

COLLOID SYSTEMS

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Abstract

In the article the equations of a kinetics of coagulation of disperse systems and theory of a solvate layer of colloidal particles are given.

1. KINETIC EQUATION of COAGULATION

The particles of colloids and suspensions in relation to molecules are macroobjects, and in matching with customary macroobjects have the microscopic sizes, i.e. take an intermediate standing in scale hierarchy. At the same time they have the particular properties, usage which one is important for a biology and technology. All living organisms as a matter of fact represent colloid systems.

I shall remind, as the colloid particle (or larger particle of suspension), shown on a figure 1 is arranged.

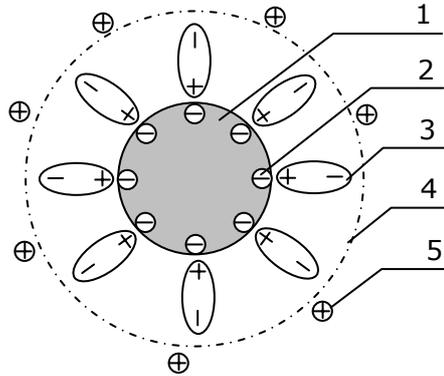


Fig. 1.

On a figure 1: 1 - colloid particle, 2 - potentialdefining ions, adsorbed on a surface of a particle, 3 - solvate layer of oriented dipoles (molecules of water) thick several hundreds molecules, 4 - sliding surface in a disperse medium, 5 - counterions.

At a Brownian motion of a particle, if it is not enough of counterions, they have no time compensate electric charge of potentialdefining ions, therefore particle has some electric potential ζ (zeta-potential). The zeta-potential stipulates stability to sticking (coagulation) of colloid particles. If in a disperse medium there will be a sufficient amount of counterions, ζ - potential is reduced and there is a coagulation. The colloid particles stick together among themselves, but the electric charge them thus practically does not vary, because of what they can not form uniform large aggregate. Therefore in the kinetic equation Smoluhovsky it is necessary to allow for equilibrium calculating concentration of aggregates C_∞ . The value C_∞ is bound, on the one hand, to a coulomb repulsion of particles component aggregate, on the other hand, this value depends on an adhesive strength of particles in aggregate, which one depends on a state of a solvate layer.

Accepting, on Smoluhovsky, the second order for a kinetics of sticking of particles taking into account of equilibrium calculating concentration, it is possible to record:

$$-\frac{dC}{d\tau} = K(C - C_\infty)^2 \quad (1),$$

where C - current concentration of particles, $1/\text{cm}^3$.

The solution of the equation (1) it is possible to present as follows:

$$\frac{C_0 - C_\infty}{C - C_\infty} = 1 + (C_0 - C_\infty)K\tau \quad (2),$$

where C_0 - initial calculating concentration of particles, $1/\text{cm}^3$, K - constant of velocity of a coagulation, cm^3/sec .

The kinetic equation of Smoluhovsky:

$$\frac{C_0}{C} = 1 + C_0 K \tau \quad (3)$$

is a particular case of the equation (2) at $C_\infty=0$. The equation of Smoluhovsky displays the rather good consent with experiment only in an initial stage of coagulation. In further decrease of concentration of particles goes slower, than on the equation (3).

At use by the equation (2) there is a problem of definition of an equilibrium concentration of aggregates. For deep stages of process C comes nearer to C_∞ and the processing accuracy of an experimental curve strongly depends on an error of definition C_∞ . If concentration C_0 to accept for unity, then C and C_∞ will be expressed in shares of unity and the equilibrium concentration can be determined from coordinates of two experimental points (τ_1, C_1) and (τ_2, C_2) on the equation:

$$C_\infty = \frac{C_2 - \frac{1-C_2}{1-C_1} \cdot \frac{\tau_1}{\tau_2} C_1}{1 - \frac{1-C_2}{1-C_1} \cdot \frac{\tau_1}{\tau_2}} \quad (4),$$

which one is received from (2). By multiplication of the retrieved value C_∞ on C_0 and substitution in (2) let's receive value constant of coagulation velocity. If the equation (2) to converse to a view:

$$\frac{1}{C - C_\infty} = \frac{1}{C_0 - C_\infty} + K\tau \quad (5),$$

that more precise value of a constant of velocity can be found from tangent of a slope angle straight line in coordinates: $\frac{1}{C - C_\infty}$ - time.

Would be insecure to search for an activation energy of a coagulation process on dependence the retrieved constant of velocity on temperature of process, since decrease of viscosity with temperature rise in this case is not consider, that will give obtained value of an activation energy above real.

On Smoluhovsky, the constant of velocity of coagulation is determined by expression:

$$K = \frac{4kT}{3\eta} W \quad (6),$$

where: k - constant of Boltzmann, erg/deg ,

T - Kelvin temperature, deg ,

η - viscosity of a colloidal solution, $\text{dyne}\cdot\text{sec}/\text{cm}^2$,

W - probability of effective collision of particles.

Here it is necessary to mark, that at a prompt coagulation the value W can appear more unity at the expense of an attraction of colloid particles, in spite of the fact that they is of the same name are charged. This attraction is stipulated by mutual reorganization of exterior solvate layers of approaching particles.

By determined experimental value of a constant of velocity, from (6) it is possible to find W . On dependence W on temperature of process we shall discover activation energy of coagulation from the equation:

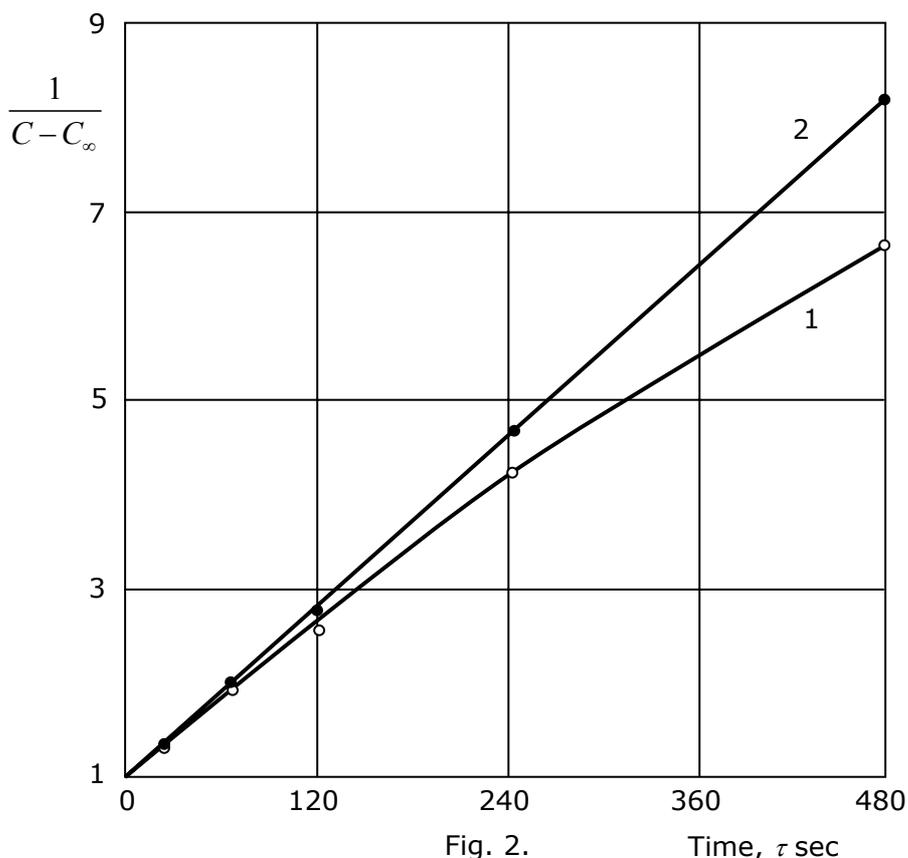
$$W = W_0 \exp\left[-\frac{E}{RT}\right] \quad (7),$$

where E - activation energy, $\text{erg/g}\cdot\text{mole}$. As the value E during coagulation is insignificant, it is better to take advantage of the equation, more approaching for this case, (Y.I. Gerasimov etc. Course of physical chemistry. v. 2, M., 1966, page 129-130):

$$W = W_0 \sqrt{T} \cdot \exp\left[-\frac{E}{RT}\right] \quad (8).$$

Calculation on (7) or (8) automatically allows for change of viscosity of a colloidal solution with temperature and consequently allows finding more precise value of activation energy of process. Here it is necessary to specify, that the activation energy of coagulation has the relation only to strength of a friable outside of a solvate layer of colloid particles. The interior parts of a solvate layer are so strong, that their reorganization and gradual obturating of aggregates can happen within several years. From this fact it is possible to draw a conclusion, that the activation energy of reorganization of a solvate layer is incremented sharply as penetration in it that indicates its special strength near to a surface of a colloid particle.

