Colloidal solutions or sols

1. The concept of dispersed systems.
2. The conditions and methods of obtaining colloidal solutions.
3. Methods of purification of colloidal solutions.
4. The properties of colloidal solutions.
5. Structure of colloidal particles.
6. Stability and coagulation of dispersed systems.

Colloid chemistry - the science that studies the physical-chemistry of heterogeneous systems and surface phenomena.

1. The concept of dispersed systems. Dispersion, a degree of grinding material. Measurement of dispersion is the value of specific surface area, which is the ratio of the total surface of all particles to their mass. Some highly substances have a high degree fragmentation. Thus, the number of particles in 1g aerosol reaches $4 \cdot 10^{16}$, and the surface area is 300 m^2 / g. In dispersed systems where one substance in the crushed state of uniform development divides into particles of different substances. There is dispersed phase (dispersed re- substances, or particles) and dispersed medium (is solvent). The main feature of dispersed systems is the presence of surface phase distribution, known as heterogeneity.

The size of the particles in dispersed systems is divided into three types:

1. A rough-dispersed systems (suspensions, emulsions, powders, coarse suspension) - particle size more than 1 m (10.6 m) and surface area less than $1 m^2$ / g;

2. Systems dispersion medium 1 - 0.1 m (10.6 - 10.7 m); sometimes they unite with roughly-dispersed systems.

3. Colloidal dispersion system (or ash) have a particle size of 100 - 1 nm (10.7 - 10.9 m), and specific surface area more than 10 m^2 / g.

Next come true (molecular and ionic) solutions that have a particle size of less than 10.9 m.

These solutions have no interface between the phases and they do not belong to dispersed systems.

Roughly disperse systems	Colloidal systems	True solutions
Opaque	Transparent, opalescent	Transparent not opalescent
Have a surface section of phases	Have a surface section of phase	Do not have the interface
The particles are cerises paper filter	Particles are cerises paper filter but linger with cellophane	Particles pass through a paper filter and cellophane
Unstable kinetically and thermodynamically	Relatively stable kinetically	Stable kinetically and thermodynamically
Grow old in time	Grow old in time	Do not grow old in time
The particles visible in optical microscope	Particles visible in electrode microscope	Particles are not visible modern microscopes

With the state of aggregation of the dispersed phase and dispersed heterogeneous systems environment divided into solid, liquid, gases (Table 2).

Table 2. Types of heterogeneous systems

Disperse phase	Dispersed environment (solvent)	Short marking	Examples of systems
Liquid	Gas	l/g	Mists, aerosols of liquid substances
Solid	Gas	s/g	Fumes, aerosols solids
Gas	Liquid	g/s	Foam, gas emulsion
Liquid	Liquid	l/l	Emulsions (e.g. milk)
Solid	Liquid	s/l	Suspensions and colloidal solutions
Gas	Solid	g/s	Solid foam, pumice, active carbon
Liquid	Solid	l/s	Gels, Jelly
Solid	Solid	s/s	Metal alloys, natural minerals

The type of interaction between dispersed phase and dispersion medium are distinguished:

Freeze system - in which the dispersed particles interact strongly with the solvent. In the case when the solvent is water, they can be called hydrophilic systems. Example - solutions of proteins or polysaccharides in water;

Lyophobic system - in which the dispersed particles interact weakly with the solvent. In the case when the solvent is water, these systems can be called hydrophobic, as surface of particles slightly moistened with water. Examples - colloidal solutions noble metals.

2. The conditions and methods of obtaining colloidal solutions.

The term "colloidal" solution offered by Thomas Graham (from the Latin word cola - adhesive) noting their similarity with solutions adhesives. Colloidal solutions take intermediate position between coarse and true systems solutions. For cooking of colloidal solutions must adhere to certain conditions, namely:

1. The particle size should be between 10.7 - 10 to 9 m.

2. Required electrolyte ions that form ion layer around colloidal particles, giving it stability.

3. Dispersed phase hydrophobic colloidal solutions must have a low solubility in water.

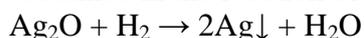There are 2 methods of obtaining colloidal solutions:

The dispersion method is grinding to small particles of matter. On- grinding exercise: 1) mechanically (ball mills, blenders, ultra- disintegrates sound); 2) physical-chemical way - peptization method - sediment material translated into colloidal state by adding surfactants - soaps, protein or electrolyte (for $Fe(OH)_3$).
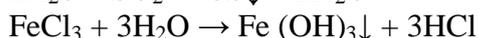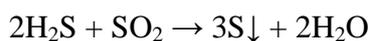
Condensation method is aimed at increasing the size of the particles through aggregation molecules or ions. For this purpose:

