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SOME RESULTS OF THE STUDIES OF THE REACTION OF WATER AEROSOL WITH THE PARTICLES OF SOLID REAGENT

by

N. G. Vereshchago, Ye. N. Ovchinnikov,
et al.

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Д д	*Д д*	D, d	Ф ф	*Ф ф*	F, f
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О о	*О о*	O, o	Ю ю	*Ю ю*	Yu, yu
П п	*П п*	P, p	Я я	*Я я*	Ya, ya

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GREEK ALPHABET

Alpha	Α	α	α	Nu	Ν	ν	
Beta	Β	β		Xi	Ξ	ξ	
Gamma	Γ	γ		Omicron	Ο	ο	
Delta	Δ	δ		Pi	Π	π	
Epsilon	Ε	ε	ϵ	Rho	Ρ	ρ	ϱ
Zeta	Ζ	ζ		Sigma	Σ	σ	ς
Eta	Η	η		Tau	Τ	τ	
Theta	Θ	θ	ϑ	Upsilon	Υ	υ	
Iota	Ι	ι		Phi	Φ	φ	ϕ
Kappa	Κ	ϰ	κ ϰ	Chi	Χ	χ	
Lambda	Λ	λ		Psi	Ψ	ψ	
Mu	Μ	μ		Omega	Ω	ω	

RUSSIAN AND ENGLISH TRIGONOMETRIC FUNCTIONS

Russian	English
sin	sin
cos	cos
tg	tan
ctg	cot
sec	sec
cosec	csc
sh	sinh
ch	cosh
th	tanh
cth	coth
sch	sech
csch	csch
arc sin	$\sin^{-1}$
arc cos	$\cos^{-1}$
arc tg	$\tan^{-1}$
arc ctg	$\cot^{-1}$
arc sec	$\sec^{-1}$
arc cosec	$\csc^{-1}$
arc sh	$\sinh^{-1}$
arc ch	$\cosh^{-1}$
arc th	$\tanh^{-1}$
arc cth	$\coth^{-1}$
arc sch	sech^{-1}
arc csch	csch^{-1}

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rot	curl
lg	log

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SOME RESULTS OF THE STUDIES OF THE REACTION OF WATER AEROSOL WITH THE PARTICLES OF SOLID REAGENT.

M. G. Vereshchago, Ye. N. Ovchinnikov, A. V. Stavitskaya, R. M. Epimakhova.

Odessa hydrometeorologic institute.

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The processes of the inertia and inertia-free capture of the drops of water aerosol by the collector/receptacles of various forms have vital importance in the theoretical examination of natural processes in clouds and fog.

The ideas of effect by different reagents on clouds and fog lean not only on condensation, but also on the coagulating mechanism of the reaction of water aerosol with the particles of hygroscopic and hydrophilic reagent.

We have carried out the number of experiments in the reaction of water aerosol with obstructions - the collector/receptacles of different geometric form, namely:

1. Flat/plane obstructions (model of snow crystals) are disks, rectangular plates, film/strip, six-ray asterisks.

2. Fiberlike obstructions.

3. Grains of the grinding of bentonite.

As the basis of investigation placed the determination of the coefficient of the capture of the obstructions, introduced into the flow of the coarsely dispersed water aerosol (diameter of drops 5-28 μm) of the assigned liquid-water content and rate.

1. Precipitation of water aerosol for flat/plane obstructions.

As the fixer of the drops, deposited to flat/plane particles, serves the plotted on them layer of gelatin. The deposited during obstruction drops leave the replicas, size/dimension and number of which they were determined under the microscope. The coefficient of capture is calculated as ratio of the mass of the deposited during obstruction aerosol to the mass of the aerosol, which leaks in with flow.

The developed by us procedure of study makes it possible to present the flow of polydisperse aerosol as totality of monodisperse flows with completely determined liquid-water content. Procedure makes it possible to experimentally define the coefficients of the capture both entire barrier as a whole and any local currents during obstruction, the so-called local coefficient of capture [1].

It should be noted that the measurements were conducted in the region between the viscous and potential flow (Re = 50-300), which was caused by the solution of the problems of applied character.