Immediate experimental check-up of the kinetic equation (2) is possible with the help of a stream ultramicroscope. I have processed major number of literary data on kinetics of coagulation. If the diversion from the equation of Smoluhovsky in case of a sluggish coagulation does not call doubts, for a prompt coagulation this equation, is customary consider valid, though the kinetics was studied only in a start of process. However, it is necessary to mark, what even in a case of «super prompt» coagulation, when $W > 1$ and the colloid particles are attracted to each other, all they have ζ -potential nonzero. It gives that as accumulation of particles in aggregate the electrostatic barrier is incremented for sticking the subsequent particles. Besides because of a Brownian motion or gradient of velocities of a dispersion medium the friable large aggregate ruins. Thus, and in this case we shall have though also small, but quite sizable value C_∞ . For an example, on a figure 2. the results of calculation of a prompt coagulation of sol of gold on data (G.R. Kroit. Science about colloids. FL, M., 1955) are given. C_∞ , retrieved from (4) equally $0.028 \cdot C_0$. A curve 1 - on the equation of Smoluhovsky, straight line 2 - on the tendered equation (2).



From a figure 2 it is visible, that the kinetic equation of Smoluhovsky does not approach for given system, since it is impossible straight lines at $C_\infty=0$. At the same time, equation (2) well describes a viewed case of coagulation given in the literature confirming a regularity of the equation Smoluhovsky. The constant of velocity retrieved from a slope angle received straight line has appeared equal $7.38 \cdot 10^{-12}$

cm³/sec. This value, apparently, a little is overstated, since the intermixing of a colloidal solution at applying a stream ultramicroscope is inevitably. In the following chapter the method investigation of a kinetic of coagulation free from it and other deficiencies will be offered. Probability of effective collision of particles from (6) is peer 1.38 that indicates a prompt coagulation.

Thus, the improvement of the equation Smoluhovsky, well-handled by us, allows considerably extending area of its applying.

2. OPTICAL METHOD STUDY of COAGULATION KINETICS

The tendered below optical method study of coagulation kinetics will be useful specially to medicine, since has an exclusive simplicity, precision and sensitivity. It will allow with a fast response on a kinetic of coagulation of blood elements to determine pathology, poisons and other substances in an organism.

The method of study of kinetics of coagulation by means of a stream ultramicroscopy can not be widely inserted in laboratory practice on two circumstances. First consists of influence of intermixing of a colloidal solution, inevitable in a stream ultramicroscopy, on kinetics of process. The second difficulty is bound to complexity of the relevant equipment and complexity of experiment. These circumstances have forced me the equation, obtained in the previous chapter, to modify so that it was possible to apply to experimental data of change of an optical behaviour of colloid systems obtained on a photocolorimeter. The record of change of an optical density of colloid system is becomes by a recorder. To avoid intermixing a solution and to avoid influence of sedimentation of aggregates, process carry on in hermetically closed down temperature-controlled to a basin without bubbles of air in it. Basin it is slowly (2 rev/min) is gyrated, thus the aggregates, generator in colloid system, at the expense of a sedimentation circumscribes circles of very small diameter in matching with a diameter of a light ray reading an optical density. Thus, the experiments on coagulation are fully automated and they are not influenced by strange actions.

2.1. Large colloid particles (suspensions).

If the size of colloid particles is more than 1/3 wave lengths of a light radiation (suspensions), under the theory Mi, the particle in aggregate exhibits the individuality and appears as simple scattering centre. If the size of a particle is less than 1/4 wave lengths of a light radiation (colloids) individuality of a separate particle is lost and, as the simple scattering centre, appears already aggregate. For such particles the theory of the Rayleigh is valid.

Viewing three cases is of interest: a coagulation in chains, planes and volumetric aggregates, since all these views of structures can be obtained both on model, and on technological systems.

For a case of aggregation in chains the current optical density will be proportional $2N+1$, where N - number of particles in aggregate, since from a requirement of an equality probability standing of aggregates, the device will be «to see» from each three aggregates two aggregate with number of the particles N and one aggregate with number of particles to equal unity (with «of a back»). The initial optical density is proportional to total of particles in these three aggregates, equal $3N$. Thus, from the ratio of an initial optical density to current, we shall discover for linear aggregates:

$$D = D_0 \left(\frac{2}{3} + \frac{1}{3N} \right) \quad (9).$$

Similarly reasoning, we shall discover for flat and volumetric aggregates, accordingly:

$$D = D_0 \left(\frac{1}{3} + \frac{2}{3\sqrt{N}} \right) \quad (10),$$

$$D = \frac{D_0}{\sqrt[3]{N}} \quad (11).$$

On the other hand, apparently, that number of particles in aggregate in any case:

$$N = \frac{C_0}{C} \quad (12),$$

where: C_0 - initial calculating concentration of particles, $1/\text{cm}^3$,
 C - Current calculating concentration of particles, $1/\text{cm}^3$.

By substituting (12) in (9), (10) and (11), we shall receive connection between calculating concentration of particles and optical density of suspension at formation of linear, flat and volumetric aggregates accordingly:

$$C = C_0 \left(3 \frac{D}{D_0} - 2 \right) \quad (13),$$

$$C = C_0 \left(\frac{3}{2} \cdot \frac{D}{D_0} - \frac{1}{2} \right)^2 \quad (14),$$

$$C = C_0 \left(\frac{D}{D_0} \right)^3 \quad (15).$$

View of the equations (13), (14) and (15), as it is visible from previous, does not depend on a packing density of particles in aggregates. From them also it is visible, that the process of coagulation in a viewed case of large colloid particles (suspensions) gives in diminution of an optical density of suspension.

Substituting the obtained equations in (2), after some transformations, we shall discover for linear aggregates:

$$\frac{D_0}{D - D_\infty} = 3C_0 K \tau + \frac{D_0}{D_0 - D_\infty} \quad (16),$$

for flat aggregates:

$$\frac{D_0^2}{(3D - D_0)^2 - (3D_\infty - D_0)^2} = \frac{1}{4} C_0 K \tau + \frac{D_0^2}{4D_0^2 - (3D_\infty - D_0)^2} \quad (17)$$

and for volumetric aggregates:

$$\frac{D_0^3}{D^3 - D_\infty^3} = C_0 K \tau + \frac{D_0^3}{D_0^3 - D_\infty^3} \quad (18).$$

The equations (16), (17) and (18) give straight lines in coordinates, on an axis of ordinates which one the values of the left-hand part of the equations, and on an abscissa axis - time are measured off.

The quantity D_∞ can be retrieved from coordinates of any three experimental points (τ_1, D_1) , (τ_2, D_2) , (τ_3, D_3) on the equation:

$$D_\infty = \frac{\left(\frac{\tau_3 - \tau_2}{\tau_2 - \tau_1} \right) \left(\frac{D_1 - D_2}{D_2 - D_3} \right) D_3 - D_1}{\left(\frac{\tau_3 - \tau_2}{\tau_2 - \tau_1} \right) \left(\frac{D_1 - D_2}{D_2 - D_3} \right) - 1} \quad (19)$$

for linear aggregates. For volumetric aggregates:

$$D_\infty^3 = \frac{\left(\frac{\tau_3 - \tau_2}{\tau_2 - \tau_1} \right) \left(\frac{D_1^3 - D_2^3}{D_2^3 - D_3^3} \right) D_3^3 - D_1^3}{\left(\frac{\tau_3 - \tau_2}{\tau_2 - \tau_1} \right) \left(\frac{D_1^3 - D_2^3}{D_2^3 - D_3^3} \right) - 1} \quad (20).$$

The equations (19) and (20) though and bulky, but are friend for practical calculations. The expression for D_∞ in case of flat aggregates is more complicated:

$$D_\infty = \frac{D_0}{3} + \frac{1}{3} \sqrt{\frac{A(3D_3 - D_0)^2 - (3D_1 - D_0)^2}{A - 1}} \quad (21),$$

where:

$$A = \left(\frac{\tau_3 - \tau_2}{\tau_2 - \tau_1} \right) \frac{(3D_1 - D_0)^2 - (3D_2 - D_0)^2}{(3D_2 - D_0)^2 - (3D_3 - D_0)^2} \quad (22).$$

For equidistant values τ equations (19), (20) and (21) are considerably simplified.