1) Solvent evaporation, resulting in Condensation is a solid phase;

2) Replacement of solvent, such as alcohol solution hole- sterol poured into water;

3) Use of reactions in which precipitates are formed from small particles. Thus, obtaining a colloidal solution of silver iodide is the reaction of substitution:

$$KJ + AgNO_3 \rightarrow AgJ\downarrow + KNO_3$$
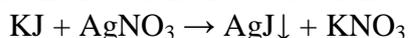
Colloidal solutions can be obtained in the reaction of reduction or oxidation or hydrolysis:

$$Ag_2O + H_2 \rightarrow 2Ag\downarrow + H_2O$$

$$2H_2S + SO_2 \rightarrow 3S\downarrow + 2H_2O$$
$$FeCl_3 + 3H_2O \rightarrow Fe\,(OH)_3\downarrow + 3HCl$$

3. Methods of purification of colloidal solutions. Cleaning colloidal solutions is needed to eliminate excess ions impurities, whose presence decreases their stability.

Dialysis - is removing low molecular impurities by diffusion through semi-permeable membrane. For this colloidal solution is injected into the bag of such membranes (e.g. cellophane) and immersed in distilled water. The molecules or ions with the size smaller than the pores of the membrane will pass from the solution into the water. To speed dialysis, you can create an electric field (electro dialysis), which accelerates the transition ions. The principles are used in dialysis apparatus "artificial kidney", where blood flows through semi-permeable and passes through the artificial membrane. On one side of the membrane circulates compressed liquid - such as saline, and the other - the blood of the patient. In resulting, compensatory excess fluid passes number of metabolites and toxins that accumulate in renal disease. Ultrafiltration- is the filtering of colloidal solution through semi-permeable membrane at high pressure. These colloidal particles are trapped membrane, and impurities leaving clonidine solution.

Ultracentrifugation - the process of the separation of particles based on their size and mass under acceleration, which creates centrifuges, giving 100 thousand revolutions per minute. In this way, they cannot distinguish particles of a certain size, but are divided in subcellular fractions. For precipitation, nuclei need to create acceleration of 600 g, mitochondria - 8000 - 12000 g, endoplasmic reticulum - 100000 g.

4.1. Molecular-kinetic properties of colloidal solutions.

Brownian motion was discovered by botanist Robert Brown in 1828 when observing Romanians Hu pollen, suspended in water. Chaotic motion is inherent and colloidal solutions. Colloidal particles in contact with the solvent molecules, acquire kinetic motion (particles at 1020 can change the position of a second).

Diffusion - the process of spontaneous leveling concentration of dispersed substance the influence of the thermal motion of particles solvent. Diffusion in colloidal solutions is slower than real solutions. If true solution diffusion particles at a distance of 1 cm is hour, then in colloidal solutions will be- days and weeks. The diffusion coefficient can be estimated by development measures of colloidal particles, the equation of Einstein:

$$D = \frac{R \cdot T}{6 \cdot \pi \cdot r \cdot N_A \cdot \eta}$$

Osmotic pressure- The phenomenon is typical for systems with semi-permeable membranes. The magnitude of the osmotic pressure (P) is defined by the known equation ($P = S \cdot R \cdot T$).

Sedimentation is the deposition of particles by the force of gravity. This process is reverse diffusion and leads to the formation of the concentration gradient, while the diffusion leads to equalize the concentration. Between the sedimentation and diffusion, eventually installed decisions and the small particles that diffuse better are placed mainly in upper solution, and larger particles are mainly in the lower layers of the solution. Phenomenon sedimentation is for fractionating substances, cell organelles, and molecular weight determination biopolymers by centrifugation.

Viscosity - is the internal friction between layers of solution, which move relative to each other. The magnitude of the reverse flow is viscosity environment. Colloidal solutions are more than true solutions, due to the larger particle size.

4.2. Optical properties of colloidal solutions. The passage of light through colloidal systems causes three optical effect: absorption, reflection and scattering of light. Thus, in absorption characteristics of all systems, there is more reflection characteristics of the coarse systems (emulsions and suspensions), where the particle size is much larger than the wavelength radiation. But unlike the molecular and ionic solutions, which are optically uniform because they do not have the interface phase colloidal solutions scatter light. Furthermore, by passing the parallel beam background through a colloidal solution is

observed by scattered light cone - Tyndall effect. With the ability, ions may diffuse light to determine the concentration of colloidal particles in solution. This nephelometry method is called.

