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## **Modern Methods (Without Determining the Contact Angle and Surface Tension) for Estimating the Surface Properties of Materials (Using Video and Computer Technology)**

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Additional information is available at the end of the chapter

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### **Abstract**

In the study of surface phenomena including nanotechnology, the main and only instrumentally determined parameters are the surface tension and the contact angle. These indicators have been introduced over 200 years ago, and any new inventions in this area do not exist anymore. In line with this, we have developed a new method and device for determining the surface activity.

The basis of the method and the device makes use of video cameras to record the droplet size and changes in the surface layer of the known thickness of the liquid droplets from the impact of surfactant substances (surfactants). Committed changes are then processed by computer programs and calculated parameters, which can be characterized by the surfactant, the surface where the liquid is and the liquid itself. Determining the surface tension or contact angle is not necessary.

Exploring the possibility of estimating the surface properties of bulk and powdered materials, without determining the surface tension and contact angle, moving particles that are conventionally divided into six groups have been detected. The possibility of moving objects to glow is suggested by a possible mechanism of movement and glow through air oxidation of the organic compounds used as surfactants in the experiments. Score particle velocity indicates that they may move at a speed of 10 - 15 and 100 - 150 mm / sec. The results of the evaluation of the surface properties of the particulate material were obtained without measuring the contact angle and surface tension.

**Keywords:** Surface tension, contact angle, the thickness of the liquid layer, the indicator grid, moving particles, , speed of movement, agglomerate, fast moving, glow, silica, nanoparticles

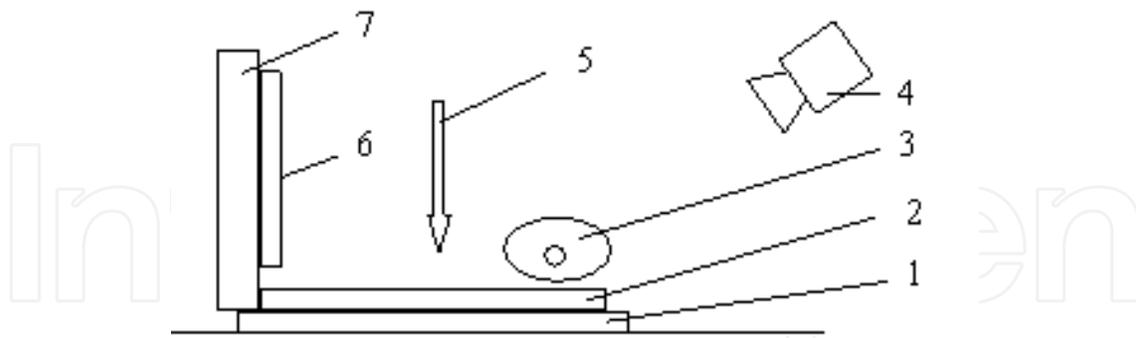
## 1. Introduction

### 1.1. Determination method of surface activity indicators that move liquid surfactants [1]

Surface activity indicators when using this method and the device are:

