Polymer chemistry and macromolecular engineering

Spring 2024

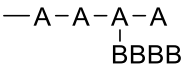
Exercise 1-Solutions

1. What is the difference between homopolymers and copolymers and draw a simplified representation for each of them?

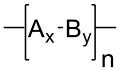
Homopolymers are polymers made up of a single repeating unit and copolymers are polymers made up of two or more repeating units.

Homopolymer: A-A-A-A and can be represented as

Copolymer: alternating: A-B-A-B- or random: A-A-A-B-A-, block; AAABBB and graft copolymer:



and can be represented as



Where x = 1, 2, 3... y = 1, 2, 3… and n = 1, 2, 3…

2. What is the difference between a condensation and an addition polymer?

Condensation polymer:

- Synthesis involves elimination of small molecules
- It contains functional groups as part of the polymer chain
- Its repeating unit lacks certain atoms that are present in the hypothetical monomer it is made of

Addition polymer

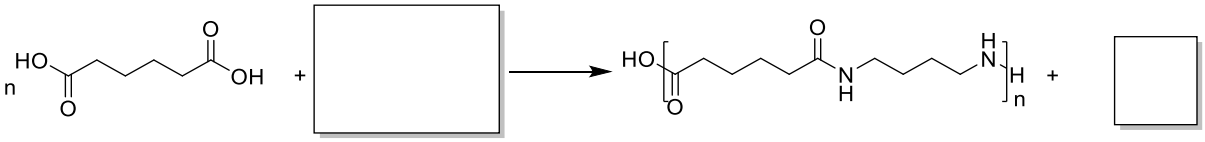
- No elimination of small molecules, all atoms in the monomer are also found in the polymer

3. List 3 examples of polymers from everyday life and write their chemical structures.

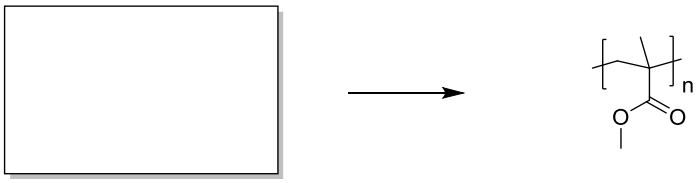
Polyethylene (PE), HDPE, LDPE, Polypropylene (PP), Polystyrene (PS), PET etc.

4. Complete the following reaction schemes and indicate (i) whether the polymers are addition or condensation polymers and (ii) whether the reactions are step or chain polymerizations.

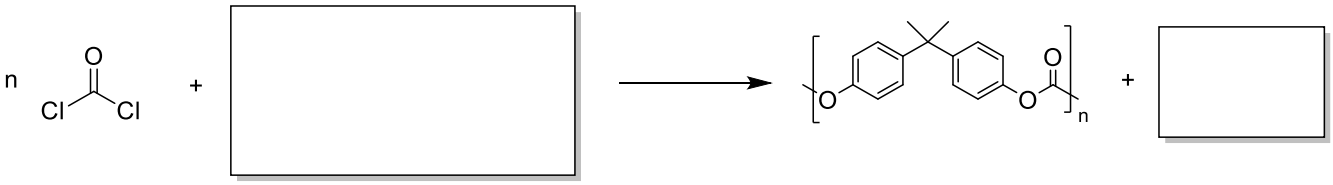
a)



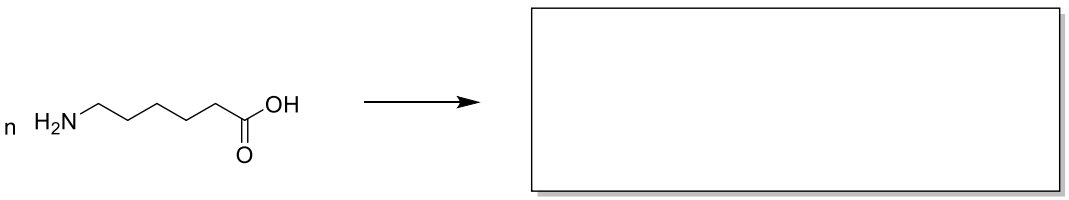
b)



