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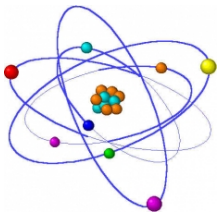
FEATURES OF THE PHYSICAL-CHEMICAL PROPERTIES OF SOLUTIONS OF HMC

Teaching and methodical manual

for foreign students of Zaporozhye State Medical University



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It is recommended by Methodic commission on chemical sciences as a textbook for students of medical faculty (Minutes №3, 27.11.2014)

Reviewers:

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CONTENTS

PREFACE

Medicinal Chemistry is one of the most rapidly developing areas within the discipline of Chemistry, both globally and locally. It is the study of the design, biochemical effects, regulatory and ethical aspects of drugs for the treatment of disease.

The aim of this discipline is to produce graduates with an appropriate background in biology and pharmacology, built upon a strong chemistry foundation.

Methodical recommendation of Medicinal Chemistry is designed to equip students with strong grounding in biological and chemical technique which is relevant to the pharmaceutical world.

The discipline gives an in-depth coverage of the chemical techniques required and relates these to the relevant pharmacology, anatomy, biochemistry and molecular biology.

The whole course of Medical chemistry which consists of ten topics is studied by students-physicians during the first year. Lecturer staff of department has prepared an educational and methodical recommendation in which the theoretical material is stated in the concise and available form.

The distribution of material on each of ten topics that are studied is set according to training program, the thematic plan of lectures and practical training.

The material of each topic is stated in such way that performance of practical work and the solution of situational tasks are preceded by theoretical part in which questions of medicine and biological value and also connection with other disciplines (biological chemistry, normal physiology, pathophysiology and others) are included.

Offered laboratory works and situational tasks will give students the chance to understand theoretical material fully and to use this knowledge in practice.

The experience of teaching medical chemistry shows that it is not always possible to coordinate an order of laboratory works realization with sequence of lecture course statement. That is why students usually have to prepare for practical work performance independently before the lesson. Therefore the theoretical part (in which the necessary volume of knowledge for conscious performance of experiment is given) precedes to each section of these Methodical recommendations.

Increasing of level of seminar and laboratory works is reached by use of such forms of occupations which open and consolidate theoretical knowledge, train scientific thinking, develop creative initiative and impart skills of handling devices and chemicals, chemical ware.

The structures, figures and schemes are clear and easy to follow and color is used well, highlighting main points without being distracting.

Chapters are helpfully signposted throughout, informing the reader how topics are related, which is especially important in such a multidisciplinary subject.

Topics are also presented clearly and with a logical progression culminating in the main points, questions and reading sections at the beginning of each chapter.

An assortment of case studies is provided and the authors work through each one in great detail, giving an overall perspective on the science.

Finally, very useful and informative appendices and a glossary are provided together with a comprehensive index that is good enough to rival any search engine!

There are many books that describe medicinal chemistry and its uses, but these methodological recommendations present medicinal chemistry and its related topics in a clear, informative and interesting way that really demonstrates the application and impact of this fundamental subject in society.

INTRODUCTION

Purpose: to study features of disolution of polymers, classification of solutions of HMC, molecular kinetic, optical, rheological behavior, ways of receiving jellies, a swelling kinetics, stability factors, polyelectrolytes, features of strong solutions of HMC.

Targets:

- to examine various ways of receiving solutions of HMC, jellies;
- to study swelling process gelatin and influences of various factors on swelling value;
- to study influence of acidity of the environment (isoelectric point);
- polyelectrolytes, Donnan's membrane equilibrium.

The student should know:

- main chemical properties of high-molecular compounds;
- classification of high-molecular compounds;
- features of a structure which define their properties;
- phenomena of swelling and condition of disolution of HMC;
- influence of the nature of polymer, concentration, pH media on swelling value of polymer;
- effect of electrolytes;
- lyotropic series of the Steward of the household;
- isoelectric condition of a proteinaceous molecule;

The student should be able:

- to prepare solutions of HMC;
- to prepare jellies;
- to prepare buffered solutions and to define them pH;
- to count swelling value gelatin by laboratory results;
- to interpret influence of a number of cations and anions on swelling process;
- to define an isoelectric point of gelatin;
- to determine a molecular mass of polymer by a viscometric method;

CONCISE THEORETICAL MATERIAL

Biopolymers are polymers produced by living organisms. Since they are polymers, Biopolymers contain monomeric units that are covalently bonded to form larger structures.

There are three main classes of biopolymers based on the differing monomeric units used and the structure of the biopolymer formed. Polynucleotides long polymers which are composed of 13 or more nucleotide monomers, Polypeptides short polymers of amino acids, and Polysaccharides which are often linear bonded polymeric carbohydrate structures.

Solutions of high-molecular compounds (HMC) are the homogeneous thermodynamic stable reversible systems which are forming spontaneously and by the nature they are true molecular solutions.

The huge sizes of macromolecules bring specifics in their properties which are the reason of two features:

1 existence of two types of connections:

- ✓ chemical
- ✓ intermolecular;

2 - flexibility of chains.

After dissolution of HMC not only true solutions can form, but also the colloidal solutions. It depends on concentration and the solvent nature. Molecular or true solutions receive in the solvents which polarity corresponds to polarity of HMC. Example - gelatin solution in water or rubber(caoutchouc) in gasoline.

The colloidal solutions of HMC are formed at discrepancy of polarity of solvent, or at concentration larger, than the critical micelle concentration (CMC).

Feature of dissolution of HMC that hat process takes place in some stages. Swelling occurs because off increasing of volume or weight of the polymer on account of absorption of them a certain amount of solvent. The

reason of swelling is sharp difference in the mobility of the solvent molecules and macromolecules HMC.

1. Properties of high-molecular compounds (HMC) solutions

HMC solutions have properties such as true solution, colloidal solution and some specific properties.

Properties HMC solution, which same as true solutions:

- ✓ Solutions of high-molecular compounds are stable as molecular solutions;
- ✓ Solutions of high-molecular compounds are convertible. If high-molecular compound was solved that the molecular solution will be farmed. And if this solution to strip to dryness, so high-molecular compound was stat, which can solve again.
- ✓ Between high-molecular compound and solvent has not boundary.

Properties HMC solution, which same as colloidal solutions:

- ✓ Size of disperse phase in solutions of high-molecular compounds are same as in colloidal solutions (10^{-7} - 10^{-9} m);
- ✓ High-molecular compounds cannot permeate through semipermeable membrane;
- ✓ High-molecular compounds slowly are diffused in solutions.
- ✓ Specific properties HMC solution:

1. For solutions of high-molecular compounds are characteristic the swelling and high viscosity

Swelling it is process solubility high-molecular compound in solvent.

Only linear molecules HMC swell in two stages:

First stage-solvation of macromolecules by solvent. Second stage-swell and then dissolution. Swelling can be limited or unlimited. It depends on

polymer structure, temperature, ratios of binding energies in polymer with energy of a solvation and an entropy factor.

Swelling is not simply physical, mechanical penetration of solvent into polymer structures. Here warmth is marked out and the contraction is observed is a decrease of total amount of system.

Contraction reasons: 1-molecules of solvent are absorbed by macromolecules of HMC. This increases the density of the substance. 2 - effect of steric factors. Contraction depends on the degree of hydration-this quantity of liquid absorbed during swelling 1 gram HMC.

Degree of hydration determined by the structure and nature of the polymer. In the first step of swelling takes place allocation of swelling heat.

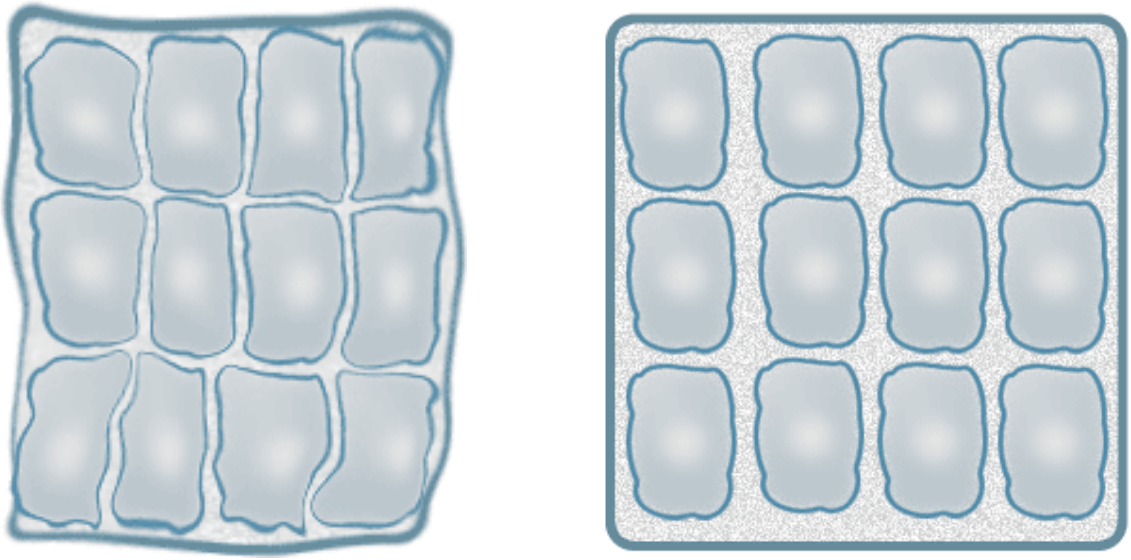


Fig.1. Photo of the cell before and after swelling

Spontaneity swelling and dissolution is possible by decrease of entropy, or by increase of entropy.With increasing of temperature, the effect of the entropy factor increase too.