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In the region of flows indicated the coefficient of the capture of the obstructions of flat/plane forms theoretically cannot be calculated in view of the absence of data on velocity field.

As a result of investigations [2] are obtained the local and full/total/complete coefficients of capture for disks (with Reynolds number 50-300), for a film/strip and a plate (Re = 120) and for a six-ray asterisk (Re = 220).

Were establish/installed the dependences of the local coefficients of capture on relative coordinates (R_i/R) for all forms of flat/plane obstructions with Stokes' numbers, equal to 0.08-1.3.

Figure 1 shows characteristic curves $\alpha_i = f(R_i/R)$ for disks with Reynolds number Stokes' 50-300 and some numbers. It should be noted that with Stokes' numbers K ≤ 0.255 the coefficient of capture sharply grow/rises to the edge of barrier. of prepyastviya. With K > 0.260, the difference in α_i in center and at the edge of collector/receptacle decreases. And finally, with certain K, named us K_0, the coefficient of capture turns out to be constant during all obstruction.

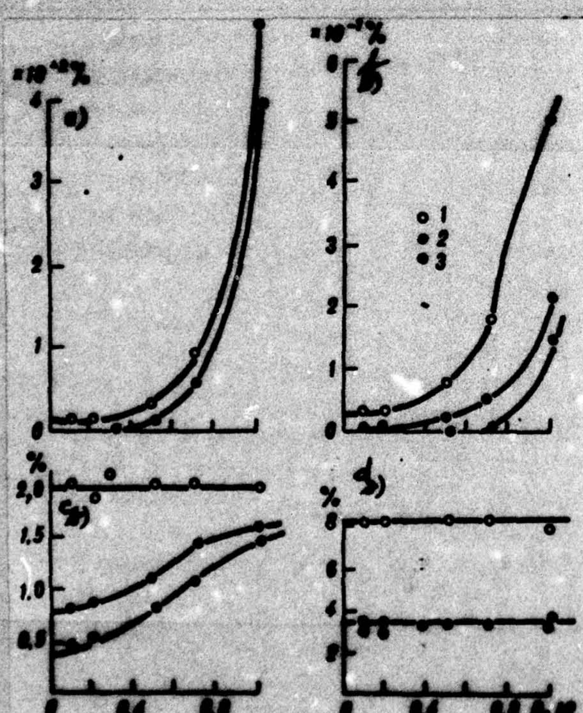

Fig. 1.

Fig. 1. Change in the local coefficient of capture along disk with Stokes' numbers: 0.130 (a); 0.200 (b); 0.400 (c); 0.600 (d). 1) Re = 280, 2) Re = 220, 3) Re = 73.

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The analogous character of the dependence of the local coefficients of capture on the coordinates of local point was obtained for all by us flat/plane obstructions being investigated.

It is establish/installed that the value of the maximum number K_0 depends on Re, streamlined obstruction and its form. Figure 2 depicts dependence $K_0 = f$ (Re). With an increase ReK_0 it decreases.

For the various forms of collector/receptacle K_0 it has the following values:

(1) Форма	K_0	
	Re = 120	Re = 180
(2) Звездочка	—	0,320
(3) Диск	0,500	0,420
(4) Пластина	0,550	—
(5) Лента	0,630	—

Key: (1). Form. (2). Asterisk. (3). Disk. (4). Plate. (5). Film/strip.

The coefficient of the capture of disks, which corresponds to Stokes' maximum number K_0, is 2.0-3.5o/o, star-shaped disks - 20o/o.

Thus, obtained by us data on the local coefficients of the capture of disks, plates, film/strip and asterisks in the intermediate region of flow will show that the precipitation of water aerosol for flat/plane obstructions can be divided into two types:

I type of precipitation - the local coefficient of capture depends on the coordinates of local point and depends substantially on form (Fig. 3a);

II type of precipitation is a local coefficient of capture for Stokes' numbers, the equal or large K_0, is constant during all obstruction and dependence on form is unessential (Fig. 3b).

The constancy of the coefficient of capture by obstructions we consider as proof of the fact that the distortion of flow as a result of the flow about the obstructions does not change the concentration of the flying with particle flux of the water aerosol. In this sense Stokes' maximum number in the intermediate number domain of Reynolds we identify with Stokes' critical number for a potential flow (obtained by the theoretical calculations).