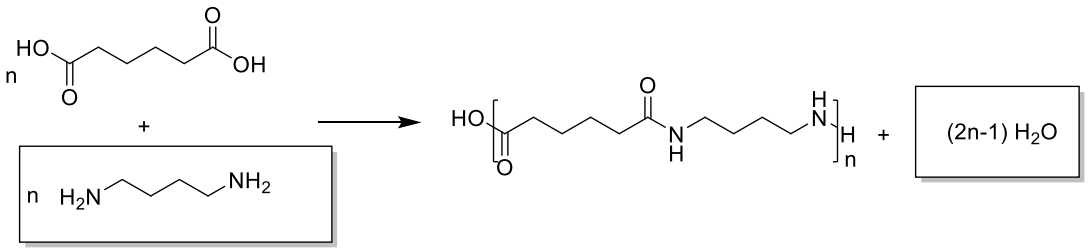
c)



d)

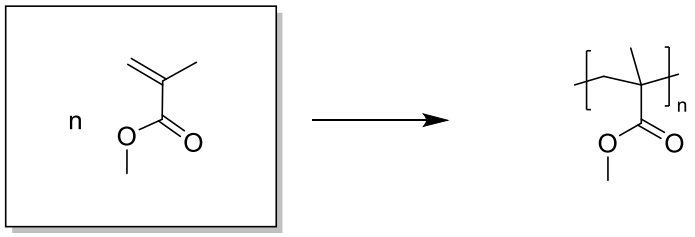


A)



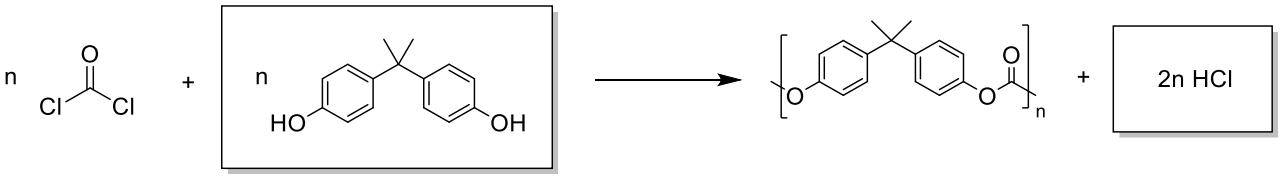
i) Condensation polymer
ii) Step polymerization

B)



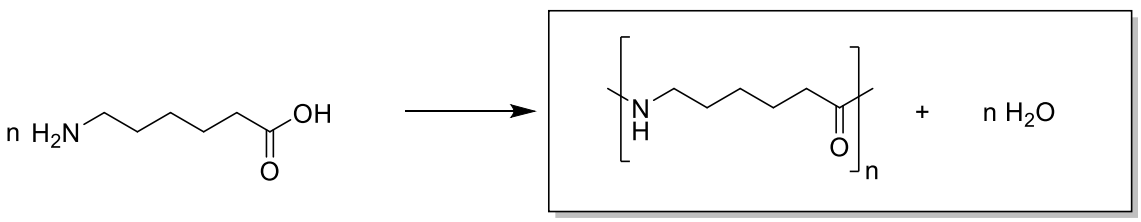
i) Addition polymer
ii) Chain polymerization

c.



i) condensation polymer ii) step polymerization

d)



i) Condensation polymer ii) Step polymerization

5. The weight fraction and molar masses for a synthesized polymer are given in the table below. Suppose the polymer is a homopolymer and is polydispersed. From the given data, please calculate:

1) Number-average (Mn) molecular weight

2) Weight-average (Mw) molecular weight

3) Viscosity-average (Mv) molecular weight (assume a = 0.5).

4) Dispersity Đ of the polymer

5) Show the distribution of molecular weights in typical polymer sample.