There is a critical for every polymer and solvent-This is temperature, above which intermiscibility is observed.It theoretically. Practically not every polymer can be dissolved in every solvent. Swellings appear in spatial grid due to increased of HMC when swelling, with cause the swelling

termination.Restricted swelling is characterized by the degree of swelling. The exemplar dissolves, weight decreases, the degree of swelling loses meaning, when the swelling is unlimited.

The second quantitative characteristic of process of swelling – the speed of swelling is a change of mass of an exemplar of polymer in time.Swelling pressure appear if volume will be constant. Swelling pressure is equivalent to the external pressure which action could stop increase in volume of swelling polymer.

To calculate swelling pressure P it is possible on Pozdnyak's equation:

$$P=P_0 \cdot C^n$$

Where P0 - pressure at C=1; n–constant,which define from graphic dependence of pressure on concentration in logarithmic coordinates, as tangent of angle of slope; C-quantity of nonvolatile soild,in unit volume of swelling polymer. pH of surroundings effect on the swelling,because changes the degree of hydration.

The anions and cations affect in accordance with the location in the Hofmeister series: $CNS^- > J^- > Br^- > NO_3^- > Cl^- > CH_3COO^- ..... > SO_4^{2-}$

Swilling degree (α) :

$\alpha = (m - m_0)/m_0 = m_p/m_0$ or $\alpha = (V - V_0)/ V_0 = V_P / V_0$

Where m_0 i V_0 – mass or volume polymer before swilling ; m i V – mass or volume polymer after swilling ; m_p, V_p – mass or volume of solvent, which is absorbed polymer.

Sometime used mass-volume swilling degree

$\alpha= (V_0 - V)/ m = см^3/g$ or $\alpha = (V_0 - V)100\ \% /m$

Protective action of liophilic colloids and gold number. It has already been explained that lyophobic sols like those of metals (Au, Ag etc.) are unstable and are easily precipitated by addition of electrolytes. However, it is observed that the addition of certain lyophiliccolloids like gums, soaps, gelatin etc. to lyophobic colloids (like a metal sol) render lyophobic colloids difficult to coagulate by the addition of electrolytes. The process is known as “protection”

and the lyophilic colloids are termed as Protective colloids. It is believed that the protective action of the lyophilic colloids is due to the covering up of the particles of the lyophobic colloid by those of thelyophilic colloid.

However, this explanation does not seem to be fully correct because the particles of the protecting substance have almost the same size as those of the substance being protected.

Thus, the exact mechanism of protection is not clear.

To compare the protective action of different lyophilic colloids, Zsigmondy (in 1901) introduced a term called Gold number. It is defined as follows:

Gold number of a protective colloid is the minimum weight of it in milligrams which must be added to 10 ml of a standard red gold sol (containing 0.5 to 0.06 g of gold per liter) so that no coagulation of the gold sol, (i.e. the change of colour from red to blue) takes place when 1 ml of 10 % sodium chloride solution is rapidly added to it.

"Iron number " of a protective HMC is the minimum weight of it in milligrams which must be added to 10 ml of a standard iron hydroxide ($Fe(OH)_3$) colloidal solution so that no coagulation of the iron hydroxide sol, takes place when 1 ml of 0,005 mol/l potassium sulfate solution is rapidly added to it.

2. Classification of Polymers

Polymers are classified by different possible:

1. Classification by source;
2. Classification by structure;
3. Classification by synthesis;
4. Classification by molecular forces.

Natural (nucleic acids, polysaccharides, protein, natural rubber (polyisoprene));

Synthetic (polyethelene, teflon, polyvinilchloride, polystyrene).

Classification by structure:

Linear polymers. In these polymers, the monomers are joined together to form long straight chains of polymer molecules. Because of the close packing of polymer chains, linear polymers have high melting point, high densities and high tensile (pulling) strength.

Branched chain polymers. In these polymers, the monomer units not only combine to produce the linear chain (called the main chain) but also form branches along the main chain

Three-dimensional network polymers. In these polymers, the initially formed linear polymer chains are joined together to form a three-dimensional network structure. These polymers are also called cross-linked polymers

The high-molecular compounds are compounds, which have 10.000 - 10.000.000 Da molecular mass.

Biological role of polymers

1. Biopolymers, have a lot functions:
2. Catalytic effect– enzymes;
3. As regulators – hormones;
4. is the storage and transfer of genetic information.(DNA);
5. Storage energy (Starch, glycogen);
6. Protection - immunoglobulin;
7. Structural (collagen, keratins, fibril).

There are macromolecules everywhere, inside us and outside us. Some are natural: they include polysaccharides such as cellulose, polypeptides such as enzymes, and nucleic acids such as DNA. Others are synthetic: they include polymers such as nylon and polystyrene that are manufactured by stringing together and (in some cases) cross-linking smaller units known as monomers. Life in all its forms, from its intrinsic nature to its technological interaction with its environment, is the chemistry of macromolecules.

Most of the reactions that have been examined so far have involved reactants and products of low molecular mass. Some of the most important organic compounds made by chemists, however, are giant molecules called polymers.

A polymer is a large molecule formed by the covalent bonding of repeating smaller molecules. Most polymerization reactions require a catalyst.

Monomers are molecules that combine to form the repeating unit of a polymer. Some polymers contain only one type of monomer. Others contain two or more types of monomers. The two most common ways for monomers to be joined are addition polymerization and condensation polymerization.

Synthesis of polymers

Addition polymerization occurs when unsaturated monomers react to form a polymer.

Addition polymerization occurs when unsaturated monomers react to form a polymer. It is a specific type of addition reaction.Ethene undergoes addition polymerization. The molecules bond one to another to form the long-chain polymer polyethylene.

Polyethylene is an important industrial product because it is chemically resistant and easy to clean. It is used to make refrigerator dishes, plastic milk bottles, laboratory wash bottles, and many other familiar items found in homes and laboratories. By shortening or lengthening the carbon chains, chemists can control the physical properties of polyethylene.

Polyethylene containing relatively short chains (x = 100) has the consistency of paraffin wax. Polyethylene with long chains (x = 1000) is harder and more rigid.

Polymers of substituted ethenes can also be prepared. Many of these polymers have useful properties.

Condensation polymers are formed by the head-to-tail joining of monomer units. This is usually accompanied by the loss of a small molecule, such as water. The formation of polyesters is an example of condensation. Polyesters

are high-formula-mass polymers consisting of many repeating units of dicarboxylic acids and dihydroxy alcohols joined by ester bonds.

The formation of a polyester is represented by a block diagram. Note that condensation polymerization always requires that there be two functional groups on each molecule.

Homopolymers and copolymers. Depending upon the nature of the relocating structural unit, polymers are divided into two categories:

(1) Homopolymers

(2) Co-polymers.

Polymers are classified in a number of ways:

(a) Classification based upon source,

(b) Classification based upon structure,

(c) Classification based upon synthesis and

(d) Classification based upon molecular forces.

I. Classification based upon source:

1. Natural (nucleic acids, polysaccharides, protein, natural rubber (polyisoprene));

2. Synthetic (polyethelene, teflon, polyvinilchloride, polystyrene).

II. On the basis of structures, polymers are divided into three types:

Linear polymers.

In these polymers, the monomers are joined together to form long straight chains of polymer molecules. Because of the close packing of polymer chains, linear polymers have high melting point, high densities and high tensile (pulling) strength.

Branched chain polymers.