Electro kinetic properties of colloidal solutions known as electro kinetic phenomenon, which first saw the famous doctor FF Flight in 1809.

Electro osmosis - the phenomenon of movement dispersed medium (is solvent) is absence of relatively immobile dispersed phase, which can be observed when an electric current through the U-shaped glass tube filled with quartz sand and water. At the cathode part tube is observed by raising the water level (Figure 1).

Electrophoresis - a phenomenon of movement relative to disperse the colloidal particles medium (solvent), under the influence of constant electric current. Thus, when passage of electric current through the device of two glass tubes is installed in damp clay detached from the surface of negatively charged particles of clay, it is moved to anode (Fig. 1). Electrophoresis method is widely used in medicine for dividing different proteins, nucleic acids, and even cells. There are many variants: free electrophoresis, paper electrophoresis on agar gel, polyacrylamide gel, and others.
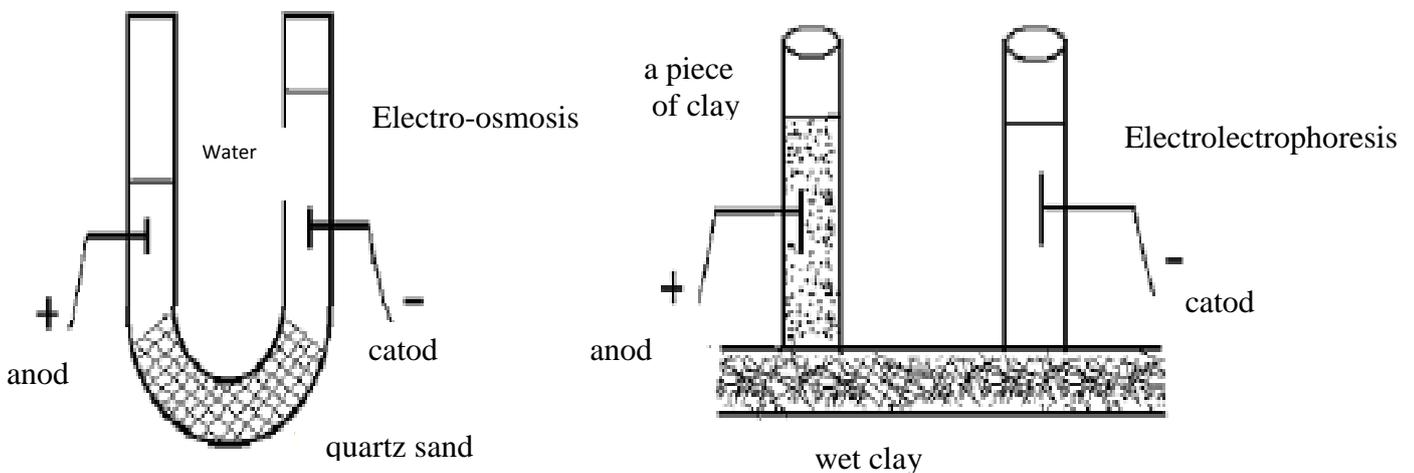
Free electrophoresis, Tiselius suggested Arne, who shared whey proteins blood (Nobel Prize). The principle of the method is that the protein mixture is placed in a cuvette with buffer solution in contact with the electrodes. Under constant electric current fibers begin to move. Fastest moved albumin, alpha 1-second globulins, third alpha 2-globulins, beta-globulins fourth and fifth gamma globulin. This method is technically challenging and requires special optical system for surveillance the movement of proteins. Much simpler is electrophoresis on paper. A strip of filter paper moistened buffer at one end of the strip is applied to a mixture of proteins, and the both ends respectively cathode and anode of the DC power supply. Since different proteins have different charge they move at different speeds in the electric field due to chum and their separation.

Great achievement was in electrophoresis gels (agar, and polyacrylamide others). Gels are a mesh structure and molecular sieves. Depending on pore size in gels some proteins can pass through it, others stay for longer time. Therefore, under these conditions is ensured not only separation of molecules by size of their charge, but also their size. Electrophoresis in agar gel has become the main method in the analysis of the structure of DNA and RNA and it is used during the polymerase chain reaction that I can detect viruses, genetic mutations, establish paternity.