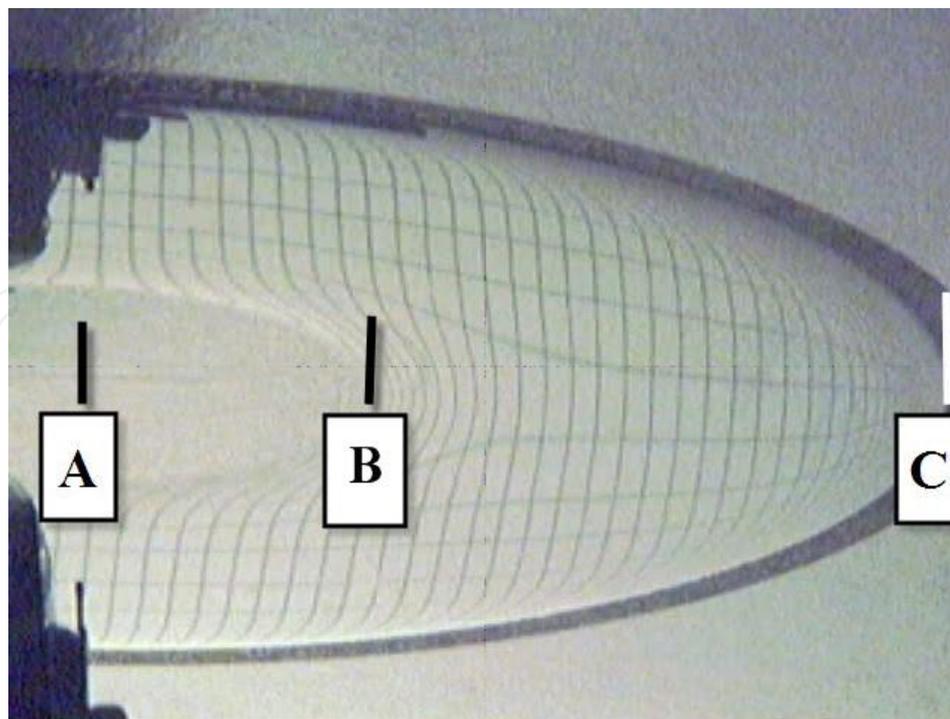
1. The amount of liquid which can move one kilogram of surfactant. The value of this parameter varies from tens up to hundreds of thousands of units. The indicator can be converted to units of energy - joules.
2. The amount of fluid retained in the surface per unit time is calculated based on the first index and the surfactant supplements characteristic may be indicative of the characteristics of the surface and the liquid.
3. The velocity of propagation of capillary and microwaves. This indicator complements the first two.

A new method for determining the surface activity is carried out on the installation (see. Figure 1). [2]



**Scheme 1.** General scheme of installation. 1. A table with an adjustable horizontal; 2. Object - preparation (surface under study); 3. The camcorder recorded the size of the drop; 4. The camcorder recorded changes in the surface of the object - the drug; 5. Pipette; 6. Indicator mesh; 7. Lights

On the table with an adjustable level of the horizontal surface of the stack 1 of the plate material properties 2, the surface of which should be investigated (Scheme 1 indicates how an object is prepared). For the retention of the investigated liquid on a surface layer with 0.1-1 mm thickness, the material deposited on the circumference of a hydrophobic material depends if the liquid is polar or not, or if the liquid are solutions of various substances. The effect of which



**Figure 1.** Measurements: A - B range displaced liquid layer. A - C size scaling

should be further investigated. Then, the camera or film camera 4 is set so that the boundary line and the center of the bounding figures were clearly visible in the viewfinder and on the possibility of occupying the entire frame (Image sharpness adjustment). After setting up the sharpness, the line is set with a scale of 1 mm, and the camera fixed for subsequent scaling measurements. The line is set perpendicular to the optical axis of the lens fixing process chamber 4 exactly at the diameter of the circle. After that, the line is removed.

In limited hydrophilic or hydrophobic substance circles, the test liquid is measured in an amount necessary to produce the liquid layer thickness selected by the researcher.

Exactly over the center of the bounding shapes, such as circles, a calibrated weight drop was established at the diameter of the capillary pipette tip 5 so that the drop fell from it as accurately as possible at the center of the figure. The edge of the pipette tip was mounted at a height of 4-30 mm. Illuminator 7 display grid 6 is set so that the reflection from the surface of the liquid in the image grid locking chamber 4 was clearly visible.

The camera captured an image at the same time to determine the volume of a drop at the moment of separation from the capillary pipette including 3 cameras that captured a larger scale, drop, and surfactant solution or sample liquid that was introduced into the center of the circle. To fix the process of the moving fluid, the film footage was consistently studied to determine the distance from the center of the drop to the ground "wave motion" and in accordance with the scale that converted the results into units of length. Similarly, the droplet diameter at the time of separation from the capillary pipette was determined.