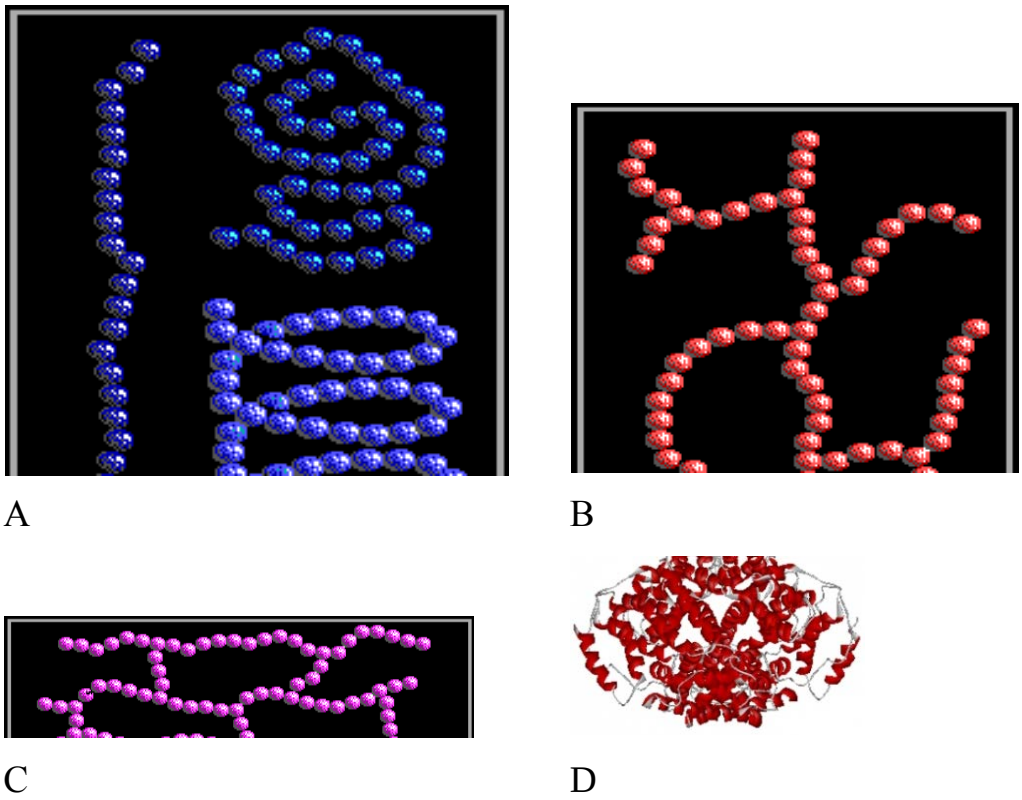
In these polymers, the monomer units not only combine to produce the linear chain (called the main chain) but also form branches along the main chain

Three-dimensional network polymers.

In these polymers, the initially formed linear polymer chains are joined together to form a three-dimensional network structure Only two cross-links per

polymer chain are required to join together all the long chain polymer molecules to form a giant molecule. Because of the presence of cross-links, these polymers are also called cross-linked polymers. These polymers are hard, rigid and brittle.

There is great value of form of macromolecules.



A B

C D

Fig. 2 Forms of macromolecules (a-liner, b-branched, c- spatial, d-globular)

III. By molecule form

1. Globular.
2. Fibril.

IV. By nature atoms, which are in molecule of polymer

1. Carbon contain polymers
2. Hetero polymers
3. Element organic
4. Inorganic

Metal oxide sols tend to be positively charged whereas sulfur and the noble metals tend to be negatively charged. Naturally occurring macromolecules also

acquire a charge when dispersed in water, and an important feature of proteins and other natural macromolecules is that their overall charge depends on the pH of the medium.

For instance, in acidic environments protons attach cobasic groups, and the net charge of the macromolecule is positive; in basic media the net charge is negative as a result of proton loss. At the isoelectric point the pH is such that there is по net charge on the macromolecule.

The primary role of the electric double layer is to confer kinetic stability. Colliding colloidal particles break through the double layer and coalesce only if the collision is suf5ciently energetic to disrupt the layers of ions and solvating molecules, or if thermal motion has stirred away the surface accumulation of charge.

This disruption may occur at high temperatures, which is one reason why sols precipitate when they are heated.

The protective role of the double layer is the reason why it is important not to remove all the ions whena colloid is being purified by dialysis, and why proteins coagulate most readily at their isoelectric point.

The presence of charge on colloidal particles and natural macromolecules also permits us to control their motion, such as in dialysis and electrophoresis. Apart from «в application to the determination of molar mass, electrophoresis has several analytical and technological applications. One analytical application is to the separation of different macromolecules.

Technical applications include the painting of objects by airborne charged paint droplets, and electrophoretic rubber forming by deposition of charged rubber molecules on anodes formed into the shape of desired product (e.g. surgical gloves).

There are macromolecules everywhere, inside us and outside us. Some are natural: they include polysaccharides such as cellulose, polypeptides such as enzymes, and nucleic acids such as DNA. Others are synthetic: they include polymers such as nylon and polystyrene that are manufactured by stringing

together and (in some cases) cross-linking smaller units known as monomers. Life in all its forms, from its intrinsic nature to its technological interaction with its environment, is the chemistry of macromolecules.

Although the concepts of physical chemistry apply equally to macromolecules as well as to small molecules, macromolecules do give rise to special questions and problems.

These problems include the determination of their sizes, the shapes and the lengths of polymer chains, and the large deviations from ideality of their solutions.

3. Size of macromolecule compounds.

X-ray diffraction can reveal the position of almost every atom, even in highly complex molecules. However, there are several reasons why other techniques must also be used. In the first place, the sample might be a mixture of polymers with different chain lengths and extents of cross-linking, in which case sharp X-ray images are unobtainable.

Even if all the molecules in the sample are identical, it might prove impossible to obtain a single crystal.

Furthermore, although the work on enzymes, proteins, and DNA has shown how immensely stimulating the data can be, the information is incomplete.

For instance, what can be said about the shape of the molecule in its natural environment, a biological cell?

What can be said about the response of its shape to changes in its environment?

Shape and function go hand in hand, and it is essential to know how the shapes of biological macromolecules, which often carry both acidic and basic groups, respond to the pH of the medium.

It is also useful to be able to follow the collapse of a macromolecule into a less orderly form: this denaturation is often accompanied by loss of

function, but when it happens in a controlled way it is sometimes an essential step in the fulfilment of function, as in the replication of DNA.

4. Mean molecular masses.

A complication that we need to address at the outset is the fact that samples of synthetic polymers and many biomacromolecules consist of molecules covering a range of molar masses. A pure protein is monodisperse, meaning that it has asingle, definite molar mass. (There may be small variations, such as one amino acid replacing another depending on the source of the sample.) A synthetic polymer is polydisperse, in the sense that a sample is a mixture of molecules with various chain lengths and molar masses. The various techniques that are used to measure molar masses result in different types of mean value. For example, the mean obtained from the determination of molar mass by osmometry gives the number-average molar mass M_n which is the mean molar mass obtained by weighting each molar mass by the number of molecules of that molar mass present in the sample:

In this definition N_i is the number of molecules with molar mass M_i and there are N molecules in all. (The number average is also used for mean score in a test or height of a population.)

Other experiments give a different average. For example, we shall see that viscosity measurements give the viscosity-average molar mass M_v, light-scattering experiments give the weight-average molar mass M_w, and sedimentation experiments can be used to obtain the Z-average molar mass M_z.

5. Conformation and cofiguration.

The primary structure of a macromolecule is the sequence of small molecular residues making up the chain (or network if there is cross-linking). In the сазе of a synthetic polymer, virtually all the residues are identical, and it is

sufficient to name the monomer used in the synthesis. Thus, the repeating unit of polyethylene is $-CH_2CH_2-$, and the primary structure of the chain is specified by denoting it as $-(CH_2CH_2)_n-$.

The concept of primary structure ceases to be trivial in the case of synthetic copolymers and biological macromolecules, for, in general, these substances are chains formed from different molecules. Proteins, for example, are polypeptides, the name signifying chains formed from numbers of different amino acids (about 20 occur naturally) strung together by the peptide link, -CO-NH-. The determination of the primary structure is then a highly complex problem of chemical analysis called sequencing.

The degradation of apolymer is a disruption of its primary structure, when the chain breaks into shorter components.

The secondary structure of macromolecules refers to the (often local) spatial, well-characterized arrangement of the basic structural units. The secondary structure of an isolated molecule of polyethylene is a random coil, whereas that of a protein is a highly organized arrangemem determined largely by hydrogen bonds, and taking the form of helices or sheets in various segments of the molecule.

The loss of secondary structure is called denaturation. When the hydrogen bonds in a protein are destroyed (for instance, by heating, as when cooking an egg) the structure denatures into a random coil.

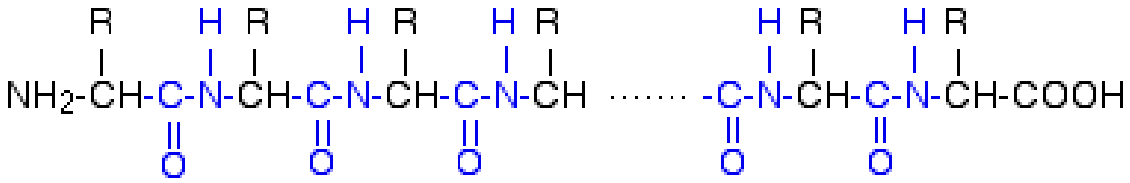
The difference between primary and secondary structure is closely related to the difference between the configuration and the conformation of a chain. The term configuration refers to the structural features that can be changed only by breaking chemical bonds and forming net ones. Thus, the chains - A-B-C- and -A-C-B- have different configurations. The term conformation refers to the spatial arrangement of the di6erent parts of a chain, and one conformation can be changed into another by rotating one part of a chain round the bond joining it to another.

The term tertiary structure refers to the overall three-dimensional structure of the molecule. For instance, many proteins have ahelical secondary structure, but in many proteins the helix is so bent and distorted that the molecule has a globular tertiary structure.

The term quaternary structure refers to the manner in which some molecules are formed by the aggregation of others. Haemoglobin is afamous example: each molecule consists of four subunits of two types (the a and the b chains).