Thus, utilizing the equations (16), (17) and (18) together with expressions (19), (20) and (21) for D_∞ it is easy to find from measurements an optical density a constant of velocity of a coagulation of suspension and, therefore, efficiency of particles collision.

2.2. Colloid systems from small particles.

The small particles collected in aggregate do not exhibit optically individuality and the aggregate as a whole appears as one scattering centre. This statement is valid for particles of smaller $1/4$ wave lengths of a light radiation, i.e. arranged more to the left of a dispersion maximum, under the theory Mi.

On the Rayleigh (G.R. Kroit. Science about colloids. FL, M., 1955, page 413) the optical density of a colloid is proportional to a quadrate of volume of a particle, scattering light:

$$D = kV^2C \quad (23),$$

where: k - coefficient of proportionality, $1/\text{cm}^3$,

C - concentration of particles in a unit volume, $1/\text{cm}^3$.

Noting the ratio of a current optical density to initial, we shall receive:

$$\frac{D}{D_0} = \frac{V^2C}{V_0^2C_0} \quad (24).$$

Weight of aggregate, formed to the instant τ :

$$\frac{4}{3}\pi r_0^3 N \gamma = \frac{4}{3}\pi r^3 \gamma' \quad (25),$$

where: r_0 - radius of a particle, cm,

r - radius of aggregate, cm,

N - number of particles in aggregate,

γ - density of a particle, g/cm^3 ,

γ' - density of aggregate, g/cm^3 .

From (25), allowing, that $N=C_0/C$ and designating $\gamma'/\gamma=\beta$, where β - packing density, in a limit varying from 0 up to 1, we shall discover:

$$\left(\frac{r}{r_0} \right)^6 = \left(\frac{C_0}{C} \right)^2 \cdot \frac{1}{\beta^2} \quad (26).$$

By substituting (26) in (24), we shall receive:

$$D = D_0 \frac{C_0}{C\beta^2} \quad (27).$$

From the equation (27) it is visible, that as against large particles of suspensions, the coagulation of small particles of colloids gives in magnification of an optical density of sol.

By substituting (27) in (2), we shall receive the equation of coagulation kinetics of sol expressed through an optical density:

$$\frac{1}{\frac{D_0}{D} - \frac{D_0}{D_\infty}} = \frac{C_0}{\beta^2} K \tau + \frac{1}{\beta^2 - \frac{D_0}{D_\infty}} \quad (28).$$

The equation (28) gives a straight line in coordinates: $\frac{1}{\frac{D_0}{D} - \frac{D_0}{D_\infty}}$ - time, constant of

coagulation velocity whence can be retrieved. The quantity β imports some indeterminacy to a true value of a velocity constant.

The value D_∞ can be retrieved on coordinates of three experimental points (τ_1, D_1) , (τ_2, D_2) and (τ_3, D_3) from the equation:

$$D_\infty = \frac{\left(\frac{\tau_3 - \tau_2}{\tau_2 - \tau_1}\right) \left(\frac{D_2 - D_1}{D_3 - D_2}\right) D_3 - D_1}{\left(\frac{\tau_3 - \tau_2}{\tau_2 - \tau_1}\right) \left(\frac{D_2 - D_1}{D_3 - D_2}\right) - 1} \quad (29).$$

Thus, using results of chapters 2.1. and 2.2. the study of a coagulation of suspensions and sols in all a range of the sizes of particles relevant selection of a wave length of light is possible, at which one will carry out measurements an optical density.

Our experiments with a coagulation of suspensions (TiO_2) and sols (AgJ) have shown, that the equilibrium size of aggregates depending on concentration of an electrolyte at a threshold of a coagulation reaches the maximal sizes, and the course of change D_∞ represents practically precise differential velocity curve of a coagulation.

3. CONNECTION BETWEEN ZETA-POTENTIAL And ION ACTIVITY In DOUBLE ELECTRICAL LAYER.

In the literature there are quantitative evaluations of change of properties of a solution, for example values pH near to colloid particles. At the same time this index in basic determines destiny of a hydrolysis of solutions and adsorption of impurities on hydrolysates. In this connection there is a necessity of a quantitative evaluation of ion activity of electrolytes near to colloid particles.

As have shown our experiments with a hydrolysis of sulphate titanium, depending on conditions deriving a metatitanic acid both in coagulated state, and as sol with positive ζ -potential is possible. The high stability of such sol to aggregation can not be explained by a repulsion of particles at overlapping double diffuse electrical layers of crystallites of a metatitanic acid because of high concentration of electrolytes in a mother solution. The more probable reason of a stability is the presence of a solvate layer environmental a particles of a metatitanic acid and at it so strong, that the ions, adsorbed from a solution, place on its surface and the allocation of ions around of a colloid particle is represented by a lamina on a surface of its solvate environment.

The deduction of the basic equation linking ion activity on a surface of a solvate layer to activity them in a mother solution and ζ -potential of colloid particles is founded on definition of concentration potential (N.A. Izmailov. An electrochemistry of solutions. M., 1966, page 467):

$$E = \frac{RT}{zF} \ln \frac{a_1}{a_2} \quad (30)$$

and discussion of the mechanism of adsorption of ions in view of a principle of detail equilibrium.

For definiteness, assume, that the colloid particle is charged positively and potentialdefining ions strongly chemisorbed by a surface of a particle and are not capable to an exchange. Let's designate potential of a colloid particle without counterions through φ . We suppose that at adsorption of ions potential of such particle is reduced on quantity, defined concentration potential of a given sort of cations and anions. Assume, that the particle is in water not containing of electrolytes. Then counterions will be ions of hydroxyl, and the blanket change of potential of a particle will make:

$$\varphi - \zeta_0 = \frac{RT}{F} \left(\ln \frac{a'_{OH}}{a^0_{OH}} + \ln \frac{a^0_H}{a'_H} \right) \quad (31),$$

where: a'_{OH} , a^0_{OH} and a'_H , a^0_H - activity, accordingly, hydroxyl and proton on a surface of a solvate layer and in a solution, g-mole /l,

F - Faraday constant, coulomb/g-mole,

ζ - zeta - potential of a colloid particle in absence of an electrolyte, v.

Let's discover connection between activities of a cation and anion in an equilibrium diffuse double electrical layer, then from a principle of detail equilibrium follows, that in the same relation cations and the anions will be sorbed and on a surface of a solvate layer of colloid particles.

From equilibrium condition of forces for a given cation in a diffuse double electrical stratum follows:

$$\frac{z_1 e q_0}{\varepsilon' x^2} + \frac{(z_1 e)^2 n_1}{\varepsilon' x^2} + \frac{z_1 z_2 e^2 n_2}{\varepsilon' x^2} + \frac{kT}{a_1} \cdot \frac{da_1}{dx} = 0 \quad (32),$$

where: e - elementary charge, units CGSE,
 q_0 - charge of a particle without counterions, units CGSE,
 n_1, n_2 - number of cations and anions in a double electrical layer inside a sphere, on a surface by which one is a given cation,
 ε' - dielectric constant of medium in a double electrical layer,
 x - distance from centre of a particle up to a given cation, cm,
 z_1 and z_2 - valence, accordingly, cation and anion.

In the equation (32) the terms sequentially correspond: to an attractive force of a cation to a particle, repulsive force from like ions, attractive force to ions of an opposite sign and «diffuse» force relevant to a repulsion from a particle.

