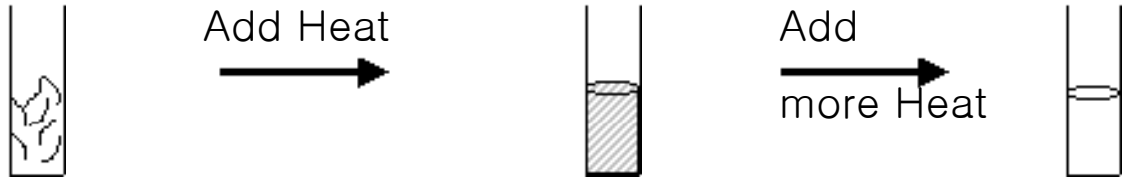
Water

Liquid water
0 degrees of order

Steam

Gaseous water
0 degrees of order

Example of a compound that shows liquid crystal phases



Crystals of a solid organic compound

3 degrees of order

Nematic liquid crystal phase

1 degree of order

Isotropic liquid

0 degrees of order

Elastomer

flexible polymer in the temperature range between its glass transition and liquefaction temperatures

Normally crosslinked (mostly chemically some times physically) polymers

Plasticizer

softens the polymers (ex phthalate esters)

antiplasticizer ?

Thermosetting resin

a range of system which exist initially as liquid but which, on heating, undergo a reaction to form a solid, highly crosslinked matrix

Polymer blends

two or more polymers are mixed together

Tacticity

chapter 4

Classification of polymer by polymerization reaction types.

1.Condensation polymers (Step reactions)

nylon, polyesters, phenol–formaldehyde resin, urea–formaldehyde resin, inorganic condensation polymers, biological polymers

And others in p. 17, 18, chapter 8 and 9

2. Addition polymers

formed by the Addition reactions of *unsaturated bonds*.

Other examples in p. 18 and 19

3. Ring opening polymerizations

polymers from cyclic compounds

Initiators

start the polymerization process

고분자의 역사

1. 인간 최초의 도구 = 나무 ? (나무: 천연 고분자 + 저분자 물질) ⇒ 원시인
2. 동물의 뿔을 이용한 램프및 창문의 제조 ⇒ 중세유럽
3. 고무나무 액을 이용한 고무공 및 방수복의 이용

   ⇒ 아메리카 인디언
4. 근대 유럽인들의 고무 이용

   ⇒ cotton (면)섬유에 coating하여 방수복으로 이용

   ⇒ 골프공 껍질

   ⇒ 1850년 영국 프랑스 해저 케이블의 피복 ....

   ⇒ 자동차 타이어? 0 ºC이하에서는 깨지고 높은 온도에서는 흐른다.

화학을 이용한 고분자의 개발

1. 황을 첨가한 천연고무: 타이어 재료
2. 나무에서 추출한 cellulose의 개질:당구공, 레이온섬유, 사진용 필름, 라커등
3. 페놀을 이용한 phenol-formaldehyde수지: 전자제품의 하우징(과거 전화기의 검정색 껍데기등), 항공기 재료, 식기

Cellulose 의 구조

고분자 분야의 노벨상 수상자

1. Staudinger (독일): 1953년 노벨 화학상
   ⇒ 고분자의 존재규명
2. Ziegler (독일)와 Natta(이태리): 1963년 노벨 화학상
   ⇒ 촉매 개발로 물성이 좋은 PE, PP의 합성 성공
3. Flory (미국, Nylon을 발명한 Carothers의연구팀 일원이었음) : 1971년 노벨 화학상
   ⇒ 고분자의 물리화학적 특성규명
4. De Gennes (프랑스): 1991년 노벨 물리학상
   ⇒ 액정과 고분자의 배열 현상규명과 그 이론
5. Heeger와 MacDiarmid (미국), Shirakawa (일본): 2000년 노벨 화학상
   ⇒전기를 통하는 고분자 그리고 전기에 의해 빛을 발광하는 고분자의 개발