The primary structure of a protein is the sequence of amino acids present in its peptide chain or chains. Knowledge of primary structure tells us which amino acids are present, the number of each, their sequence, and the length and number of polypeptide chains.

The first protein whose primary structure was determined was insulin, the hormone that regulates blood-glucose level; a deficiency of insulin leads to diabetes. The sequencing of insulin, which took over 8 years, was completed in 1953. Today, thousands of proteins have been sequenced; that is, researchers have determined the order of amino acids within the polypeptide chain or chains.



The primary structure of a specific protein is always the same, regardless of where the protein is found within an organism.

The structures of certain proteins are even similar among different species of animals.

For example, the primary structures of insulin in cows, pigs, sheep, and horses are very similar both to each other and to human insulin.

Until recently, this similarity was particularly important for diabetics who required supplemental injections of insulin.

An analogy is often drawn between the primary structure of proteins and words. Words, which convey information, are formed when the 26 letters of the English alphabet are properly sequenced. Proteins, which function biologically, are formed from the proper sequence of 20 amino acids.

The proper sequence of letters in a word is necessary for it to make sense, just as the proper sequence of amino acids is necessary to make biologically active protein. Furthermore, the letters that form a word are written from left to right, as are amino acids in protein formulas.

As any dictionary of the English language will document, a tremendous variety of words can be formed by different letter sequences. Imagine the number of amino acid sequences possible for a large protein.

There are 1.55×10^{66} sequences possible for the 51 amino acids found in insulin! From these possibilities, the body reliably produces only one, illustrating the remarkable precision of life processes. From the simplest bacterium to the human brain cell, only those amino acid sequences needed by the cell are produced.

The secondary structure of a protein is the arrangement in space of the atoms in the backbone of the protein. Three major types of protein secondary structure are known; the alpha helix, the beta pleated sheet, and the triple helix.

The major force responsible for all three types of secondary structure is hydrogen bonding between a carbonyl oxygen atom of a peptide linkage and the hydrogen atom of an amino group (-NH) of another peptide linkage farther along the backbone.

Proteins have varying amounts of α-helical secondary structure, ranging from a few percent to nearly 100 %. In an α-helix, all of the amino acid side chains (R groups) lie outside the helix; there is not enough room for them in the interior. Figure.3d illustrates this situation. This structural feature of the α-helix is the basis for protein tertiary structure.

The beta pleated sheet (β-pleated sheet) secondary structure involves amino acid chains that are almost completely extended. Hydrogen bonds form

between two different side-by-side protein chains (interchain bonds) as shown in Figure.3, or between different parts of a single chain that folds back on itself (intrachain bonds).

The term pleated sheet arises from the repeated zigzag pattern in the structure (Figure.3b). Amino acid side chains are located above and below the plane of the sheet.

Very few proteins have entirely n helix or p pleated sheet structures. Instead, most proteins have only certain portions of their molecules in these conformations. The rest of the molecule assumes a "random structure." It is possible to have both a helix and p pleated sheet structures within the same protein.

Collagen, the structural protein of connective tissue (cartilage, tendon, and skin), has a triple-helix structure. Collagen molecules are very long, thin, and rigid. Many such molecules, lined up alongside each other, combine to make collagen fibers. Cross-linking gives the fibers extra strength.

The tertiary structure of a protein is the overall three-dimensional shape that results from the attractive forces between amino acid side chains (R groups) that are widely separated from each other within the chain.

A good analogy for the relationships among the primary, secondary, and tertiary structures of a protein is that of a telephone cord. The primary structure is the long, straight cord. The coiling of the cord into a helical arrangement gives the secondary structure. Thesupercoiling arrangement the cord adopts after you hang up the receiver is the tertiary structure.

Interactions responsible for tertiary structure. Four types of attractive interactions contribute to the tertiary structure of a protein:

(1) covalent disulfide bonds,

(2) electrostatic attractions (salt bridges),

(3) hydrogen bonds,

(4) hydrophobic attractions.

All four of these interactions are interactions between amino acid R groups. This is a major distinction between tertiary-structure interactions and secondary-structure interactions. Tertiary-structure interactions involve the R groups of amino acids; secondary-structure interactions involve the peptide linkages between amino acid units.

Disulfide bonds, the strongest of the tertiary-structure interactions, result from the –SH groups of two cysteine molecules reacting with each other to form a covalent disulfide. This type of interaction is the only one of the four tertiary-structure interactions that involves a covalent bond. That – SH groups are readily oxidized to give a disulfide bond, – S – S –. Disulfide bonds may involve twocysteine units in the same chain or in different chains.

Electrostatic interactions, also called salt bridges, always involve amino acids with charged side chains. These amino acids are the acidic and basic amino acids. The two R groups, one acidic and one basic, interact through ion — ion attractions.

Hydrogen bonds are relatively weak and are easily disrupted by changes in pH and temperature. Hydrophobic interactions result when two nonpolar side chains are close to each other, In aqueous solution, many proteins have their polar R groups outward, toward the aqueous solvent (which is also polar), and their nonpolar R groups inward (away from the polar water molecules). The nonpolar R groups then interact with each other.

Hydrophobic interactions are common between phenyl rings and alkyl side chains.

Although hydrophobic interactions are weaker than hydrogen bonds or electrostatic interactions, they are a significant force in some proteins because there are so many of them; their cumulative effect can be greater in magnitude than the effects of hydrogen bonding.

In 1959, a protein tertiary structure was determined for the first time. The determination involved myoglobin, a protein whose function is oxygen storage in muscle tissue. It involves a single chain of 153 amino acids with numerous a

helix segments within the chain. The structure also contains a heme group, an iron-containing group with the ability to bind molecular oxygen.

Quaternary structure is the highest level of protein organization. It is found only in proteins that have structures involving two or more polypeptide chains that are independent of each other — that is, are not covalently bonded to each other. These multichain proteins are often called oligomeric proteins. The quaternary structure of a protein involves the associations among the separate chains in anoligomeric protein.

6. The rheological properties of the solutions of HMC

The viscosity of the solution of HMC is much higher than the true solutions and sols, the same concentration.Anomalous viscosity - a characteristic feature of solutions of HMC caused by clutch structured systems. Viscosity increases in proportion to the asymmetry of molecules of molecular weight increase HMC if the same chemical structure (a homologous series) will depend on the concentration and strength. In 1922, Bingham coined the term "plastic flow" because structural grids in the flow break resulting in different rates of flow of the layers. The more the system is structured, the higher the viscosity.

Types of viscosity solutions of HMC

For solutions of HMC are distinguished:

1. Relative viscosity:

$$\eta_{rel} = \eta/\eta_0 = 1 + \beta V$$

Where η is viscosity of the solution; η_0 is viscosity of the solvent; V is volume ratio of polymer; β is the coefficient depending on a form of particles.

2 . Specific viscosity

$$\eta_{sp} = (\eta - \eta_0)\ \eta_0$$

Staudinger derived a formula for the specific viscosity of dilute solutions of rigid rod-HMC

$$\eta_{sp}=KMC$$

where: M is the molecular weight of the polymer, C is mass concentration of the polymer, K is constant polymer-homologous series

3 . Reduced viscosity

$$\eta_{sp}/C = KM$$

Reduced viscosity does not depend on a form of molecules.

4 . Intrinsic viscosity

$$[\eta]= \lim[\eta sp/C]_{C \to 0}$$

It is reduced viscosity at concentration aspiring to zero. Determine graphically by extrapolation to zero concentration or it is possible to calculate on Mark-Kuhn-Hauvinka's equation:

$$[\eta]=\mathbf{KM^B}$$

where B - the coefficient depending on a form of a molecule. This coefficient for flexible molecules has slight size, and for rigid molecules – aspires to one.

On viscosity it is possible to find a molecular mass of polymer by viscometric method.

7. Optical properties of solutions of HMC

Solutions of HMC scatter light,Tyndall effect is observed, although to a lesser degree than in the sols.Apart from light-scattering solutions of HMC may selectively absorb light like true solutions.For some solutions the optical anisotropy is characteristic.This phenomenon is observed in solutions with oblong, capable molecules to deformation.Birefringence provide polymer solutions due to the fact that the optical axes of the individual units located in the space of macromolecules disposed in the space at different angles, and

consequently the difference in refractive indices of the solvent and HMC. HMC solutions for most typical photoelastic anisotropy resulting from the deformation of the polymer particles.

Debye proposed a method for determining the molecular weight of the polymer by turbidity:

$$\tau = HMC$$

where H - coefficient depending on the refractive index of the solvent and the solution, the wavelength of the incident light, osmotic pressure. The molecular weight of the polymers can be determined graphically.

8. Molecular - kinetic properties of solutions of HMC

In solutions of HMC diffusion speed is small. Polymers solutions sedimented only be ultracentrifugation.Equilibrium is established for a long time. Unlike the sol solutions of HMC osmotic pressure is much bigger,because flexible molecules behave like a few short.For dilute solutions of HMC holds the van't Hoff equation.With increasing solution concentration deviations from the van't Hoff equation and must be used Haller:

$$\pi = CRT/M+BC^2,$$

where B - constant depending on the nature of the solvent and the polymer.This precise method. It can be used to determine the molecular weight of HMC.