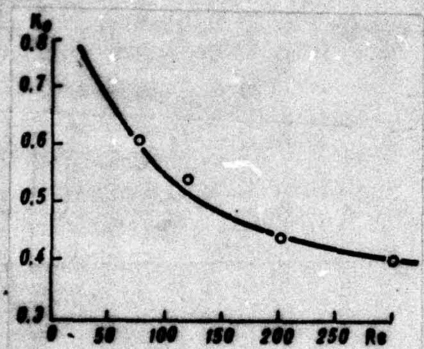

Fig. 2. Dependence K_0 local on Reynolds number (disk).

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The dependence of the coefficient of capture on the coordinates of local point for the first type of precipitation, possibly, indicates an increase in the concentration of smaller particles of the edge of the streamlined obstruction during the distortion of flow, and also to the fact that we here observe the noninertia precipitation of particles.

By us experimentally have been established the dependences of the full/total/complete coefficients of capture on the number of Stokes and Reynolds number. It is establish/installed that the full/total/complete coefficient of capture increases with an increase of the number of Stokes and Reynolds number, it depends on form (Fig. 4). Disk has a coefficient of capture larger than plate and film/strip.

The analogous character of curves is obtained for the full/total/complete coefficients of capture by obstructions in the form of asterisks.

The studies of the precipitation of water aerosol for flat/plane collector/receptacles in the intermediate region of flow showed that for all studied forms occurs the precipitation of drops with the number of Stokes, considerably smaller than the critical number even for a potential flow.

It was establish/installed that the capture of collector/receptacle-asterisks considerably exceeds the capture of the flat/plane obstructions of other forms.

Figure 5 shows the capture of asterisks and disks with $S_2 = S_0$ and $R_2 = R_0$ other conditions being equal.

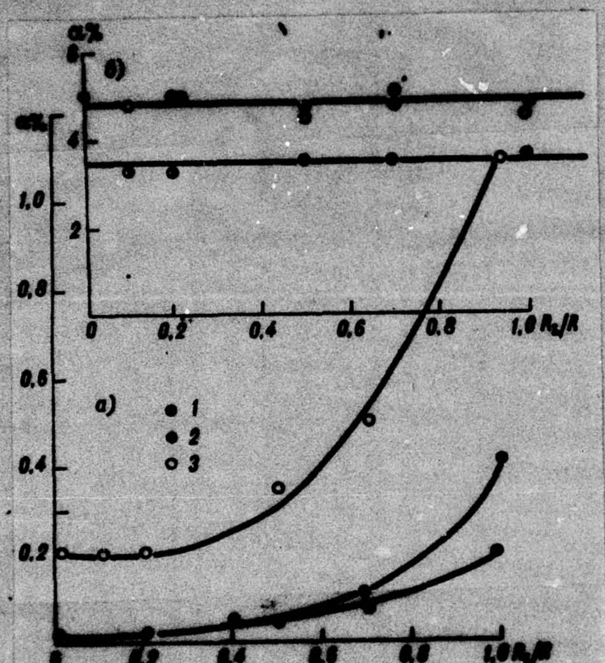

Fig. 3. Characteristic curved changes in the local coefficients of capture along the obstructions of various forms. a) I type of precipitation, b) II type of precipitation; 1 - for a film/strip, 2 - plate, 3 - disk.

