

## High molecular compounds

**High molecular compounds (HMC) have high molecular mass – from several thousands to many millions.**

Most of organic HMC – polymers, molecules of which (macromolecules) consisted of large amount of repeating monomeric elements, connected by chemical bonds.

### Classification of HMC

By origin polymers are divided in to natural or biopolymers (proteins, polysaccharides, nucleic acids) and synthetic, prepared with polymerization or poly condensation. Besides this there are semi-synthetic HMC, prepared by chemical reactions with natural (nitrocellulose, acethylcellulose).

By structure of macromolecule HMC are divided in to linear (cellulose, polyethylene), branched (glycogen), space (proteins), reticulated (polystirol) and crosslinked (rubber).

By chemical content homopolymers, containing the same chemical groups (polyethylene), copolymers, consisting of two or more different monomers (nucleic acids).

By location of macromolecules – amorphous and crystal

При низких температурах ВМВ находятся в **стеклообразном состоянии**, для которого характерно отсутствие перемещения относительно друг друга как макромолекул в целом, так и их сегментов. Внешне, на макроуровне это состояние проявляется в виде твёрдости и хрупкости. В таком стеклообразном состоянии эксплуатируются органические стекла и пластмассы, в том числе ионообменные смолы.

In low temperatures HMC are in vitreous state, it looks hard and fragile.

When heating amorphous polymers turn to high elastic state (vitrification temperature).

When cooling lower than vitrification temperature polymers turn to vitreous state.

High elastic state exists in wide range of temperatures to temperature of fluidity, higher which they turn to viscous fluid state.

While interacting with solvents polymer can absorb them in significant amounts. It leads to increasing of volume. This increasing of volume (and mass) of polymer as a result of absorption of low molecular liquid or its vapor is called **swelling**.

In many cases swelling goes without changing of form.

Quantitative characteristics of swelling is the degree of swelling  $\alpha$ , defined as volume of mass of liquid, absorbed by one unit of volume or mass of polymer:

$$\alpha_v = \frac{V - V_0}{V_0} \quad \text{or} \quad \alpha_m = \frac{m - m_0}{m_0},$$

where  $m_0$  and  $m$  – mass of polymer before and after the swelling,

$V_0$  and  $V$  – volume of polymer before and after the swelling.

### **Properties of HMC solutions**

1. Solutions of HMC are formed spontaneously
2. Thermodynamic stability.
3. Reversibility – they can be many times split and solvated.
4. Opalescence.
5. Low osmotic pressure.
6. Low diffusion velocity.
7. Ability to electrophoresis.

### **Polyelectrolytes. Proteins. Isoelectric point.**

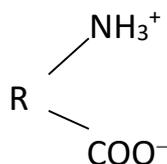
Polymers, macromolecules of which contain ionic groups are called polyelectrolytes. Depending on nature of ionic groups polyelectrolytes are

classified in to poly acids, poly bases and poly ampholytes (contain acid and base groups). In water solution polyelectrolyte molecule exists in form of poly ion. Examples of polyelectrolytes are nucleic acids, polypeptides and proteins. Besides this proteins are one of main components of living organisms and important nutrition product, they are used in pharmacy and medicine.

Proteins consist of amino acids, which contain  $-\text{NH}_3^+$  (base) and  $-\text{COO}^-$  (acid) groups. Depending of pH this groups can be ionized in different degree. In acid environment macromolecules exist as cations, in base environment carboxylic groups ionized and polymers become negative.

In some concentration of hydrogen ions the amount of cationic and anionic groups become equal and total charge of macromolecules turns to zero. This state is called isoelectric state and according pH value – isoelectric point (IEP).

In IEP macromolecule exists in form of amphion (zwitterion), structure of which can be presented as:



In most of proteins there is more carboxylic groups than amino groups. That's why proteins commonly have IEP in pH lower than 7.

### **Methods of IEP determining**

Electrophoretic method

Method associated with stability to salts and organic solvents

Viscometric method

Minimum degree of swelling method