9. Polyelectrolytes

Polyelectrolytes called HMC, having ionic groups. All polyelectrolytes are divided into:

a) acid-type polyelectrolyte - a substance having-COO^-groups;

b) the basic type polyelectrolyte having a basic group-NH_3^+;

c) polyampholytes containing both acidic and basic groups (proteins).

pH surroundings affects on polyelectrolytes.In the acidic surroundings the protein is positively charged, while in the alkaline - negative.A condition in which the number of opposite charges in the same protein molecule and its overall charge is zero is called isoelectric state and pH corresponding to this state is called the isoelectric point (IEP).

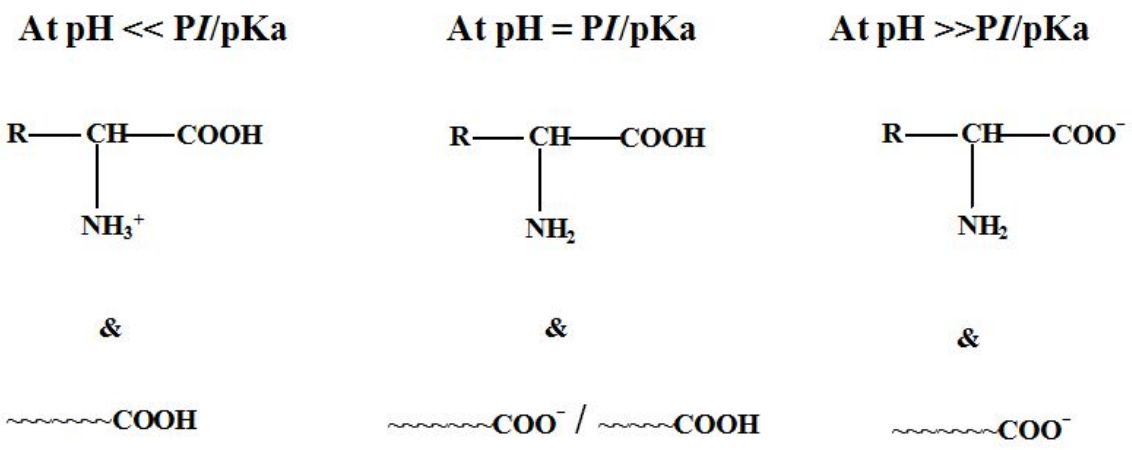


Fig.3. Isoelectric state of a protein

In IEP reduced viscosity of the solutions, the swelling is minimal, drops to zero electric mobility, solubility decreases. At pH less than the isoelectric pH of the protein is in a state of a cationic form, with a pH greater than the isoelectric pH of status - in anionic form.

Isoelectric point can be determined:

1-on degree of swelling (it is minimal in the IEP);

2 on the electrophoretic mobility (it drops to zero at pI);

3 according to the degree of coagulation (it is maximal in the IEP);

4 - by gelation (with a maximum IEP).

In the IEP pH equal to the arithmetic mean of indicators of acidity and basicity constants of the protein molecule.

In polyelectrolyte solutions must take into account the Donnan membrane equilibrium.

Membrane called Donnan equilibrium balance in the system establishes the solutions separated by a membrane which is impermeable to at least one ion species.

The presence of HMC and low molecular electrolytes solutions separated by a membrane, affect the osmotic pressure on both sides of the membrane. Donnan equilibrium ion treated on both sides of the cell membranes. Through the cell membrane might penetrate true electrolyte ions, but ions trapped large polyelectrolytes, e.g. anions or cations proteins.

Ion detained by a membrane, call don’t dialyzable.

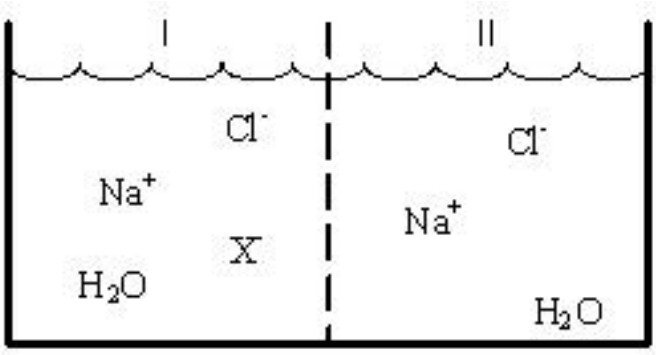


Fig. 4.Donnan membrane equilibrium (X-nondialyzable ion)

Consider the ionic equilibrium between the cell and the external environment. Assume that the inside is a sodium salt of protein dissociating:

$XNa = X^- + Na^+$

Outside, there is sodium chloride, dissociating:

$NaCl = Na^+ + Cl^-$

Sodium and chloride ions can pass through the membrane and ion X - nondialyzable ion.

Suppose that from the external environment enters the cell "D" of chlorine ions, then it will move together with the cage in the same amount of sodium ions,that is the system has to remain electroneutral. Let's designate an ion concentration C, and extracellular electrolyte - Cn.

Then in a general view Donnan's equation:

$D=Cn^2/Cb+2Cn$

Consider the basic three possible cases:

1-Outer concentration much greater than the concentration inside the cell, while Cb as a small quantity, can be neglected. Electrolyte evenly distributed on both sides of the membrane

2-outdoor concentration is much smaller than the inside.

Ion distribution will depend on the ratio of Cn and Cb

3-concentration inside and outside the cell are equal - will pass through the membrane while 1/3 of all ions.

10. Sustainability factors solutions of HMC

Solutions of HMC as true solutions, and stable aggregate state is thermodynamically stable. As conditions change, due to the large dimensions of macromolecules HMC stability is violated.

It arises at: centrifugation, dehydration, change pH (it is less pH=3 more pH=10), that is in sour and alkaline environments.

Polymer solutions are stable over the pH range 4 to 9.

To physical factors influencing stability of solutions of HMC are negative: temperature is higher than 50^0C; multiple freezing and thawing; build-up of pressure; ultrasound action; ultraviolet rays; radiation; introduction of electrolytes.

The process of selecting the HMC from the solution by desolvation of macromolecules electrolytes called salting-out.

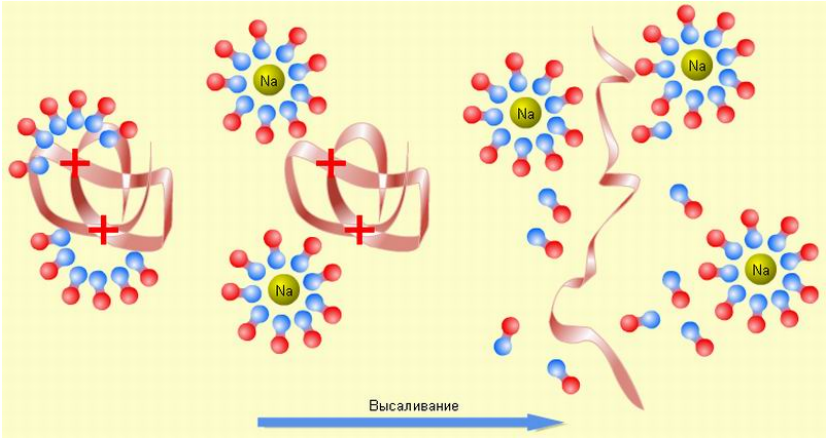


Fig. 5 Salting-out by electrolytes.

Salting-out reversible and require high concentrations (in contrast to the coagulation) salting-out effect depends on the electrolyte hydration abilities. In 1889 W. Hofmeister showed that salted-out mainly anions. By the force of the action he placed them in a row:

$$CNS^- > J^- > Br^- > NO_3^- > Cl^- > CH_3COO^- ..... > SO_4^{2-}$$

- Ions standing in a row to the left of the chlorine ion reduce resistance, right - increase.

The concentration of the electrolyte, at which a rapid precipitation of the polymer is called the threshold salting-out of HMC.

Almost salting applicable for fractional separation of mixtures of proteins, polysaccharides, amino acids.

Kreuth proposed scheme of deposition of HMC.The essence of the process lies in the fact that the loss of stability of the polymer , it is necessary to remove the water and remove the shell of charge with polyelectrolyte molecules . To this effect the particle alcohol (aqueous shell removed) , and then neutralize the charge of the electrolyte . The sequence does not matter. You can remove the original charge of the particle , and then - dehydrated . These two processes can replace a large concentration of the electrolyte , providing charge and

removal of particles and dehydration can be used instead of alcohol acetone, instead of salts - acid or alkali solution with the appropriate pH value .

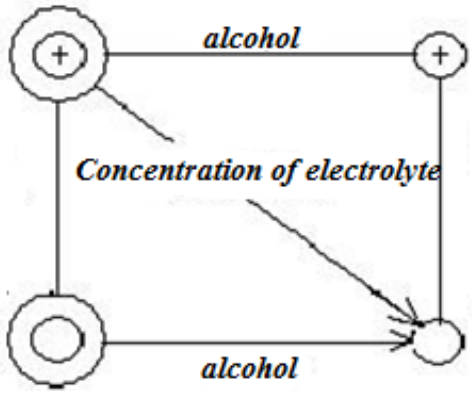


Fig. 6 Kreuth's scheme of salting-out

11. Effect of concentration on the properties of solutions of HMC

Strong solutions possess specific properties:1 - the considerable viscosity, 2 - formation of reticulate structures, 3 - the thixotropy is characteristic is a reversible isothermal destruction of structure and restitution her ambassador of the termination of mechanical influence.