Potential flow - an electric potential flow of solvent in relatively immobile dispersed phase. Potential sedimentation - of the potential difference between the electrodes, which set at different heights cylinder, in which the dispersed phase deposition.

5. Structure of colloidal particles.

It is believed that the colloidal solution consists of micelles formed by charged colloidal particles. The charge arises from the selective adsorption of ions on the surface of chap articles, or by ionization of surface functional groups of the solid phase.

In the micelle are three components: core layer adsorption and ion diffusion corrosion layer of ions. The kernel is the bulk of the micelles and is a combination of neutral atoms or molecules and a total of hundreds of millions of units. At the core of adsorbed ions (sample adsorption) which give it a certain charge, so-called potential forming. The potential that occurs in the nucleus got another name electrodynamic due to subsequent accession to the potential-forming ions with certain number of other ions of opposite sign charge. This electric double layer-forming potential ions with counterions (ions of opposite sign) is ion adsorption layer.

Some are poorly counterions are connected to the potential-forming ions are freely stirred in a solvent to form a diffusion layer. Kernel with adsorption and diffusion layers of ions and micelles is that, the whole is electroneutral (whereas the colloid chap article carries a charge).

Consider the micelle structure of silver iodide, which is formed by the following reaction:
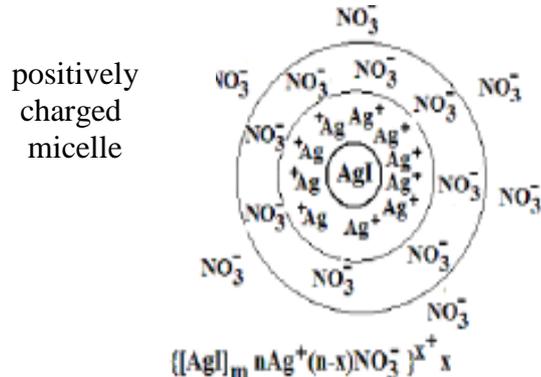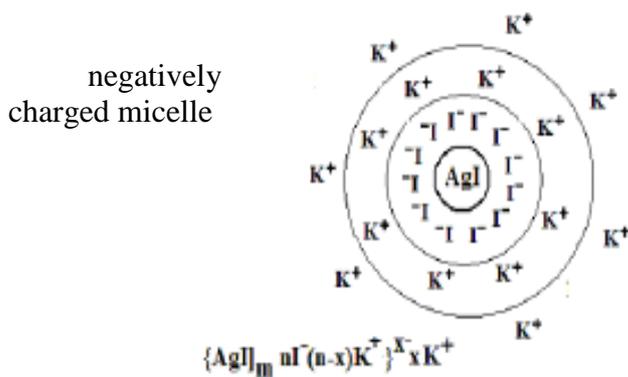
$$AgNO_3 + KI \rightarrow KNO_3 + AgI\downarrow$$

Two variants of the formation of micelles. 1. The solution is excess iodide anions (KI solution dropwise a solution of silver nitrate). The core of the micelles is formed from dropdown precipitated insoluble silver iodide AgI. On its surface begin in absence conformity with the rule of selective adsorption Pskov pottery, carbonates iodide ions (I-), which in solution in excess and which can go for the completion of the core. They create negative nuclear charge and is the potential-forming. To this layer is joined positively potassium ions (K +), which form the adsorption layer of ions and counterions. Part of potassium ions are weak and are connected with the nucleus. It can dissociate and again join to form ion diffusion layer. The structure of the micelles is:

$\{[AgI] m \cdot nI- (n - x) K +\} x- \cdot xK +$
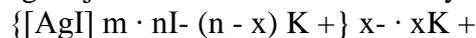
where braces shown granule micelles (colloidal particles), which consists of aggregates Gath m · [AgI], which align potential-forming ions n · I-, to form charge - Jenny core m · [AgI] · n · I⁻, which joined counterions (n-x) · K + with formation of ions adsorbed layer n I- · (n-x) · K⁺} - x as a double layer that gives charge of colloidal particle neutralization which is due to ion diffusion layer xK^+, micelles is a whole electrically.

