3.091 Fall Term 2002

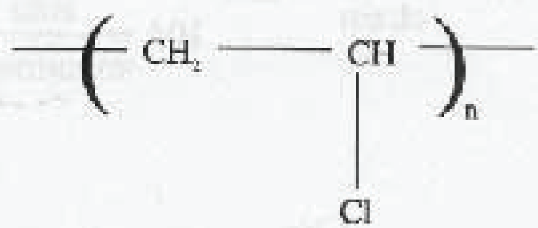
Homework #11

with solution outlines

(to be tested)

from Module Chapter 10 "Polymer Chemistry": 8, 9 plus the following problems.

1. Poly (vinyl chloride) is represented by the formula



(a) Draw molecular structures for tetramers (n=4) of the atactic, isotactic, and syndiotactic forms of PVC.

(b) Calculate the molecular weight of PVC composed of 4000 monomer units. Express your answer in g/mol.

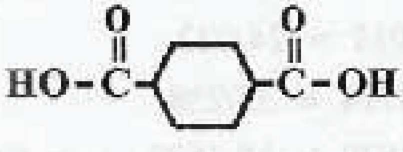
2. (a) Polyethylene exists either as a linear (straight-chain) polymer or as a branched polymer. Which is the high-density form? Explain.

(b) In visible light high-density polyethylene (HDPE) is opaque (white) while low-density polyethylene (LDPE) is transparent. Explain.

(c) Which form of PE is mechanically more flexible? Explain.

(d) Which form of PE has the higher melting point?

3. Show how the following monomer can be polymerized. What type of polymerization is used?



4. Show how $H_2C{=}CH_2$ can be polymerized. What type of polymerization is used?

5. Why can PE milk jugs be recycled while automobile tires cannot?

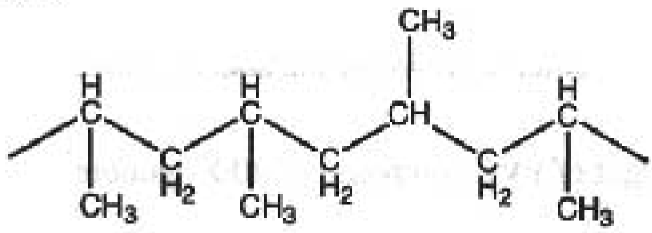
6. A polymeric ski boot has been designed to be flexible at room temperature but stiff out on the slopes. What is going on at the molecular level to confer this behavior?

Poly-8. The molecular weight of the monomer ($-C_2H_4-$) is 28 amu.
The molecular weight range is:
500 (28) to 50,000 (28) = 14,000 amu to 1,400,000 amu

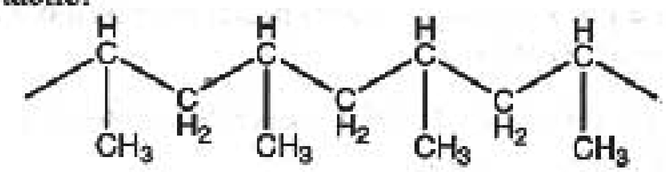
Poly-9. The molecular weight of the monomer ($-C_8H_8-$) is 104 amu.

$$\frac{200{,}000\ \frac{\text{amu}}{\text{chain}}}{104\ \frac{\text{amu}}{\text{monomers}}} = 1.92 \times 10^3\ \frac{\text{monomers}}{\text{chain}} \quad \text{and} \quad \frac{300{,}000\ \frac{\text{amu}}{\text{chain}}}{104\ \frac{\text{amu}}{\text{monomers}}} = 2.88 \times 10^3\ \frac{\text{monomers}}{\text{chain}}$$

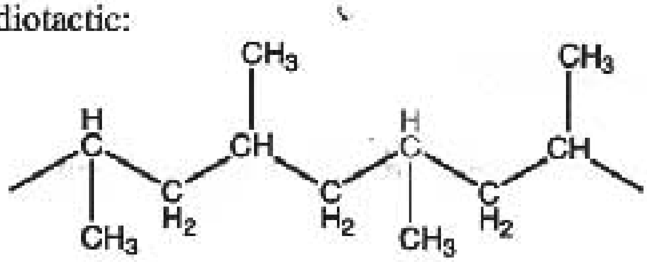
1. (a) atactic:



isotactic:



syndiotactic:



(b) mol. wt. $_{\text{monomer}}$ = $2 \times 12.011 = 24.022$
$3 \times 1.00794 = 3.0238$
$1 \times 35.4527 = 35.4527$ $\quad \therefore$ 4000 mers = 2.500×10^5 g/mol

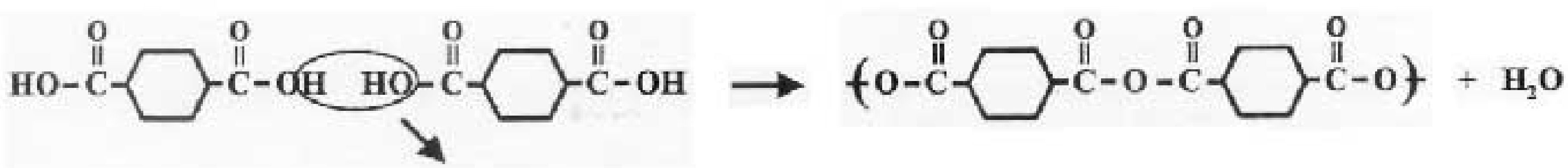
2. (a) – linear is HDPE
– straight chains pack better

(b) HDPE straight chains are capable of some degree of crystallization
⇒ interface between amorphous and crystalline material scatters visible light
⇒ white appearance.

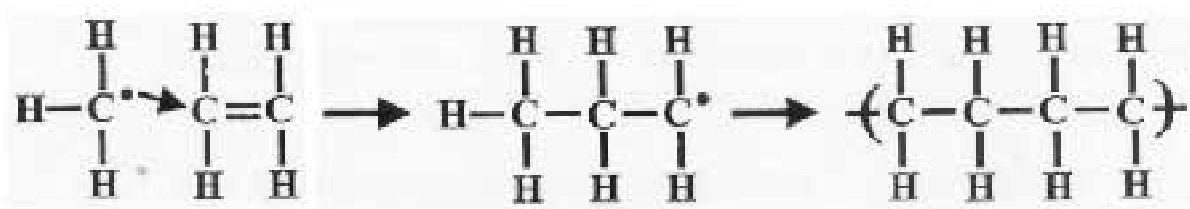
(c) semi-crystalline nature of HDPE adds rigidity
⇒ LDPE is more flexible

(d) partial crystallization leads to better packing which in turn implies a higher degree of secondary bonding within the macromolecule
$\Rightarrow$ HDPE has the higher melting point

3. condensation polymerization



4. addition polymerization



5. PE has no crosslinks; therefore, all inter-chain bonding is secondary. This means the bonds can be broken by heating the material above the glass transition temperature to form a liquid which can be reformed into another shape. Tires are made of rubber which is crosslinked. i.e., covalent bonds forms between chain segments. To break these bonds would require heating to temperatures so high that the backbone of the chain itself would break dowm resulting in the wholesale degradation of the rubber. Thus rubber tires are not recyclable.

6. The glass transition temperature of the polymer must lie between room temperature and ~0°C.