Noting similar expression for an anion and substituting n_2 from it in (32), we shall receive the differential equation linking of activity of a cation and an anion in a double electrical layer. The solution of this equation following:

$$\frac{a_1}{a_1^0} = \left(\frac{a_2^0}{a_2} \right)^{\frac{z_1}{z_2}} \quad (33).$$

Charges of a cation and anion in the equation (33) are taken on an absolute value. This equation will be valid and for a flat double electrical layer, since a view of the first three members of equation (32) does not influence the solution.

Substituting (33) in (31), we shall receive:

$$a'_H = a_H^0 \exp \left[-\frac{(\varphi - \zeta_0) F}{2RT} \right] \quad (34).$$

Potential φ for the majority of sols makes about 0.2-0.3 v, and ζ_0 about 0.1 v. Then of the equation (34) follows, that pH near a particle of refined negatively charged hydrosol, approximately, on 2 unities it is less, than in a solution at pH~7.

The obtained result completely coincides experimental data (Harter Robert D., Anrichs James L. Soil Sci. Soc. America Proc., 31, 30, #1, 1967), which one have found, that on a surface of bentonitic clay pH on 2 unities it is less, than in a solution at pH~7.

For a case, when at a solution there is an electrolyte and ζ_0 up to value ζ is reduced, similar (31) it is possible to note:

$$\zeta_0 - \zeta = \frac{RT}{F} \left(\ln \frac{a'_{OH}}{a_{OH}} + \ln \frac{a_H}{a'_H} \right) + \frac{RT}{z_2 F} \left(\ln \frac{a_2}{a_2^0} + \frac{z_2}{z_1} \ln \frac{a_1^0}{a_1} \right) \quad (35),$$

where: a_{OH} , a_2 and a_H , a_1 - activities, accordingly, hydroxyl and anion, proton and cation on a surface of a solvate layer, g-mole/l,

a_2^0 and a_1^0 - activities, accordingly, anion and cation in a solution, g-mole/l.

From (35), utilizing (33), we shall discover:

$$a_H = a'_H \exp \left[\frac{(\zeta_0 - \zeta) F}{4RT} \right] \quad (36).$$

The equation (36) with the registration (34) it is easy to converse to a view, friend for counting pH near positively of charged colloid particles:

$$pH = pH_0 + 2 - \frac{(\zeta_0 - \zeta) F}{9,212 \cdot RT} \quad (37),$$

where: pH_0 - value pH in a mother solution.

For negative of charged colloid particles signs of two last members of equation (37) it is necessary to change on opposite.

The physical sense of obtained expression consists in dependence of adsorption of hydrogen ions on a surface of a solvate layer of colloid particles from presence in a solution of other ions.

Substituting (36) in (35), we shall discover activity of counterions on a surface of a solvate layer for positively or negatively of charged colloid particles:

$$a = a^0 \exp \left[\frac{(\zeta_0 - \zeta) z F}{4 R T} \right] \quad (38),$$

where: z - valence of a counterion.

4. ADSORPTION of IMPURITIES ON a SOLVATE LAYER of PARTICLES AND STABILITY CRITERION of COLLOID SYSTEMS.

The numerous experiments with all evidence display, that the aggregate stability of colloid systems is determined by presence of a strong solvate layer environmental a colloid particles. All our attempts to explain the test data from stands alone now to quantitative stability theory of colloids DLFO invariably conflicted to experiment. In a basis of this theory two basic interactions are included: Van der Waals an attraction and repulsion at overlapping diffuse layers of counterions of colloid particles. In technological systems as against model laboratory systems there are both factors absent. First - because of presence of a thick solvate layer superior on the sizes a radius of action of Van der Waals forces, second - because of high concentration of electrolytes.

In work (G.A. Martinov, V.P. Smilga. The colloid journal, 27, 250, 1965) was shown, that the particles boarded with dipoles will be attracted. Such deduction is grounded on high mobility of polar molecules on outside boundary of a solvate layer. However, in my opinion, the sign of interaction depends on amount of counterions adsorbed on a surface of a solvate layer. If it is not enough of counterions, the dipoles on a surface of a solvate layer have no time to be turned during collision of colloid particles and between them the repulsion is watched. If it is enough of counterions for loosening to an outside surface in such degree, that it is possible to consider dipoles practically as free, the repulsion is replaced by an attraction according to the above-stated reference. The particles in this case will formed aggregate as a result of touch of solvate envelopes.

Derivation of an equation linking adsorption of ions on a surface of a solvate layers of colloid particles to an activity coefficient them in a solution given below. On the basis of this equation the stability criterion of colloid systems is obtained, the stability which one is bound to presence of a solvate layer.

Adsorption rate of counterions on a surface of a solvate layer:

$$V_1 = K_1 \rho_1 \quad (39),$$

where: K_1 - constant of an adsorption rate, cm^2/sec ,

ρ_1 - surface density of counterions in a dispersion medium, $1/\text{cm}^2$.

Velocity of desorption of counterions from a surface of a solvate layer in a dispersion medium:

$$V_2 = K_2 \rho_2 \quad (40),$$

where: K_2 - constant of velocity of a desorption, cm^2/sec ,

ρ_2 - surface density of counterions on a solvate layer, $1/\text{cm}^2$.

As the factors impeding installation of equilibrium in a considered case miss, the equilibrium is established rather promptly:

$$K_1 \rho_1 = K_2 \rho_2 \quad (41).$$

Substituting in (41) the equation of the Arrhenius:

$$K = K_0 \exp \left[- \frac{E_{akm}}{R T} \right] \quad (42)$$

and apparent relation between ρ_1 and concentration of counterions in volume of a colloidal solution:

$$\rho_1 = \left(\frac{CN_A}{1000} \right)^{2/3} \quad (43),$$

let's discover:

$$\rho_2 = \left(\frac{CN_A}{1000} \right)^{2/3} \cdot \frac{K_{01}}{K_{02}} \exp \left[-\frac{E_1 - E_2}{RT} \right] \quad (44).$$

For an activation energy of a desorption, as a first approximation, omitting interaction with a solvate layer, we shall accept an electrostatic energy interaction of a counterion which is taking place on a surface of a solvate layer, with a charged colloid particle:

$$E_2 = \frac{qze}{\varepsilon'a} - \rho_2 \frac{4\pi az^2 e^2}{\varepsilon'} \quad (45),$$

where: q - charge of a colloid particle, unit CGSE,
 z - valence of a counterion,
 a - distance from centre of a colloid particle up to an outside surface of a solvate layer, cm,
 ε' - medial effective dielectric constant of a solvate layer (it is diminished as approaching a surface of a particle).

The equation (45) without damage to a further deduction it is possible to exchange by an apparent and more blanket relation: $E_2 = E_2(\rho_2)$.

Energy of activation of adsorption is peer a viewed case to exuberant work of transport of a counterion from volume of a colloidal solution on a surface of a solvate layer. This work is peer to the total of exuberant work on transport of a counterion from a given solution in indefinitely a weak solution (N.A. Izmailov. An electrochemistry of solutions. M., 1966, page 53):

$$A^* = kT \ln \gamma^* \quad (46),$$

where γ^* - concentration activity coefficient of a counterion and exuberant work on transport of an ion from a dispersion medium (free dipoles) on a surface of a solvate layer (bound dipoles):

$$A_0 = -kT \ln \gamma_0 \quad (47),$$

where γ_0 - uniform zero activity coefficient of counterions.

Thus, the aggregate exuberant work of transport of a counterion will be:

$$E_1 = -kT \ln \gamma \quad (48),$$

where:

$$\gamma = \frac{\gamma^*}{\gamma_0} \quad (49).$$

By substituting the equations (45) and (48) in (44), we shall receive the basic transcendental equation:

$$\rho_2 = \left(\frac{CN_A}{1000} \right)^{2/3} \cdot \frac{K_{01}}{K_{02}} \gamma \exp \left[\frac{ze}{a\varepsilon'RT} (q - 4\pi a^2 ze \rho_2) \right] \quad (50).$$

From the equation (50), as the special case, is possible to find a requirement, at which one density of counterions on a surface of a solvate layer is peak, and, therefore, the efficiency of a concussion of particles is peak, as the quantity of the liberated dipoles on a surface of a solvate layer is proportional to quantity of adsorbed counterions.