2. The excess silver ion solution (solution of silver nitrate was added dropwise potassium iodide solution). In this case the micelles formed with opposite sign potential-forming ion. The structure of the micelles will be: $\{[AgI] m \cdot nAg^+ (n-x) NO_3^-\} x + xNO_3^-$.

negatively charged micelle

$\{AgI]_m \ nI^-(n-x)K^+\}^{X-}xK^+$

positively charged micelle

$\{[AgI]_m \ nAg^+(n-x)NO_3^-\}^{X+} x$

negatively charged micelle

The presence of the interface between phase adsorption and diffusion layers' micelles is due to the occurrence of zeta potential (ζ) or electrokinetic potential that present the difference between the total charge potential-forming ions and charge counterions that are in the adsorption layer.

$$V = \frac{\varsigma \cdot \varepsilon \cdot H}{4 \cdot \pi \cdot \eta} \ ,$$

Where ζ - zeta potential; ε - dielectric constant of the medium; η - medium viscosity
    H - the electric field; V - the velocity of particles in an electric field

It is not only charged colloidal particles, but all living cells, and the surface cell carries a negative charge (i.e., a negative electro kinetic potential). For example, zeta potential of red blood cells at pH 7.4 is equal to -16.3 mV. The negative surface charge cells are formed due to the presence of acidic phospholipids in the composition of the membranes. Size zeta potential cell depends on pH, with increasing pH the negative charge cell surface increases with decreasing pH and - conversely decreases. Availability on the surface charge cells prevents agglutination and convergence, and the magnitude of absence pushing cell is proportional to their zeta-potential. The factors leading to the decrease of the zeta potential increase the likelihood of cell adhesion between them. Zeta potential red blood cells can significantly vary in different diseases, which affect the rate erythrocyte sedimentation under the force of gravity (ESR). It is established that inflammatory processes in plasma enhances content acute phase proteins - fibrinogen, haptoglobin, immunoglobulins and others. These proteins are adsorbed on the surface of red blood cells, which reduces their zeta potential, and this accelerates their draft.

6. Stability and coagulation of dispersed systems.

  The stability of disperse systems - describes the tenure of the time its main character- stick particularly such as size and charge of the particles, uniform distribution of particles in volume solvent. These are kinetic and aggregative stability of colloidal solutions.

Kinetic stability is the ability for dispersed system to be in colloidal state and do not settle. It largely depends on the size and surface charge diffusion actually become two adsorption layer. Aggregate stability is the ability to disperse system to keep the same size particles. Loss of aggregative stability is due to the adhesion of the particles and their association in units. The result is loss of sediment dispersion phase and coagulation colloid. Most colloidal solutions and aggregation are kinetically unstable, and their resistance increases:

 1. In the presence of the same charge on the particles, leading to mutual coagulation, preventing aggregation;

 2. In the presence of the hydration shell around the counter ion which prevents adhesion of particles; Coagulation of colloidal solutions - a process of association and increase the size of the particles and eventually dispersed phase loss in the sediment. Coagulation of colloidal systems can call the following factors:

1. Increase or decrease in temperature; 2. Mixing the solution; 3. Adding to solution alkaloids, dyes; 4. Change reaction medium; 5. Adding ions that have with the same charge against ion battery that is opposite to the charge granules. Coagulating action of ions characterized by coagulation threshold is the lowest electrolyte concentration at which coagulation occurs in colloidal solution. Coagulating electrolyte performance depends on the charge and ion concentration. Rule Schulze - gas: - coagulating action of ions increases with their valence. Yes, coagulating ability Al^{+3} ions greater than Ca^{+2} and greater than the ions Na^+.

 Stabilization (protection) colloidal solutions is achieved by adding a small quantities macromolecular substances adsorbed on the particle surface and prevent them from sticking together. Most additives stabilize proteins and polysaccharides. Colloidal defense proteins are important for biological fluids. So, in urine soluble phosphates and calcium carbonates and organic matter in the colloidal state supported through adsorption on the surface of these substances are protein molecules. For example, dissolution wrong number soluble substances which are in 1 liter of urine would have to spend 7 - 14

liters of water. All biological fluids are colloidal solutions because they are present in soluble substances (cholesterol, triglycerides, higher fatty acids, etc.) can be kept in soluble state only due to stabilization. Violation of colloid stability bile and urine leading to stone formation, reducing colloidal stability of blood leads to deposits cholesterol and lipids in the vascular wall. Most often, the loss of stability of colloidal systems biological fluids are the result of lack of proteins that stabilize the lipid particles and other substances, or (more often) is the result of qualitative changes in these proteins. In the body, there are processes that resemble the processes of coagulation colloidal solutions. Specifically transition Blood from liquid to solid also called coagulation (clotting) of blood.