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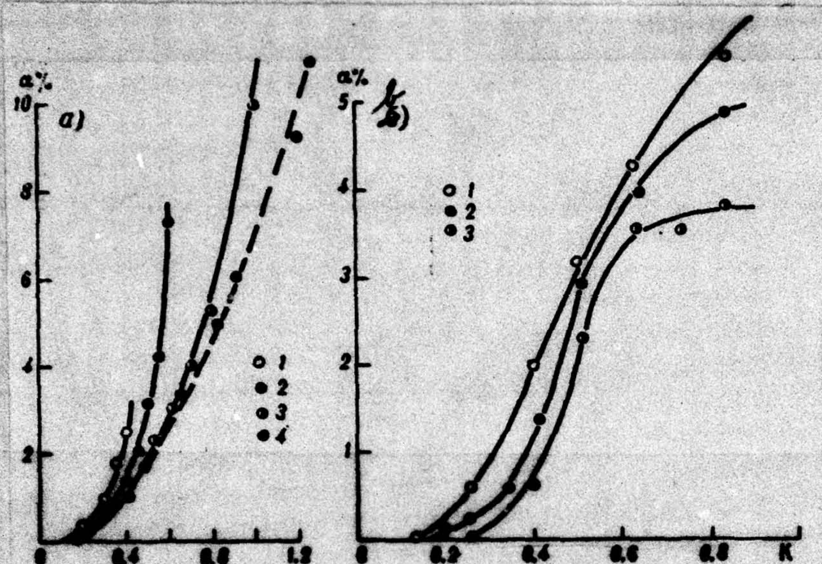

Fig. 4.

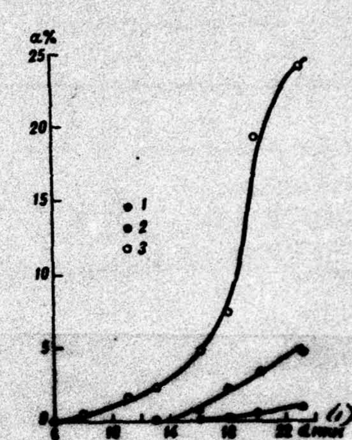

Fig. 5.

Fig. 4. Dependence of the full/total/complete coefficients of capture on the number of Stokes and form of collector/receptacle. a) dependence α = f (K) for disks with Reynolds number: 1) 280, 2) 220, 3) 120, 4) 73; b) dependence α = f (K) with Re = 120 for disk (1), plates (2) and film/strips (3).

Fig. 5. Capture of asterisks and disks. 1 - for a disk with $R_{д}=R_{з}$; 2 - for the disk of identical area. $S_{д}=S_{з}$; 3 - for an asterisk.

Key: (1). μm.

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Under our conditions the star-shaped obstructions prpvide the capture of the smallest drops, namely: asterisk is drops 8 μm (diameter), disk from $R_n = R_0$ - drop 16 min, disk from $S_n = S_0$ - drop 12 μm.

one of the essential efficiency factors is a small mass of collector/receptacle relative to the mass of the assembled on it liquid. Consequently, interesting is the investigation of the collector/receptacles of various forms, which possess large specific surface area.

one of the sets of experiments is related to research on the reaction of fine/thin disk-shaped films with the flow of water aerosol. Films by radius $0.25 \cdot 10^{-2}$, $0.37 \cdot 10^{-2}$, $0.50 \cdot 10^{-2}$, $0.65 \cdot 10^{-2}$ m with thickness from 1 to 30 μm more are prepared from Black Sea agaroid and possess hydrophilic behavior and hygroscopicity. They are suspended on three fine/thin caprone filaments in the vertical current of water aerosol and are maintained by flow in suspended state so that filaments were stretched. With an increase in the mass of film is increased the speed of the maintained flow, in value of which it was possible to judge the mass of film with moisture.