From here, for a threshold of a coagulation it is possible to note a requirement:

$$\frac{d\rho_2}{dC} = 0 \quad (51).$$

The equation (50) under condition of (51) to become:

$$-\frac{d(\ln \gamma)}{dC} = \frac{2}{3C} \quad (52).$$

By accepting dependence between $\ln \gamma$ and C under the theory of a Debye-Hukkel (N.A. Izmailov. An electrochemistry of solutions. M., 1966, page 106):

$$\ln \gamma = -A\sqrt{C} \quad (53)$$

and by substituting it in (52), we shall discover a requirement for a threshold of a coagulation:

$$\ln \gamma = -\frac{4}{3}; \quad \gamma = 0,263 \quad (54).$$

The equation (54) it is necessary to view as a stability criterion of colloid systems. The result obtained in this equation does not depend on a view of the equation (45).

By taking advantage a stability criterion (54) it is possible to find a stability criterion of hydrosols. For this purpose it is necessary to determine value of a dielectric constant on a surface of a hydrated layer of colloid particles.

On data of many researchers the thickness of a solvate layer oscillates from 100 up to 2000 angstrom units. The majority of the researchers give for a hydrated layer numeral about 350-400 Å. The dielectric constant of water varies depending on thickness of a film from 4.5 at thickness 70 Å up to 75 at thickness 1600 Å, the value for free water 80 is reached at thickness of a film 37000 Å. At interpolation of these data to thickness of a film in 350-400 Å there corresponds a dielectric constant of water about 40. Then, accepting quantity of a dielectric constant equal 40 on a surface of a hydrated layer that corresponds to «half-bound» dipoles of water, from the appendix to the monograph (N.A. Izmailov. An electrochemistry of solutions. M., 1966) we shall discover approximate experimental value γ_0 : $\lg \gamma_0 \approx 0.45$, $\gamma_0 \approx 2.82$. After substitution (54) in (49.), we shall receive at a threshold of a coagulation of hydrosols:

$$\gamma^* = \text{const} \approx 0.74 \quad (55).$$

If to substitute (55) in the equation of a Debye-Hukkel for an activity coefficient of ions, we shall receive expression for concentration of an electrolyte at a threshold of a coagulation.

The equation (55) known empirical regularity detected by Oswald on hundreds of experiments and a corollary from it explicitly are argued in his work (V. Oswald. Successes of chemistry, 9, #5, 1940). It is possible to term as a stability criterion, defined equation (54) generalized rule of Oswald. This criterion allows both property of a dispersion medium, and property of a solvate layer of colloid particles and, therefore, is bound to properties of matter of these particles. Allowing expression (48.), it is possible to formulate this criterion in a little bit diverse view: the colloid system will have a minimum stability to aggregation, when the activation energy of adsorption of counterions on third is more than their thermal energy.

In that specific case of lyophobic sols the obtained stability criterion transfers in a rule of Oswald. For example, studying a coagulation of sols of sulfur (S.E. Harin, I.V. Chaikovskaya. A colloid journal. 18, 350, № 3, 1956) writers have found affirming to a rule Oswald: $\gamma^* = \text{const} = 0.73$.

Физический смысл этого результата состоит в том, что при малой концентрации электролита ионы сильнее удерживаются на поверхности адсорбента, чем в растворе, а при большой концентрации взаимодействие ионов с раствором сильнее, чем с адсорбентом. View of a relation (54.) displays, that it can be applied to a general case of adsorption of ions from solutions of electrolytes on a surface of an adsorbent, when the activation energy of a desorption is some function from quantity of adsorbed ions (that almost always has a place). In this general case we shall receive the same result: the maximum of adsorption is watched at $\ln \gamma = -4/3$, where $\gamma = \gamma^* / \gamma_0$. The physical sense of this result is, that at small concentration of an electrolyte the ions are retained stronger on surface of an adsorbent, than in a solution, and at major concentration the interaction of ions with a solution is stronger, than with an adsorbent.

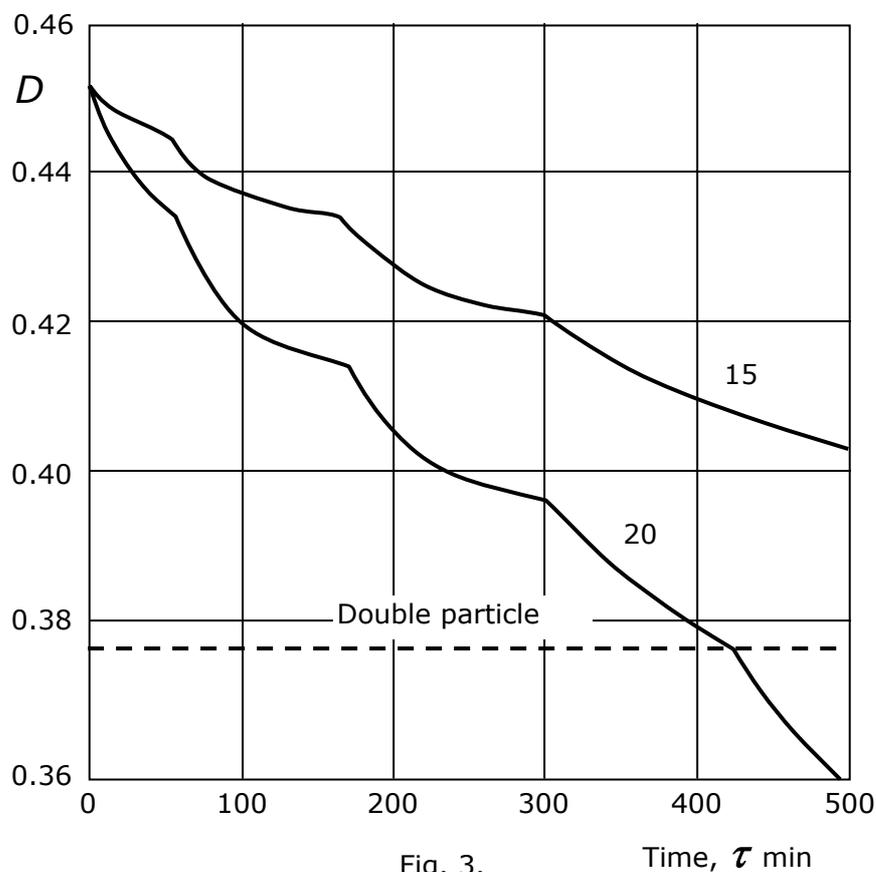
5. STEPPED PROCESSES in a WORLD ON an EXAMPLE of a COAGULATION of COLLOID SYSTEMS.

Aliasing of processes in a world we apparent always and everywhere. Watching any phenomenon it is possible guaranteed to state: «all will pass, will pass also it».

Idiosyncrasy of aliasing, ensuring advance, is that circumstance that each subsequent stage is essentially or in principle differs from the previous stage.

At a coagulation of colloid systems the aliasing of this process is exhibited clearly at efficiency of collisions of particles less unity (slow coagulation). Our experiments on a slow coagulation of anatase (modification of titanium dioxide) in 25 mmole/l a solution KCl have shown fracture of a kinetic curve in a point $D=0.3747$ ($D_0=0.4535$). This fracture corresponds to formation of double particles on all volume of suspension. Really, on the equation (9), optical density at a double particle $D_2=0.3779$, that with precision 0.85 % coincides experiment. The analysis of major number of literary data confirms aliasing of process of coagulation. My experiments uniquely display, that the process of a sluggish coagulation goes in such a manner that in the beginning in all system the double particles, then quater etc will be formed. It indicates an applicability of a rule of phases of the Gibbs to process of coagulation of particles, and double, quater etc. the particles should be viewed as separate «phases» of system.

On a figure 3 the kinetic curves of a coagulation of suspension of titanium dioxide are shown at concentration of potassium chloride less threshold. Numerals for curves - concentration KCl in mmole/l.



As it is visible from a figure 3 on these curves fractures up to a double particle clearly are watched. It managed to be detected because of absence of intermixing of a solution and fast response of a method of measuring. The explanation of these fractures by a state transition of a double electrical layer of colloid particles because of major time of coagulation is impossible, at which one the fractures are watched. It is necessary to refer fractures of kinetic curves, apparently, to a step change of coagulative ability of particles, bound with a state transition of their solvate layer having, apparently, composite structure and consisting from several underlayers (in our example 3), become revealed in accordance with destruction of a solvate layer by counterions, penetrants into it. The considerable strength of a solvate layer of anatase particles is confirmed by a major time term, after which one the fractures are watched. For the benefit of this assertion speaks that fact, that the fractures are watched at particular time of coagulation. The ions of potassium dive inside of a solvate layer and disturb its structure. The velocity of a diffusion of ions in a case concerning to a figure 3 practically does not depend on concentration them in volume

of a colloidal solution and together with a high monodispersity of colloid particles gives in fractures of a kinetic curve to a particular instant.