If it is necessary to define or map out the properties of the surfactant, one can use the "standard" surface, which are heat-resistant hydrophobic films or writing paper, or surface-modified paper, for example with gelatin.

When working with paper, it is applied to the circumference of the necessary internal diameter of the hydrophobic dye. The line width of the bounding figure is 5 - 6 mm. The damaged part of the paper with her bounding figure (object - a drug) is soaked in a solvent (for example water) for a certain time (for example 10 minutes) and placed on a table or laid on a plane-parallel plate (thick glass). In this straightened paper, because it is removed from air extruded by a glass tube with rounded ends, (for example a diameter of the pipette 10 - 15 mm) or other device, (for example a roller or roller glossing pictures for unfolding and adhering wallpaper). In the area of the paper, you applied bounded by lines (circle, square). The test liquid is applied in an amount necessary to produce the layer thickness that is determined by experimental conditions. In the center of the pipette tip, the locking chamber is included and applied to the center of the bounding shape of the object - a drop of solution of the test drug surfactant.

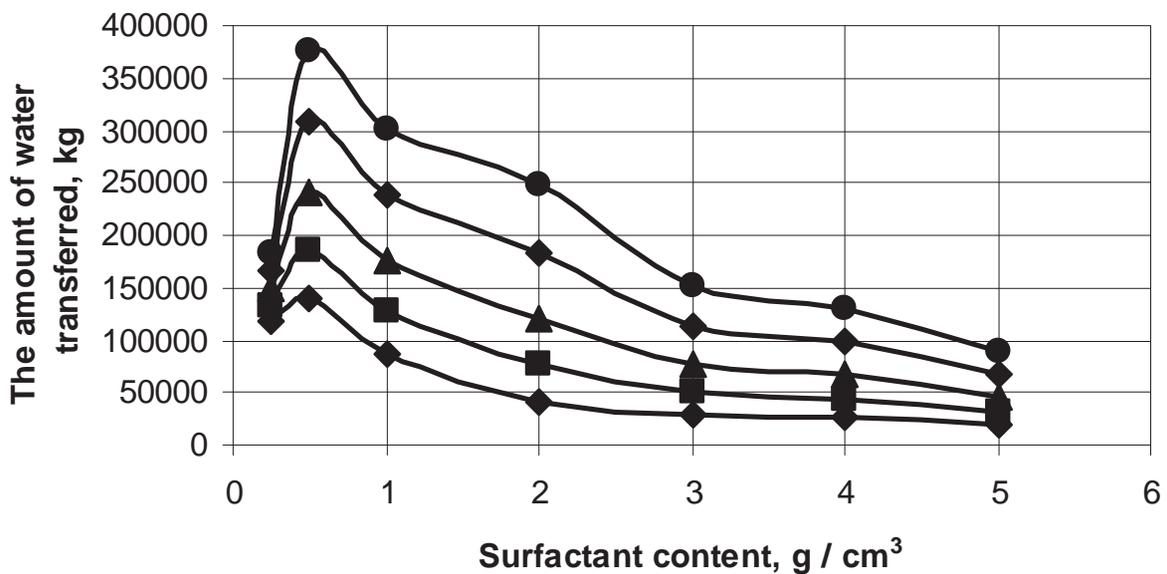
## 2. Determination of the amount of the liquid conveyed surfactant

To determine the amount of fluid displaced in the scan frame, the frame corresponded to the maximum radius (diameter) of the displaced fluid layer using standard computer programs to measure it. Figure 1 shows an example of the measurement. After finding the radius determined by