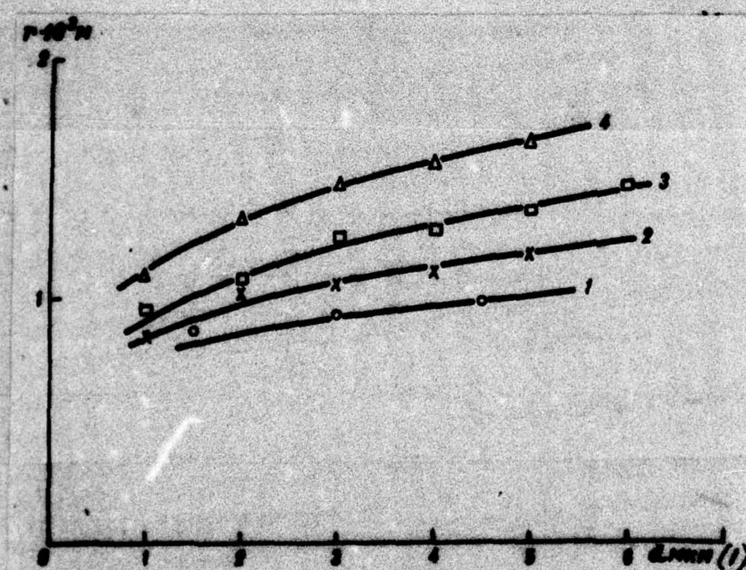

Fig. 6. Dependence of the size/dimensions of the drops, obtained on the being displaced films, on the thickness of films for their following size/dimensions: $0.25 \cdot 10^{-2}$m (1); $0.37 \cdot 10^{-2}$ m (2); $0.50 \cdot 10^{-2}$

m (3); $0.65 \cdot 10^{-2}$ m (4).

Key: (1). μm.

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In the initial stage of an increase in the films occurs the bloating their, and then accumulation of the being precipitated out water on surface. With thickness more than 25 μm of film they are not strained and are not displaced, but if the thickness of films less than 9 μm, is observed the turning of films and the formation of drops. In the intermediate region of thicknesses is observed the incomplete turning of films.

Upon reaching of certain mass of the untwisted films occurs the dropping of drops from them, after which the process of the precipitation of water aerosol to films begins first. The dependence of the size/dimensions of the expendable drops on the size/dimensions of films the is following:

radius of the film	$0,65 \cdot 10^{-2}$	$0,50 \cdot 10^{-2}$	$0,37 \cdot 10^{-2}$	$0,25 \cdot 10^{-2}$
Radius of the drop	$0,33 \cdot 10^{-2}$	$0,36 \cdot 10^{-2}$	$0,33 \cdot 10^{-2}$	$0,27 \cdot 10^{-2}$

It is evident that for the different radii of the films, which exceed $0.37 \cdot 10^{-2}$ m, the expendable drops in the range of experimental error are identical and only for the smallest size/dimension of film the expendable drops considerably less. Hygroscopic addition the film plays the role only in the initial stage of an increase in the untwisted films, subsequently occurs the washout of salt rom the surface of film.

The dependence of the size/dimensions of the drops, which are obtained on the being displaced films, on the thickness of films is given in Fig. 6. From the figure one can see that with an increase in the geometric dimensions of films is increased the size/dimension of the generating on them drops. With the turning of the films, which have hygroscopic salts, are formed the drops whose increase subsequently occurs according to the laws of an increase in the hygroscopic drops.

In such a manner both the being displaced and untwisted polymer films they can be used for formation in the natural aerospl of large drops. Moreover during the utilization of the being displaced films the number of drops is equal to the number of films. The untwisted films in the presence of the corresponding upflows can repeatedly form large drops.

2. Precipitation of aerosol for fine/thin filaments.

As is known from literature sources, the greatest coefficient of capture have the obstructions, significant dimension of which is less than the diameter of the leaking-in drops. So, for cylinders it is known that the coefficient of capture $\alpha = 1 + r/R$, where r is a radius of drops, R - the radius of cylinder [3].

Since with precipitation and merging/coalescence of drops on cylinders (filaments) appears the constantly changing in time configuration from the drops of different value, in consequence of which is changed the aerodynamic field of the flow about the system, it is of interest to study the laws governing the precipitation of water aerosol for fine/thin filaments [4, 5].

As a result of the fact that the filaments with incidence/drop through aerosol cloud can accept different orientations, necessary to study the laws governing precipitation, merging/coalescence and runoff of drops from filaments in different positions, in particular with their horizontal and vertical arrangement.

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Since to merging/coalescence and runoff of drops from filaments can have an effect the chemical nature of their surface, for investigation were taken filaments with hydrophobic and hydrophilic surfaces.

Investigations are conducted by flow method. Filament on special holder is inserted into the flow of aerosol with the following parameters: the speed of flow 0.5 m/s, liquid-water content 1.5 g/m³, the diameter of the leaking-in drops of virtually monodisperse aerosol 8 μm. Conducts microcinematography of the process of precipitation with speeds [16, 24, 48 frame/ss. For investigation are applied the filaments from Plexiglas 1, 3 and thickness 6 μm. As hydrophobic filaments were applied the filaments without surface treatment, since the Plexiglas is the badly/poorly hydrophilic material. As hydrophilic are applied the same filaments, but with surface treatment OP-7.

