Lecture 2.

Theme. Classification of polymers. Molecular weight of polymers and its types.

Aim: generate the following learning outcomes:
-recognize the principles underlying the various variants of the nomenclature;
- to name polymers according to the chemical formula of their composite repeating units;
- list polymers to a particular group based on classification features.

Purpose:
To explain the main principles of polymer classification and to introduce the concept of molecular weight, its types, and significance in determining polymer properties.

Lecture content:
Classification of polymers depending on the origin, chemical composition and structure of the main chain, depending on the topology of macromolecules.
Single-storey and two-storey macromolecules.
Natural and synthetic polymers.
Organic, organoelement and inorganic polymers.
Linear, branched, ladder and crosslinked polymers, dendrimers.
Homopolymers, copolymers, block copolymers, grafted copolymers.
Homocain and heterocain polymers.
Biopolymers, the main biological functions of proteins, ribonucleic and deoxyribonucleic acids.
Brief description and application areas of the most important representatives of various classes of polymers.
Molecular weights and molecular mass distributions (MMR).
Averaged (average) molecular weights (average number, average weight).

Main Questions:
1. How are polymers classified according to different criteria?
2. What is molecular weight in polymers?
3. What types of molecular weights exist and how are they calculated?

4. How does molecular weight affect polymer properties?
5. What methods are used to determine the molecular weight of polymers?

Key Theses:

- **Classification of polymers** is based on several main criteria:
  1. By origin:
  - *Natural polymers* — cellulose, proteins, starch, rubber.
  - *Synthetic polymers* — polyethylene, polystyrene, nylon, PVC.

  2. By structure of the polymer chain:
  - *Linear polymers* — consist of straight chains (e.g., high-density polyethylene).
  - *Branched polymers* — contain side chains (e.g., low-density polyethylene).
  - *Cross-linked or network polymers* — have interconnected chains forming 3D structures (e.g., vulcanized rubber, epoxy resins).

  3. By composition of repeating units:
  - *Homopolymers* — made from one type of monomer (e.g., polystyrene).
  - *Copolymers* — made from two or more types of monomers (e.g., styrene-butadiene rubber).

  4. By synthesis method:
  - *Addition polymers* (formed by polymerization without by-products).
  - *Condensation polymers* (formed with elimination of small molecules like water or HCl).
- **Molecular weight (MW)** of a polymer refers to the sum of the atomic weights of all atoms in a macromolecule. Unlike small molecules, polymers consist of chains of varying lengths, so molecular weight is expressed as an average value.
- **Types of molecular weight:**
  1. **Number-average molecular weight (Mn)** — average based on the number of molecules; calculated as the total weight of all polymer molecules divided by the total number of molecules.
  2. **Weight-average molecular weight (Mw)** — takes into account the weight fraction of each molecular species; gives greater weight to heavier molecules.
  3. **Viscosity-average molecular weight (Mv)** — determined from solution viscosity measurements.
  4. **Z-average molecular weight (Mz)** — used for light scattering studies; emphasizes the contribution of very large molecules.
- **Polydispersity index (PDI)** = Mw / Mn — indicates the distribution of molecular weights in a polymer sample. A perfectly uniform polymer has PDI = 1 (rare in practice).

- **Effect of molecular weight on properties:**
  - Higher MW → higher tensile strength, toughness, and melting point.
  - Lower MW → better processability, lower viscosity in melts and solutions.
  - Optimal MW depends on application requirements.
- **Methods for determining molecular weight:**
  - *Physical methods:* osmometry, viscometry, light scattering.
  - *Chemical methods:* end-group analysis.
  - *Instrumental methods:* gel permeation chromatography (GPC), mass spectrometry.

Control Questions:

1. What are the main criteria used to classify polymers?
2. What is the difference between homopolymers and copolymers?
3. List the names of the steps and classification features in the general classification of polymers.
4. Define molecular weight in polymers.
5. What are the main types of molecular weight and how do they differ?
6. What does the polydispersity index represent?
7. How does molecular weight influence the physical properties of polymers?
8. What methods are used to determine polymer molecular weight?

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