It is reversible transition of sol to gel and vice versa; 4 - the coacervation is a selection of a new phase in the form of shallow droplets.

Arises when strengthening, temperature fall, change pH, introduction of low-molecular electrolytes, 5 - jellification – process of deep structuring with grab of all dispersion medium in uniform system, i.e. macromolecules form grids, a framework in which 99% of mass of solvent keep.

Process of jellification influence: concentration, temperature, form of particles, SAS, effect of electrolytes.

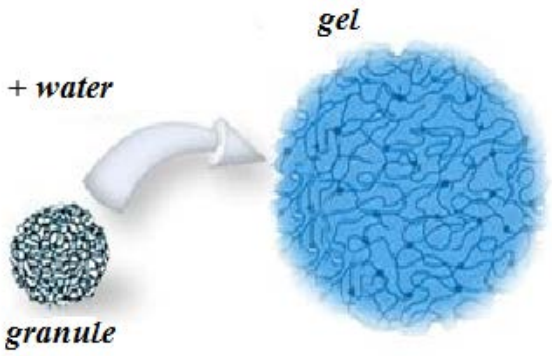


Fig. 7 Sol-gel transition

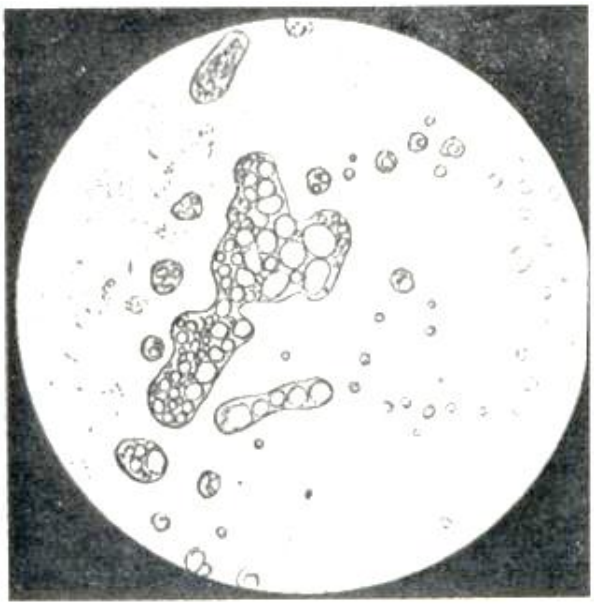


Fig. 8 Coacervation in solutions of HMC

Transition of solutions of polymers to not fluid elastic form is called as a gelation. Polymeric jellies can be homogeneous (1 type) and heterogeneous (the 2nd type).

Reactions in jellies flow past sluggishly since the space grid interferes with diffusion.

If resultants of reaction are insoluble, they deposit with layers in the form of the concentric painted deposits which are called as Lizegang's rings. Such reactions are called periodic (cause stones in kidneys, a liver).

Heterogeneous polymeric jellies are formed as a result of a coacervation at disintegration of solution of not sewed polymer. There is a two-phase nonequilibrium system.

12 . Methods of receiving jellies

All methods of receiving jellies divide into two larger groups:

1 jellification;

2 swelling of nonvolatile solids in the corresponding fluid environments;

Gelation mechanism of the process can be represented as elongated macromolecules , colliding with each other during the motion , joined lyophobic areas. The result is a loose mesh frame . Between molecules of solvent and ionization groups of macromolecules communications are formed. Emergence of internal structures is observed. Such connections are fragile . Shaking enough to destroy the structure of jelly, and again to get a solution which on standing may freeze again, so observed thixotropy.

The process of jellification is not accomplished instantaneously, but requires the time necessary for rearrangement of components in the viscous system. This process is called as maturing which proceeds and after formation of jelly and is expressed in acquisition of larger mechanical strength by it.

Electrolytes have different influence on the jellification. Effect of cations is little different from each other.

Anions are arranged so:

$SO_4^{2-} > Cl^- > NO_3^- > J^- > CNS^-$

As much as possible sulfate ion, and rhodanate influences - the ion already brakes.

Of great importance is pH. Rate of jellification increases at an approximation pH to an isoelectric point.

Action of nonelectrolytes is specific: the nonelectrolytes reducing solubility, promote jellification. The form of particles so affects process: well gelatinize the solutions formed by threadlike or taenioid HMC.

13. Common properties of jellies

1 - reversible deformation - the ability to reversibly change shape under the applied stress;

2 - flowing - irreversible deformation - after the application of large loads. greater than the critical shear stress;

3 - slow diffusion (batch reactions, the formation of Liesegang rings);

4 - syneresis - exudation of jelly, the aging of its division into two phases. Causes syneresis - change system parameters: temperature, external field of force due to formation of additional bonds , the change in pH of the medium , the action of oxygen or impurities by mechanical action. The volume is reduced, but the shape is retained. Syneresis regulates vital functions of cells of living organisms, explains aging. It can strengthen , speed up or slow down a spontaneous process, so can not be eliminated.

5 - thermal reversibility is a characteristic of heterogeneous gels. Not the case with homogeneous gels, as they are thermally irreversible.

QUESTIONS FOR SELF-PREPARATION

1. Explain the terms monomer and polymer.
2. What are natural and synthetic polymers? Give two examples of each type.
3. Distinguish between the terms homopolymer and copolymer and give an example of each.
4. How do you explain the functionality of a monomer?
5. Define the term polymerization.
6. Is (NH-CHR-CO)n a homopolymer or copolymer?
7. In which classes, the polymers are classified on the basis of molecular forces?
8. How can you differentiate between addition and condensation polymerization?
9. Explain the term copolymerization and give two examples.
10. Write the free radical mechanism of polymerization of an alkene.
11. Define thermoplastics and thermosetting polymers with two examples of each.
12. Write sstructures of monomers used for getting the following polymers: a. PVC b. Teflon c. PMMA
13. Write the name and structure of one of the common initiators used in freeradical addition polymerisation.
14. How does the presence of double bonds in rubber molecules influence theirstructure and reactivity?
15. Discuss the main purpose of vulcanization of rubber.
16. What are the monomeric repeating units of Nylon-6 and Nylon-6, 6?
17. What is a biodegradable polymer? Give an example of a biodegradable aliphatic polyester.
18. Classification of solutions of polymers.
19. In what feature of disolution of polymers?
20. What features of a structure of molecules of HMC define? the abnormal properties of solutions of polymers?

21. Swelling. Than degree and swelling speed is characterized?
22. What influence of various electrolytes on swelling value?
23. What understand as restricted and unlimited swelling?
24. By what principle ions in lyotropic series are located?
25. How change thermodynamic functions at the spontaneous dissolution of the HMC?
26. Characterize types of viscosity of solutions of HMC?
27. What is the swelling pressure? Pozdnyak's equation?
28. Isoelectric point gelatin. Isoelectric condition of a proteinaceous molecule.
29. What is the syneresis? Its biological value.
30. What methods of definition of IET of protein to you are known?
31. By what methods it is possible to determine a molecular mass of polymer?

TASKS

Task 1.

Predict the products of the following reactions:

a) benzene-1,4-dicarboxylic acid with 1,2-diaminoethane

b) hexane-1,6-dioyl chloride with propan-1,2-diol

c) ethanedioicacidwith ethan-1,2-diol

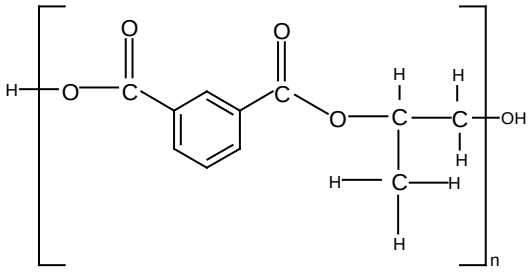
Task 2.

From what monomers can the following condensation polymers be made:

a) terylene

b) nylon 66

c)



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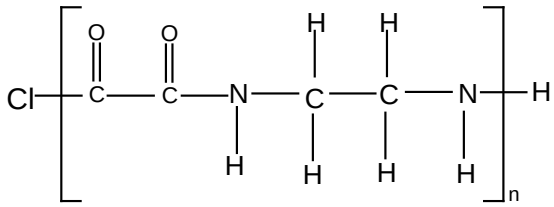
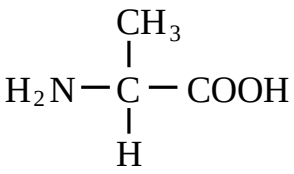
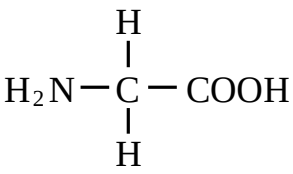


Task 3.