The capture efficiency of filaments is calculated from the formula

$$\varepsilon = \frac{\Delta m_1}{\Delta m_2}.$$

where Δm_1— the mass of the water, precipitated for the filament for time Δt, determined on the basis of the experimental data; Δm_2— the mass of water, leaking in after Δt for the midsection of filament - drop system.

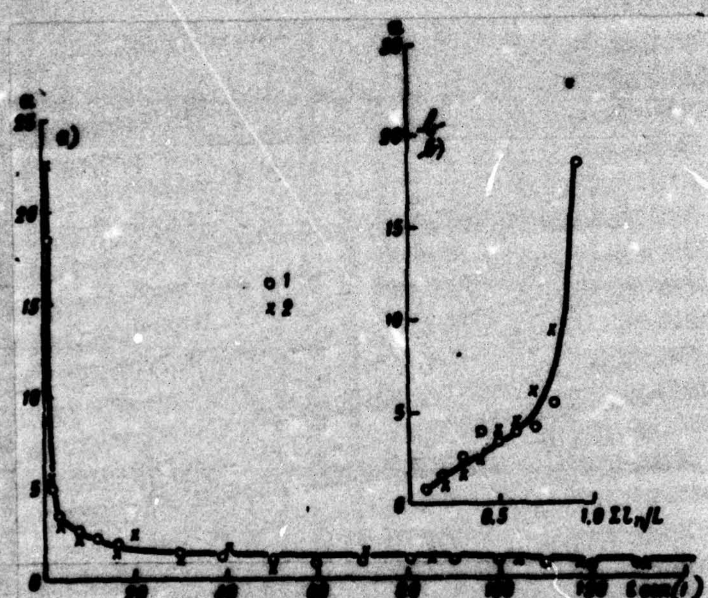

Fig. 7. Dependence of the effectiveness of the capture of filament on time (thickness of filament 1 μm) (a) and of the relative length of

the free from drops sections of filament (b). L is length of filament in sequence, Σ_s - the total length of the free from drops sections of filament, 1 - pure/clean filament, 2 - filament with surface covering.

Key: (1). s.

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The investigations will show following.

1. The capture efficiency of filament has the greatest value at the first torque/moment of the process of precipitation, then its value decreases in the course of time (Fig. 7a). So, for a filament 1 μm thickness α = 22.0; for 3 μm α = 8.5; for 6 μm α = 5.5.

2. Capture efficiency depends on the thickness of filament in the initial stage of the process of precipitation, and then it is determined by the degree of the filling of filament with drops and falls with the decrease of the free length of filament (Fig. 7b).

3. During the precipitation of drops for hydrophobic filament they virtually do not change their form, during precipitation for the

hydrophilic (hydrophilic) filament of drop they acquire spindle-shaped form and their merging/coalescence during filament it is facilitated, to what contributes, evidently, formation between the drops of water cross connection.

4. The chemical nature of the surface of filament (hydrophobic, hydrophilic) in effect does not affect the capture efficiency of horizontal filaments.

5. During the precipitation of drops from flow for vertical hydrophilic filaments is observed the intense action of drops under the action/effect of the force, their merging/coalescence and runoff from filament, which contributes to the cleansing of filament from drops and to an increase effectiveness of capture on the average 2 times.

6. The diameter of the drops, which flow from vertical hydrophobic filaments, is 100 μm and more, whereas the diameter of the drops, which flow from vertical hydrophilic filaments, on the order of 70-80 μm.

3. Reaction of water aerosol with the grains of the grinding of bentonite.

For research on the reaction of water aerosol with the hydrophilic and hygroscopic substance, which consists of particles of the incorrect geometric form, was used the grinding of bentonite of Ukrainian deposits.

Of 11 specimen/samples of bentonite of Gorbskiy, Kurtsovskiy, Dashukovskiy and Pyzhevskiy deposits were selected the specimen/samples, the most active in relation adsorption of water vapors made of air-steam mixture and possessing the maximum electric particle charge.