Fraction	Weight fraction	Mi (g/mol)
1	0.1	350 000
2	0.15	220 000
3	0.2	150 000
4	0.25	80 000
5	0.18	60 000
6	0.12	35 000

1) Number-average molecular weight

$$\bar{M}_n = \frac{\sum(n_i M_i)}{\sum n_i}$$

$$w_i = \frac{m_i}{w} = \frac{n_i M_i}{w}$$

$$therefore, \qquad n_i = \frac{w\, w_i}{M_i}$$

where w_i is the weight fraction, w is the total weight of all molecules, n_i is the number of moles of weight M_i

$$\text{So,} \quad \bar{M}_n = \frac{\sum(w\, w_i)}{\sum \frac{w\, w_i}{M_i}}$$

$$\bar{M}_n = \frac{\sum w_i}{\sum \frac{w_i}{M_i}}$$

$$\bar{M}_n = \frac{1}{\sum \frac{w_i}{M_i}} \; is\ equivalent\ to \; \frac{1}{\bar{M}_n} = \sum \frac{w_i}{M_i}$$

$$\bar{M}_n = 84356.6\ g/mol$$

2) Weight-average molecular weight

$$\bar{M}_w = \sum (w_i M_i) \quad inserting\ the\ values$$

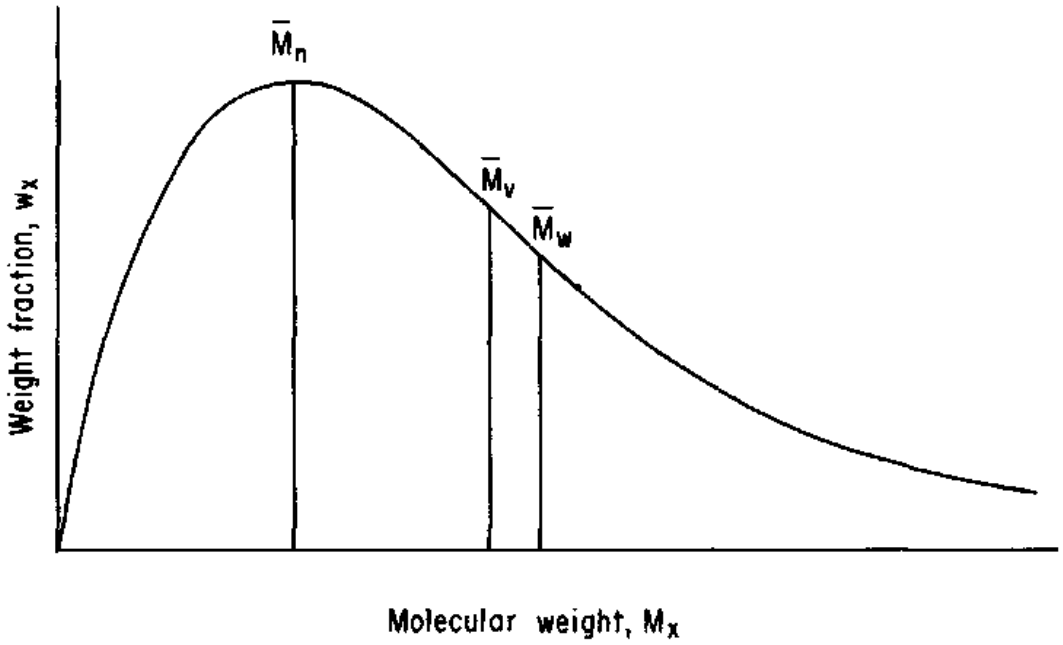
$$\bar{M}_w = 133000\ g/mol$$

3) $\bar{M}_v = [\sum (w_i {M_i}^a)]^{1/a}$ *inserting the values*

$$\bar{M}_v = 118493\ g/mol$$

4) Dispersity Đ is $M_w/M_n = 1.58$

5)



Distribution of molecular weights in a typical polymer sample.