The structures of the amino acids *alanine* and *glycine* are shown below.



alanine



glycine

(a) Give the systematic name for *alanine.*

(b) *Alanine* exists as a pair of stereoisomers. Explain the meaning of the term *stereoisomers.* State how you could distinguish between the stereoisomers.

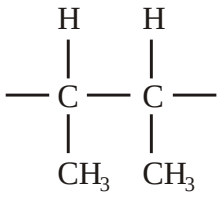
(c) Give the structural formula of the species formed by *glycine* at pH 14.

(d) When two amino acids react together, a dipeptide is formed. Give the structural formulae of the **two** dipeptides which are formed when *alanine* and *glycine* react together.

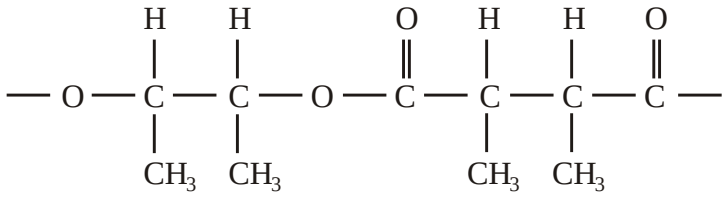
(e) Give the structural formula of the organic compound formed when *glycine* reacts with methanol in the presence of a small amount of concentrated sulphuric acid.

Task 4.

(a) The repeating units of two polymers, **P** and **Q**, are shown below.



P



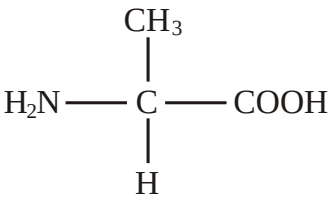
Q

Draw the structure of the monomer used to form polymer **P**. Name the type of polymerisation involved.

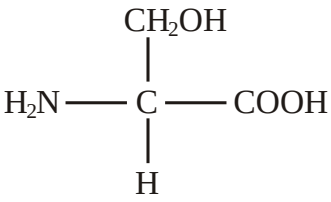
Draw the structures of **two** compounds which react together to form polymer **Q**. Name these **two** compounds and name the type of polymerisation involved.

Identify a compound which, in aqueous solution, will break down polymer **Q** but not polymer **P**.

(b) Draw the structures of the **two** dipeptides which can form when one of the amino acids shown below reacts with the other.



Structure 1

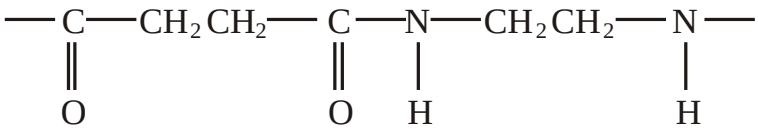


Structure 2

(c)Propylamine, $CH_3CH_2CH_2NH_2$, can be formed either by nucleophilic substitution or by reduction. Draw the structure of a compound which can undergo nucleophilic substitution to form propylamine. Draw the structure of the nitrile which can be reduced to form propylamine.State and explain which of the two routes to propylamine, by nucleophilic substitution or by reduction, gives the less pure product. Draw the structure of a compound formed as an impurity.

Task 5.

(a) The structure below shows the repeating unit of a polymer.



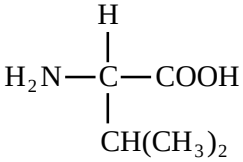
By considering the functional group formed during polymerisation, name this type of polymer and the type of polymerisation involved in its formation.

(b) Draw the structure of the species present in solid aminoethanoic acid, H_2NCH_2COOH

(c) Explain why the melting point of aminoethanoic acid is much higher than that of hydroxyethanoic acid, $HOCH_2COOH$

Task 6.

(a) Consider the following amino acid.



Draw the structure of the amino acid species present in a solution at pH 12.Draw the structure of the dipeptide formed from two molecules of this amino

acid.Protein chains are often arranged in the shape of a helix. Name the type of interaction that is responsible for holding the protein chain in this shape.

(b) Consider the hydrocarbon **G**, $(CH_3)_2C=CHCH_3$, which can be polymerised. Name the type of polymerisation involved and draw the repeating unit of the polymer. Draw the structure of an isomer of **G** which shows geometrical isomerism.Draw the structure of an isomer of **G** which does not react with bromine water

THESTANDARDANSWERS

Example #1

Determine the rate constant swelling of the polymer, if the initial weight of the polymer sample is 100g, and at time 8:00 - 102g. The maximum degree of swelling is 0.3.

Decision.

α =(m-m_0 ₀)/m_0 =(102-100)/100= 0,02

k=$\frac{1}{t} \cdot ln \frac{\alpha_{max}}{\alpha_{max}-\alpha_1} = \frac{1}{8} ln \frac{0,3}{0,3-0,02}$=0,008 hour^{-1}

Example #2

Human plasma protein (albumin) has a molecular weight of 69,000. Calculate the osmotic pressure of the solution, which contains 2 mg of protein in 100 ml at constant C. 25□ is 0.51.

Decision.

c = 2 mg / ml = 2 EP / m ³; 69000g/mol = M = 69kg/mol;

$\pi = \frac{cRT}{M} + bc^2 = \frac{2 \cdot 8,31 \cdot 298}{69} + 0,51 \cdot 2^2$=73,82 Pa

Example #3

Staudinger equation constants for a synthetic rubber in such chloroform: α = 0,56; K = 1,85 • mol / m³. Determine what is the intrinsic viscosity of the sample having a molecular weight of 300,000.

Decision.

[η] = K • = 1,85 • 3 • 5,55 m³ / mol

Task 4. Determine the sign of the charge of the particles globulin (p = 5.4) which is in a buffered solution at pH = 3.2.

Decision.

Since the pH of the buffer solution is less than p globulin particles have a positive charge

NH_3-R-COO^- + H → NH_3-R-COOH.

Example #4

Draw two repeating units of the polymer produced by the following alkenes:

a) propene

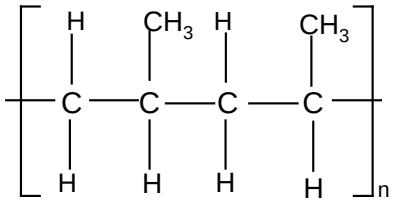
b) but-1-ene

c) but-2-ene

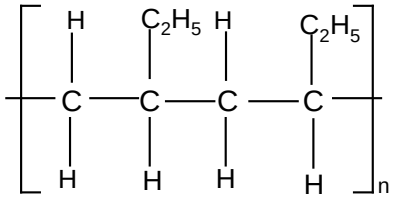
d) phenylethene

Answer:

a)



b)



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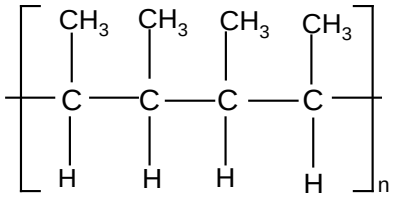

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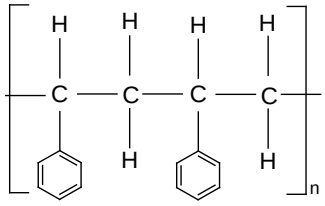
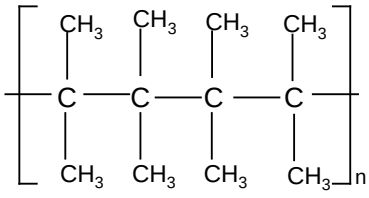


Example #5

Name the following polymers and draw the monomer from which the polymer is made:

a)



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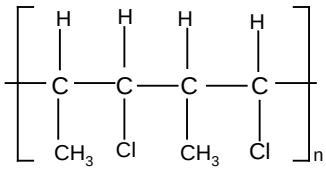
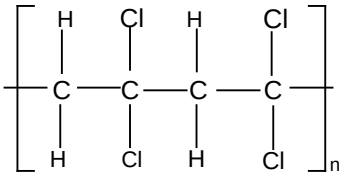
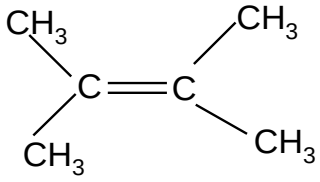


c)

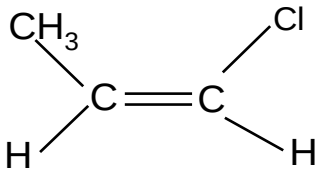


Answer:

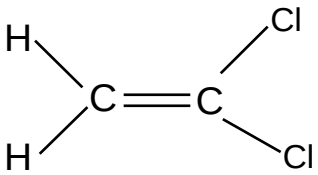
a) poly(2,3-dimethylbut-2-ene)



b) poly(1-chloropropene)



c) poly(1,1-dichloroethene)



EXPERIMENTAL PART

Laboratory work: Definition of gelatiniso-electric point, finding the dependence of gelatin swelling degree from pH.