Adsorption of water vapors on bentonite is conducted under dynamic conditions from air flow. Is determined the curve of kinetics and the value of maximum adsorption.

The particle distribution of the bentonitic powders according to charges is studied by the method of the deviation of the trajectory of the freely falling/incident monodisperse particles in uniform electric field. All powders are characterized by the asymmetric distribution function with the preponderance of the negatively charged particles.

Are investigated natural bentonite and the specimen/samples, which subjected to heat and chemical (acid, alkaline, salt) treatment.

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It was explained that the optimum adsorptive properties and the maximum portion/fraction of charged particles with the charges of both signs possesses the Kurtsovskiy bentonite, thoroughly heated at temperature of 200°C.

The reaction of the bentonitic powder, which has the maximum of the particle-size distribution function 10-15 μm in diameter, with condensation fog is studied in the chamber of fog of GGO [ГГО - Main Geophysical Observatory] with respect to a change in the optical transmission of fog, which is record/written on recorder tape EPP-09. The powder of bentonite (60 g) is sputtered with the aid of the pulverizing device in the upper part of the chamber during 10 minutes. To two working experiments is conducted one control. For a comparison with bentonite in the chamber test/undergo the powders of cement and hydrophobic calcium stearate. The estimations of the kinetics of scattering fog under the influence by reagents it is reveal/detected by the statistical interpretation of the large number of experiments. Each working experiment is compared with adjacent control.

The seeding of reagent begins in all experiments upon reaching by the formed fog of the certain degree of transparency, through 5-7 minutes after fog formation. Time of observation for the scattering curve of fog is 35-40 minutes.

Typical scattering curve of fog during continuous trace for the working and control of experiments, transferred to one curve/graph, take the form, shown in Fig. 8a.

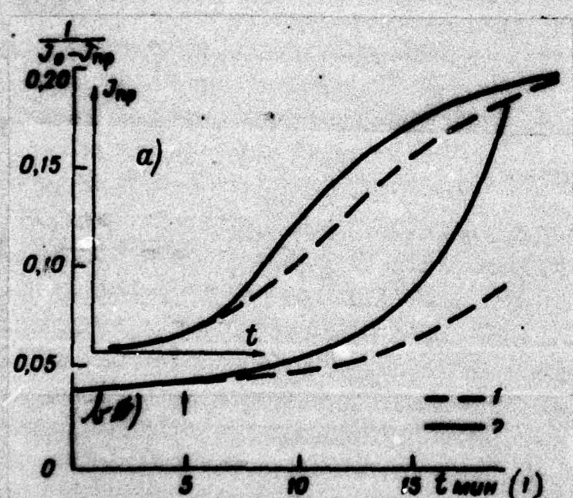

Fig. 8. Typical scattering curve of fog. a) change in time of the transparency of fog at its scattering, b) a change in value $\frac{1}{J_0-J_{np}}$ in time during scattering fog: 1 - control experiment, 2 - working experiment. Arrow/pointer showed the beginning of the introduction of reagent.

Key: (1). min.

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The estimation of reaction conducts on the processed curve, expressing the dependence

$$\frac{1}{J_0 - J_{\text{пр}}} = f(t).$$

where J_0 is intensity of luminous flux without fog. $J_{\text{пр}}$ — the intensity of the luminous flux, passed through fog. During this treatment of the scattering curves of fog the effect of reagent appears more clearly (Fig. 8b).

The experiments will show that the effectiveness of Kurtsovskiy bentonite will render/show 2 times more than the effectiv ness of cement. The hydrophobic calcium stearate, atomized under different conditions, effect will not give.

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P005 ERDA	1
P055 CIA/CRS/ADD/SD	1
NAVORDSTA (50L)	1
NAVWPNSCEN (Code 121)	1
NASA/KSI	1
AFIT/LD	1

ORGANIZATION	MICROFICHE
E053 AF/INAKA	1
E017 AF/ RDXTR-W	1
E404 AEDC	1
E408 AFWL	1
E410 ADTC	1
E413 ESD	2
FTD	
CCN	1
ETID	3
NIA/PHS	1
NICD	5