At concentration of an electrolyte below threshold, the process of a coagulation is determined by quantity of a repulsion, bound with a charge of particles. The equilibrium aggregates can not reach the major sizes, since between particles of aggregate the considerable electrostatic repulsive force operate. In accordance with diminution of a charge of particles with magnification of concentration of an electrolyte, the equilibrium size of aggregates grows. Up to a threshold of a coagulation the dense aggregates of a noncrystalline type are gained, since such aggregation of small number of particles energy is favourable. At presence of a residual electrostatic barrier, the particles do not remain in place of their first touch, and take most energy favourable standing.

In work (A.A. Shternberg. The collection of papers: Growth of crystals. v.5, M., 1965, page 179) is shown, that the most stable formation of a noncrystalline type is the regular icosahedron containing 13 particles. The packing density of particles in such aggregate very high also has not analogs in crystalline structures with a close packing of particles.

When the concentration of an electrolyte exceeds threshold, the energy barrier becomes so small, that the particles in aggregate remain in a standing of their first touch. It gives in formation quasicrystal filiform, flat and volumetric aggregates with small density. The not spherical shape of aggregates is easily detected, if in a basin to leave a small bubble of air not hitting on a reading beam of light and intermixing solution at gyration of a basin. Thus the aggregates are oriented across a light ray and the optical density varies at rotational displacement of a basin on 180° so strongly, that the recorder writes a curve of breadth almost on half of scale.

As a result of experiments the following picture of a sluggish coagulation was clarified. At first till all to system the aggregates from a double particle will be formed. Only after terminating this process the coagulation of double particles among themselves with formation of aggregates from 4 particles starts. Further process goes similarly and the aggregates from 8 particles will be formed. After that the surprising appearance is watched. The aggregates from 8 particles stick together with formation of aggregate from 16 particles, inside this aggregate the regular icosahedron from 13 particles will be promptly formed, the coulomb repulsion for «superfluous» three particles becomes such, that they abandon aggregate. The process very much resembles decay of a nucleus many protons.

To test, whether has a detected appearance universal character or concerns only to a special case, the experiments were well-handled with a hydrolysis of industrial solutions titanyl sulphate with the content TiO_2 200 g/l. That prehydrolysis the solution represents a dark-brown fluid with a strong light absorption in the first series of experiments an industrial solution it was necessary to dilute with distilled water till 6-36 g/l TiO_2 . At concentration of titanium dioxide is higher 30 g/l kinetic curves have the S-figurative shape with an induction period, which one take place in actual production process of production of pigmental titanium dioxide.

By results of experiments the following mechanism of a hydrolysis is clarified. Crystallites of a metatitanic acid the size 40-50 Å in the beginning will be formed (on our data of radiography analysis they in further practically are not incremented in the sizes). Then these crystallites coagulates pairwise on all system, further pairs are agglomerated in tetrahedrons, which one in further will forms aggregates from 8 particles. Then at coagulation they are re-forms, by forming a regular icosahedron from 13 particles, throwing out superfluous 3 particles. The size of a regular icosahedron makes in a diameter 100 Å, i.e. is peer to a radius of action of Van der Waals forces for crystallites of a metatitanic acid, which one we have determined from experiments of peptization of this acid by a triethanolamin. Further regular icosahedrons are joined in pairs, and then the pairs will forms a tetrahedron from 4 icosahedrons. These aggregates containing 52 initial crystallites appear very stable against further aggregation and in technological solutions coagulates only during water delivery at the end of a hydrolysis.

For verification that the coagulation of crystallites of a metatitanic acid is the basic feature of a hydrolysis, an industrial solution diluted not with distilled water and 0.8 %

by a solution of agar up to concentration 36 g/l TiO_2 . During observation within 18 clocks of change of an optical density of a solution it is not discovered. This experiment has shown, that in requirements, when the mobility of ions has not varied, and the colloid particles have lost mobility (solution has consistence of dense kisel), the process of a hydrolysis (aggregation of particles) ceases.

The initial segment of kinetic curves of a hydrolysis goes with acceleration. It is stipulated by that the forces of Van der Waals are additive and in accordance with magnification of number of particles in aggregate the attraction between aggregates will increase. At reaching the size of aggregates to an equal radius of action of these forces (icosahedron 100 Å) the further magnification of the size does not give in magnification of attractive forces. Therefore, the formation of icosahedrons should be watched near to an inflection point of a kinetic curve of a hydrolysis, that is confirmed experimentally (table 1).

Table 1.

Optical density of a solution (36 g/l TiO_2) in points of fracture of a kinetic curve of a hydrolysis.

Nº	Label of points of a kinetic curve	D exp.	D theor. on (27)	Comment
1	Beginning of a horizontal segment	0.0118	0.0116	Tetrahedron from 4 icosahedrons
2	Before a horizontal segment	0.0083	0.0082	Double icosahedron
3	In inflection of curve	0.0066	0.0065	Icosahedron from 13 crystallites
4	Breakpoints from an induction period up to inflection of curve	0.0039	0.0040	The 8-th particle
5		0.0019	0.0020	Tetrahedron from crystallites
6		0.0009	0.0010	Aggregate from two crystallites
7		0.0005	0.0005	Single crystallites

On electron-microscopical snapshots samples of a metatitanic acid from a horizontal segment of kinetic curves the tetrahedrons from 4 icosahedrons are well visible. The quantity of crystallites in a icosahedron is difficult for counting up because of limiting magnification.

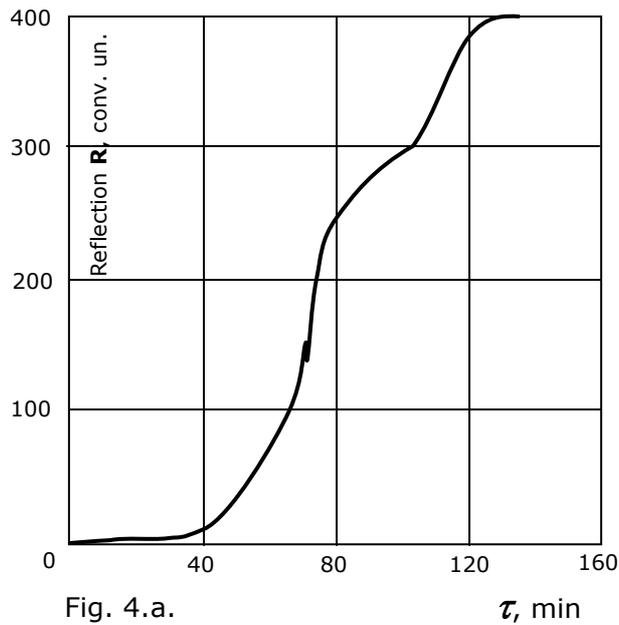


Fig. 4.a.

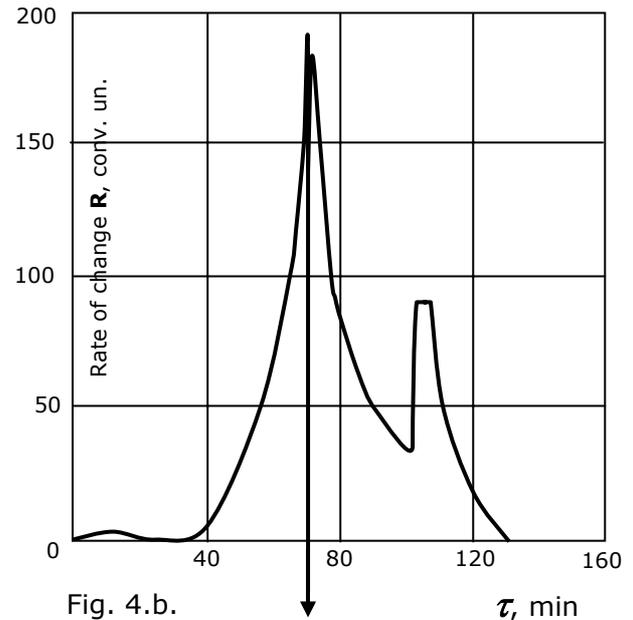


Fig. 4.b.