Prepare the following solutions in the tubes (look at the table). Calculate the pH of buffer mixtures using $K_{CH_3COOH} = 1{,}76 \cdot 10^{-5}$

Put thoroughly mashed gelatin powder into six narrow tubes, gelatin powder height in the tube must be 0,5 cm=a_1. Then add 5 ml of solutions listed in table. Gently shake and left for 40 minutes. Then, using strips of graph paper determine the height of the gel (a_2) and calculate the degree of swelling:

$$B = \frac{a_2 - a_1}{a_1} \times 100,$$

where, B – swelling degree, %,

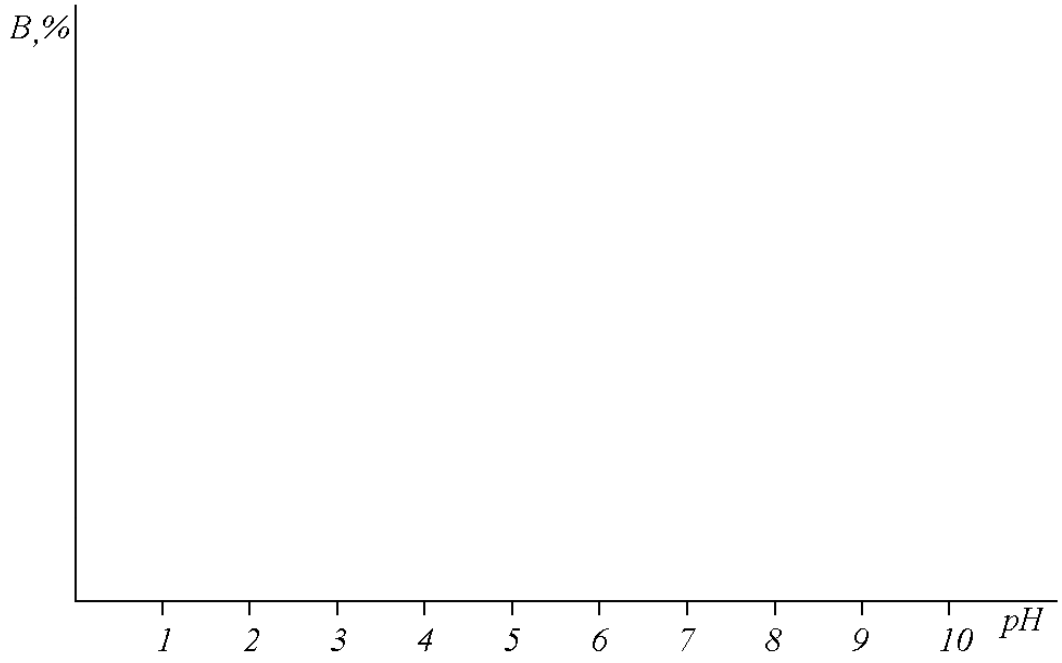
a_1 and a_2 - the height of sediment before and after swelling , cm.

Таблица:

№ tube	buffer mixtures, ml		pH	a_1	a_2	$\frac{a_2 - a_1}{a_1}$	Swellingdegree 100%
	0,1 eq/l	0,1 eq/l					
	CH_3COOH	CH_3COONa					
1	9	1					
2	7	3					
3	5	5					
4	3	7					
5	1	9					
6	H_2O, 10,0 ml						

Built the graph B = f(pH).

Findiso-electric point.



The dependance of swelling degree on pH

TESTS

Orlon is a polymer of

a) Styrene

b) Vinyl chloride

c) Tetrafluoro ethylene

d) *Acrylonitrile

Polymer formation from monomers starts by

a) Condensation reaction between monomers

b) Conversion of monomer to monomer ions by protons

c) *Coordinate reaction between monomers

d) Hydrolysis of monomers

Which of the following is not an example of natural polymer

a) Wool

b) *Leather

c) Silk

d) Nylon

Which of the following is not a polymer

a) Gun cotton

b) Shellac (eg. lac shellac)

c) Perspex

d) *Wax (eg. bees wax)

Terylene is used for making

a) Silks

b) Seat belts

c) Fabrics

d) *All of these

Glyptal is a

a) Viscose rayon
b) Polystyrene
c) Nylon
d) *Alkyd resin

The synthetic polymer which resembles natural rubber is

a) *Neoprene
b) Glyptal
c) Chloroprene
d) Nylon

Which of the following is an example of condensation polymer

a) Nylon
b) Urea-formaldehyde resin
c) Bakelite
d) *All of these

Which is a naturally occurring polymer.

a) Polythene
b) Acetic acid
c) PVC
d) *Protein

The catalyst used in the manufacture of polyethene by Ziegler method is

a) Titanium tetrachloride and triphenylaluminium
b) Titanium dioxide
c) *Titanium tetrachloride and trimethylaluminium
d) Titanium isopropoxide

Which one of the following is a linear polymer

a) Amylopectin

b) Starch

c) Glycogen

d) *Amylose.

Whichis not a polymer

a) *Ice

b) Protein

c) Starch

d) Cellulose

Perlonis

a) Rubber

b) Terelene

c) *Nylon-6

d) Oxlon

The product of addition polymerisation reaction is

a) *Terylene

b) Nylon

c) Polyamide

Which of the following is a chain growth polymer

a) Nylon-6

b) Glyptal

c) Dacron

d) *Polypropylene

Which of the following is fully fluorinated polymer

a) Neoprene
b) Thiokol
c) *Teflon
d) PVC

Three dimensional molecules with cross links are formed in the case of a

a) Thermoplastic
b) Both
c) *Thermosetting plastic
d) None

The basis on the mode of their formation, the polymers can be classified

a) As addition polymers only
b) As copolymers
c) As condensation polymers only
d) *Both as addition and condensation polymers

Which of the following is a step-growth polymer

a) Polyisoprene
b) *Nylon
c) Polythene
d) Polyacrylonitrile

The alkyd resins are condensation polymers obtained from dibasic acids and

a) *Phenol
b) Glycerol
c) Glycol
d) Formaldehyde

Which one among the following is a thermosetting plastic

a) PVC
b) *Bakelite
c) PVA
d) Perspex

Acetate rayon is prepared from

a) Acetic acid
b) Starch
c) Glycerol
d) *Cellulose

Which of the following has been used in the manufacture of non-inflammable photographic films

a) Cellulose nitrate
b) Cellulose xanthate
c) *Cellulose acetate
d) Cellulose perchlorate

The polymer used for making contact lenses for eyes is

a) *Polymethylmethacrylate
b) Polyethylacrylate
c) Polyethelene
d) Nylon-6

PVC is used for ……..

a) Manufacture of cosmetics
b) Manufacture of nonstick pans
c) Manufacture of tyres
d) *Manufacture of plastic pipes

Which of the following is not correct regarding terylene

a) Step-growth polymer
b) Condensation polymer
c) Synthetic fibre
d) *Thermosetting plastic

Which of the following is not an example of additional polymer

a) *Terylene
b) Polyethylene
c) Polypropylene
d) Polystyrene

Bakelites are

a) Rubber
b) *Resins
c) Rayon
d) Plasticisers

Molecular mass of a polymer is

a) Small
b) Negligible
c) Very small
d) *Large

Synthetic fibres like nylon-66 are very strong because

a) They have high molecular weights and high melting points
b) They have linear molecules consisting of very long chains
c) They have a high degree of cross-linking by strong C-C bond

d) *They have linear molecules interlinked with forces like hydrogen bonding

The molecular weight of cellulose varies between

a) 1000 to 20000
b) 100 to 200
c) *20000 to 500000
d) 1000000 to 5000000

Which of the following is a chain growth polymer

a) *Polystyrene
b) Starch
c) Protein
d) Nucleic acid

Melamine is

a) Gas
b) *White crystalline solid
c) Yellow liquid
d) Colloidal solution

Natural rubber is which type of polymer.

a) Condensation polymer
b) Co-ordination polymer
c) *Addition polymer
d) None of these

Celluloid is

a) A thermoplastic material obtained from caprolactam and urea
b) A thermosetting material obtained from urea and formaldehyde

c) *A thermoplastic material obtained from cellulose nitrate and camphor

d) A thermosetting material obtained from glycerol and phthalic anhydride

Which of the following statement is correct regarding the drawbacks of raw rubber

a) It is plastic in nature

b) It has large water-absorption capacity

c) It has little durability

d) *All of these

The catalyst used for the polymerisation of olefins is

a) *Ziegler Natta catalyst

b) Pd-catalyst

c) Wilkinson’s catalyst

d) Zeise’s salt catalyst

Among the following a natural polymer is

a) *Cellulose

b) Teflon

c) PVC

d) Polyethylene

The starting material for the preparation of styrene is

a) Ethane

b) *Ethyne

c) Ethene

d) Vinyl chloride

Polyvinyl chloride is

a) An isomer of vinyl chloride
b) An allotrope polymer of vinyl chloride
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d) A polymer of hydrated vinyl chloride

Triethylaluminium titanium chloride used in plastic industry is a

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Complete hydrolysis of cellulose gives.

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Which of the following is synthetic rubber.

a) Buna-S
b) *Both (a) and (b)
c) Neoprene
d) None of these

Polyethylene is

a) Random copolymer
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Which of the following is not polyamide

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d) Nylon-6

PVC is prepared by the polymerisation of.

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Cellulose is a polymer of

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d) Sucrose

Caprolactam is the monomer of.

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Rayon is

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