CHAPTER I.2.2

Polymers: Basic Principles

QUESTIONS

1. This question is related to your knowledge of how chemical structure affects a polymer’s glass transition temperature. For each pair below draw the repeat unit of the polymers, select which polymer you believe has a higher glass transition temperature, and explain your answer.
   **Pair 1**: polyethylene versus poly(vinyl alcohol)
   **Pair 2**: poly(hydroxyethyl methacrylate) versus poly(propyl methacrylate)
   **Pair 3**: poly(vinyl chloride) versus poly(vinylidene chloride).

2. You have polymerized a product containing seven PMMA molecules: three of the molecules have a degree of polymerization of 150; two of the molecules have a degree of polymerization of 400; one has a degree of polymerization of 500; and the last has a degree of polymerization of 1000. Calculate the number average and weight average molecular weights of the polymer product and the polydispersity index. Ignore the presence of initiator fragments.

3. Your boss asks you to design a polymer biomaterial for use as a tooth enamel replacement. Based on the characteristics we have discussed in this chapter, what biomaterial properties are needed and how would you go about designing such a material?

ANSWERS

1. Please see Figure I.2.2.9.

![Figure I.2.2.9](image_url)
2. In the problem statement, you are supplied with the number of molecules with “i” repeat units \(N_i\). With this information, the molecular weight of each molecule \(M_i\) can be calculated by knowing the molecular weight of the PMMA repeat unit \(MW = 100\) Daltons/repeat unit). This information is compiled in the table below.

<table>
<thead>
<tr>
<th>Number of Molecules (N_i)</th>
<th>Degree of Polymerization (i)</th>
<th>Molecular Weight of Molecule (M_i)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>150</td>
<td>15,000</td>
</tr>
<tr>
<td>2</td>
<td>400</td>
<td>40,000</td>
</tr>
<tr>
<td>1</td>
<td>500</td>
<td>50,000</td>
</tr>
<tr>
<td>1</td>
<td>1000</td>
<td>100,000</td>
</tr>
</tbody>
</table>

Through application of the equations: \(M_n = 39,000\) Daltons, \(M_w = 60,000\) Daltons, and PDI = 1.5.

3. Tooth enamel is a hard tissue that will be exposed to many stresses, especially compressive stresses. Furthermore, the material must be biostable and not swell at all in the presence of water. The material must be stiff, with a high modulus, and very tough and wear resistant. This means that it must be highly cross-linked to provide the necessary strength and wear resistance. It should be relatively hydrophobic or so highly cross-linked that it will not absorb water. It should also exhibit a negligible rate of degradation \textit{in vivo}.