For verification of made deductions on actual technological solutions the experiments with a thermal hydrolysis of a solution containing 206 g/l TiO_2 were posed. On installation fixed process of a hydrolysis, measuring not light transmission, and reflection it from a solution which is taking place in a glass cylindrical vessel. The requirements of a hydrolysis strictly corresponded to the regulation indication on carrying out of this operation in production of pigmental titanium dioxide. Record of a kinetic curve executed simultaneously by two recorders EZ-2, one of which noted an integral curve, another - differential. 6 hydrolyses in total were realized to be convinced, that the obtained effect is not contingency. As the reproducibility of experiments was high, on a figure 4. the kinetic curve in integrated (a) and differential (b) to the shape, identical to all executed experiments is given.

Converts on itself attention sharp diminution of a reflection power of a solution about an inflection of a kinetic curve of a hydrolysis, and this spring is performed in time less than second, about what speaks so high negative value of a derivative, that it did not managed to lock in even at presence on a recorder 11 spare scales (blanket height of a line with arrow on a figure 4.b. more than 4 meters). After spring the process goes from smaller value of intensity of scattered light and with smaller velocity.

The author incurs boldness to state, that the icosahedrons will arise in any processes, the weep which one is impeded by any factors.

Thus, the process of a hydrolysis represents strictly ranked aggregation of particles in space both in time and in this sense confirms global world regularity of the time-space order of any processes and phenomena.

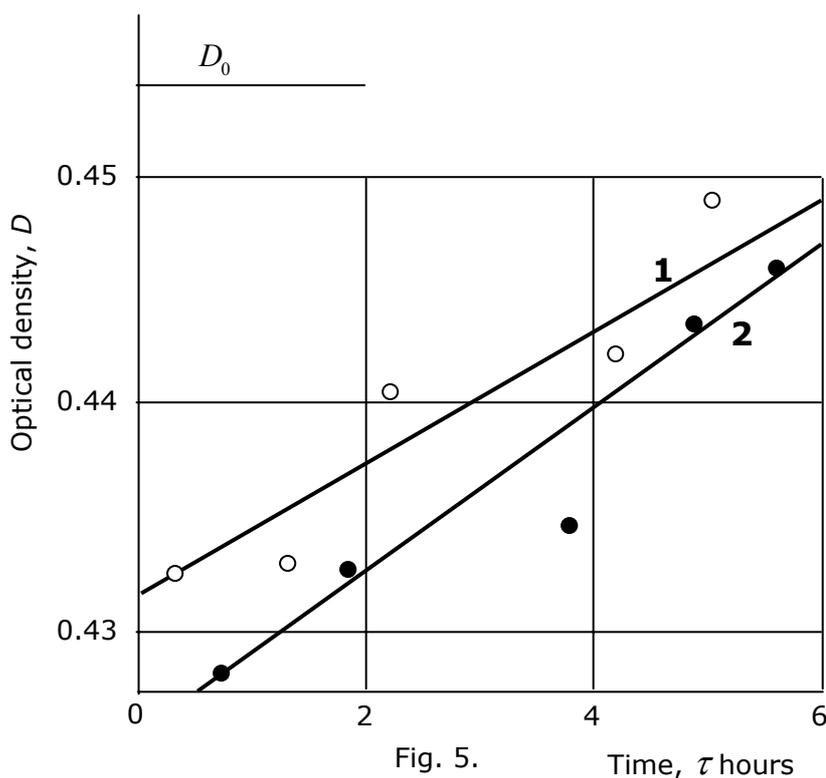
The colloid systems from alive organisms are separated by one step, for which one are necessary hundred millions years. But if this step is made, the further strife for resources accelerates of evolution in thousands time.

6. INFLUENCE of MAGNETIC And PULSING ELECTROSTATIC FIELDS

The author in 1974 has made discovery under the name "Influence of a magnetic field of the Earth and electrostatic fields on coagulation kinetics" and has submitted the appropriate application for recognition of discovery. But system of a science throughout corrupts. Try to present to a solid magazine perfect scientific article. If in the authors there will be no known name any mafia man from a science, your article will be never published, what value it would not represent. Official oppressor of new ideas will send you the review (unsigned to not risk by esprit de corps), in which will be refused in the publication. For me, for example, cowardly grave digger of discoveries directly has declared what to make an application it is necessary, when will

become the academician. Only the democratic Internet has allowed to be published by everyone, whom not laziness, and me including. The truth thus arise the large dump of scientific rubbish, but, having rummaged in it, always it is possible to find mass of original ideas and stimulus for the further work.

Influence of a magnetic field of the Earth. The experiments carried out on modeling system in environment 0.1 M KCl on green suspension of anatase, which stability raises after dilution within day at the expense of gegenions desorption from of a solvation layer. In 10 minutes the after of a beginning coagulation cuvette suspended on a long string (17 fluctuations one minute) and resulted in oscillatory movement along magnetic force lines of the Earth or across them. After fluctuations within 10 minutes measured optical density of suspension, which corresponds to an experimental point on a figure 5. The beginning of an axis of ordinates is chosen arbitrary. 1- fluctuations along a field, 2 - fluctuation across a field.



At fluctuations across a magnetic field of the Earth the acceleration of process coagulation is clearly shown. Irrespective of stability initial suspension, the effect of increase of speed coagulation at fluctuations of cuvette across a magnetic field of the Earth remains, approximately, constant and equal 26%. The disorder of experimental points is connected to insufficient accuracy of installation cuvette with a solution in cuvetteholder. The effect of acceleration at application of constant magnets in the same conditions is so significant, that the difference in optical density is easily found out by a simple eye.

It is interesting to note, that the probably direct decision of a question: whether is the reason of acceleration coagulation the polarization of a double electrical layer or of a dipole solvation layer. The relaxation time of a double electrical layer changes from 10^{-5} up to 10^{-7} sec (N.A. Izmailov. Electrochemistry of solutions. M., 1966, page 122). The relaxation time of a outside solvation layer makes, on my data, quantity, about 1 second. It is determined by supervision in optical microscope. The particles of anatase suspension in microscope look by diffraction ringlets with intensive Brownian movement. In a field of vision microscope the set of collisions of particles without any seen interaction between them is observed, but in rare cases it was possible to see effective interaction. It looks as follows. Cooperating particles, the relative speed of which rapprochement at the given moment is insignificant, suddenly begin synchronous Brownian movement, forming as though dumb-bell with distance

between particles about several diameters than diffraction of rings. Then in time, about 1 second, the particles are pulled together and form the steady aggregate.

Hence, if to change direction moving of cuvette or direction of a vector of a magnetic induction with frequency, intermediate between 10^5 cec and 1 second, the effect of acceleration coagulation at the expense of polarization of a double electrical layer should be remain, and at the expense of polarization of a dipole solvation layer this effect will disappear. The check has shown that for the given system even at application of constant magnets with frequency of change of a vector of a magnetic induction making only 6 sec^{-1} effect is absent. From here it follows, that the magnetic field accelerates coagulation at the expense of polarization of a solvation layer of colloidal particles.

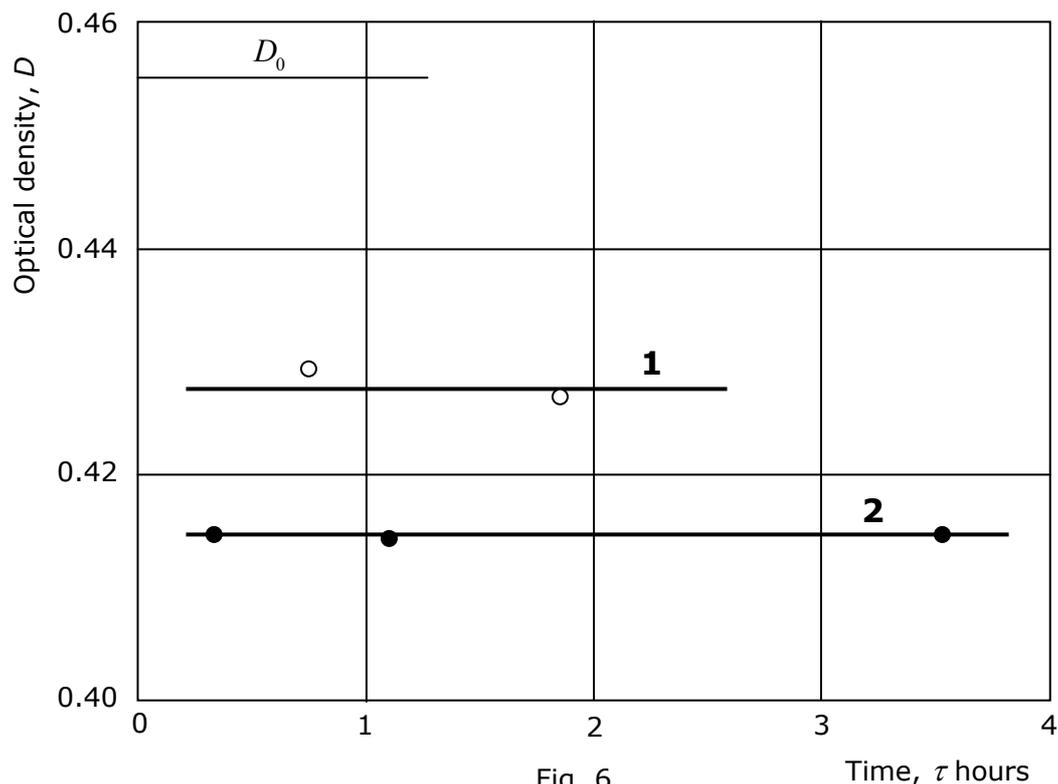


Fig. 6.

Time, τ hours

Influence of a pulsing electrostatic field. The results of experiments on influence of a pulsing electrostatic field on coagulation of suspension titanium dioxide in 0.1 M a solution *KCl* are given on a figure 6.

On a figure 6: 1 - coagulation in absence of a field, 2 - coagulation in pulsing a field.

After coagulation within 10 minutes cuvette placed in a Petri dish and closed by a plexiglass plate. During next 10 minutes coagulation went under action of a pulsing electrostatic field created by friction about plexiglass of the paper filter. It is clear from figure 6. effect of increase of speed coagulation in an electrostatic field has appeared twice more and makes 52%, therefore it is well fixed even visually. Such increase of speed has appeared sufficient for nonequilibrium course coagulation and, after removal of a field, the weak effect peptization within two minutes is found out, i.e. is observed convertible coagulation. Peptization can be explained to that at removal of a field the structure of a surface of a hydrate layer of anatase particles is partially restored. The application of pulsing electrostatic and magnetic fields in technological processes connected to a condition of an outside solvation layer of colloidal particles can be very effective. For example, in the given system such speed coagulation is reached which can not be achieved at any concentration *KCl*.

The described effect in 52% is caused by an electrostatic field of small quantity, though the outside field was strong enough. It follows that the external field is compensated by a field arising inside conducting environment, what is anatase suspension with electrolyte. Therefore at a constant external electrostatic field, inside

cuvette the field is absent. Shielding of this field occurs in time relaxation of conducting environment, which is equal ε/K , where K - conductivity of environment, ε - its permittivity. From here it follows that the field inside of cuvette lags behind an outside electrostatic field. The effective field working on particles will be proportional to size of backlog. Thus, the pulsing electrostatic field, the same as also magnetic, causes acceleration coagulation at the expense of polarization of a solvation layer of colloidal particles.

The described discovery has huge importance, is especial for biology. Any living organism represents complex colloidal system. Each cell of organism has a membrane bearing double electrical and a solvate layer. All properties of a membrane, at the end, are defined by properties of a solvate layer and ions. The discovery makes scientific base under the uncountable observant facts, which orthodoxies are inclined to attribute false-scientific to imaginations or mysticism. For example, professor Chishevsky, which on an example of the large number of the facts has proved influence of solar activity on many biological processes on the Earth, and has died, spit upon by the orthodoxies, which accused him of all mortal sins. At the same time, now authorities are compelled to warn the population about forthcoming magnetic storms. At any movement across magnetic force lines of the Earth we magnetized our internal environment. A mobile water stream, rivers and ocean currents is effective enough magnetized and always contains aquacellas. Especially this phenomenon has an effect in high latitudes of the Earth, where the magnetic force lines are condensed and are directed almost perpendicularly the surface of ground. The especially strong influence of magnetic processing should have an effect for origin and development of embryos, where the slightest changes of conditions have far-reaching consequences.

7. Apparatus for separation of liquid isotopes

Surprisingly, that the good ideas frequently come in a head in many years after realization of the applicable experiments when to play back or to update them already it is impossible. Why these ideas do not come at once? The answer I see in the depravity of the system of science. Frequently coming with work complain to mother:

- Mama, do not give to work.
- And you do not pay attention and work.

Then it was necessary long to explain, that it is necessary to write the sham records, to go in business trips to implant the own inventions, to drink with a management of plants, that they have signed the act on which one we «trained staff» and made other useful for a plant of business make something out of thin air, sittings of senatus academicus, recalls on works of competitive organization, the conferences both sittings and other devildom did not leave at all time for creative scientific activity. When I have become, at last, by the free artist and anybody by nothing is obliged, then began substantial creativity. After that lyrical digressions it will become understandable, why the idea in 40 years after my occupations by colloid chemistry was born.

The principle of operation of the apparatus though is original, but very much is simple in fulfilment and is shown on a figure 7.1 on an example of a single cell of separation customary and heavy water. The unit cell of separation consists of a vessel 1, filled water. On water the platform 2 floats. On a platform tube 3, approximately, 1 cm diameter and same altitude is fixed. The platform has of such weight, that the top of a meniscus of water in a tube almost coincides the upper shear of a tube. The activity of the device is illustrated by a figure 7.2.

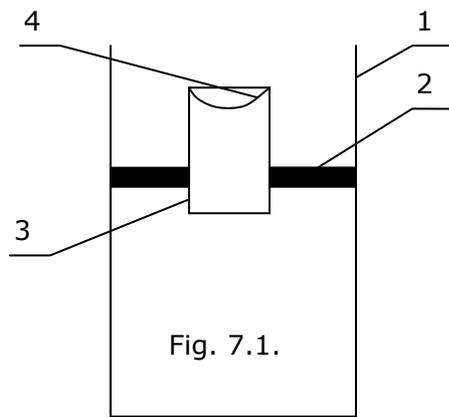


Fig. 7.1.

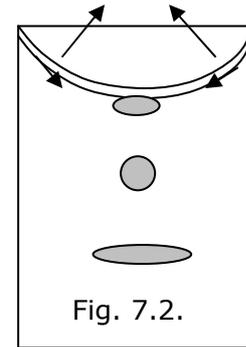


Fig. 7.2.

At vaporization of water from upper face of a film of surface tension on a underside of this film the heavy water is concentrated, since its vaporization from a concave meniscus is hindered because of padding connections with adjacent molecules. The heavy water flows off downwards on an internal surface of a film of surface tension and is stored in lower point of a meniscus so long as under operating of gravity will not be torn off as a drip. This drip, certainly, deliquesces at motion on bottom of a vessel, but in absence of a considerable convection this phenomenon does not hinder separation. The visually described effect is inconspicuous, but the device neatly fixates an alternation of an optical density of a liquid at dip of «drip».

The apparatus as a whole is the rectangular container, filled water, in which one the platform with numerous tubes. Thus, is simultaneous on bottom of a vessel thousand «drips» of a heavy water can simultaneously drop. During activity the platform is automatically travels to bottom of the container and slightly floats up, since density of a liquid is step-by-step augmented. At achievement by a platform of bottom of the container the process of separation customary and heavy water is as a matter of fact repeated a uncountable number of times, that guarantees a high degree of separation. The apparatus works independently and does not require service and power supply. For preventing a considerable convection of a liquid the thermal insulation of the apparatus is advisable. Naturally, that in conditions of the customary research institute I could not analyse presence of a heavy water because of uncountable obexes of our security system.

References:

- 1 <http://www.new-physics.narod.ru>