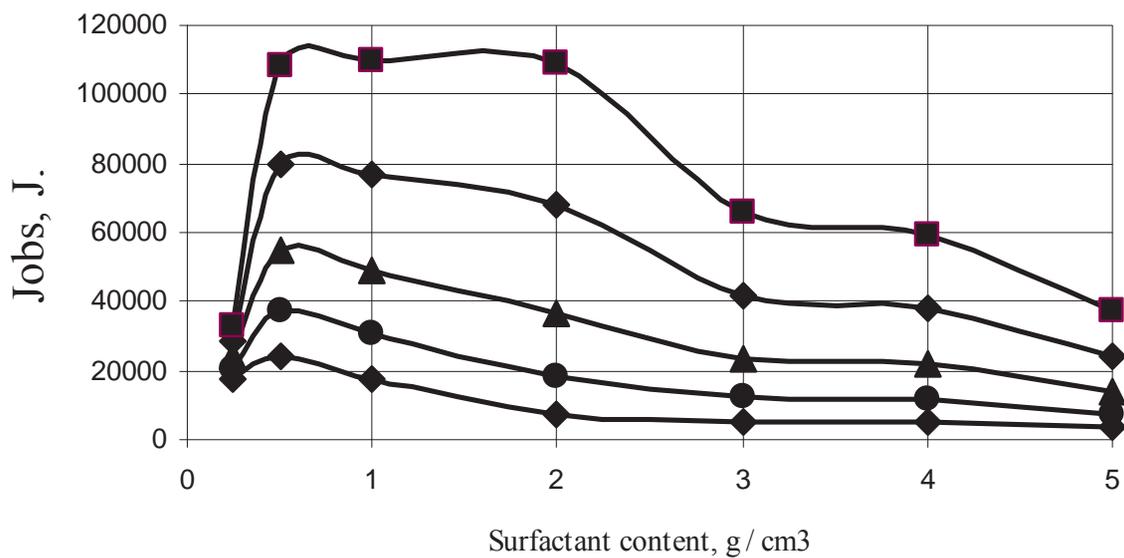
the amount of moving water, its density is given. For example, the volume of the displaced fluid was found to be  $9.4 \times 10^{-7} \text{ m}^3$ , the water depth was  $5.0 \times 10^{-4} \text{ m}$ , and the weight of displaced fluid was 0.00094 kg. When the surfactant concentration is  $5 \text{ kg/m}^3$ , the diameter is 0.00229 m, and the droplet amount of the surfactant is equal to  $3.15 \times 10^{-8} \text{ kg}$ , then, the specific liquid transfer amounts to 29,688.55 kg. One kg of surfactants is able to move the 29.7 tons of water. This is consistent with the work produced in J 7106.37.

Fig. 2 shows the results of a study based on the effect of these parameters on the amount of fluid displacement surfactants. Figure 3 shows the results of the determination of the perfect work in moving liquid surfactants.

From these results, it is evident that one kilogram of surfactant with a great deal of movement implements 110,000 joules, and it depends on the area of the movement. The greater the radius of the bounding area of a circle, the more work is done. The quantity of the displaced fluid is enormous given that 1 kg of the liquid surfactant mass moves in 370000 kg., and one of the surfactant molecules can move 3500000 water molecules [4]. It can be assumed that the distribution of the surfactant on the surface is liberated in the form of a film, which pushes their hydrophobic boundary forming a hydrophilic water wave motion (see Fig. 9, wave movement is marked C).



**Figure 2.** The change in the specific amount of water transferred and surfactants "balancer", depending on the content of the surfactant and the confining diameter of the circle (the layer thickness of 0.0005 m). Bounding circle radii (curves upward) 0.04; 0.05; 0.06; 0.07; 0.08 m. [1,3]



**Figure 3.** The change in the specific operation when water is moving and a surfactant "equalizer", depending on the content of the surfactant and the confining diameter of the circle (layer thickness 0.005 m). Bounding circle radii (curves upward) 0.04; 0.05; 0.06; 0.07; 0.08 m [1].

Change in the diameter of the displaced liquid layer during the movement is shown in Figure 4. It can be seen that the diameter increases rapidly passing through the maximum point and then decreases slowly.

Increase in the diameter occurs almost in a straight line (see Figure 5). A reduction in the diameter is well described by a second degree polynomial shape and is very close to the

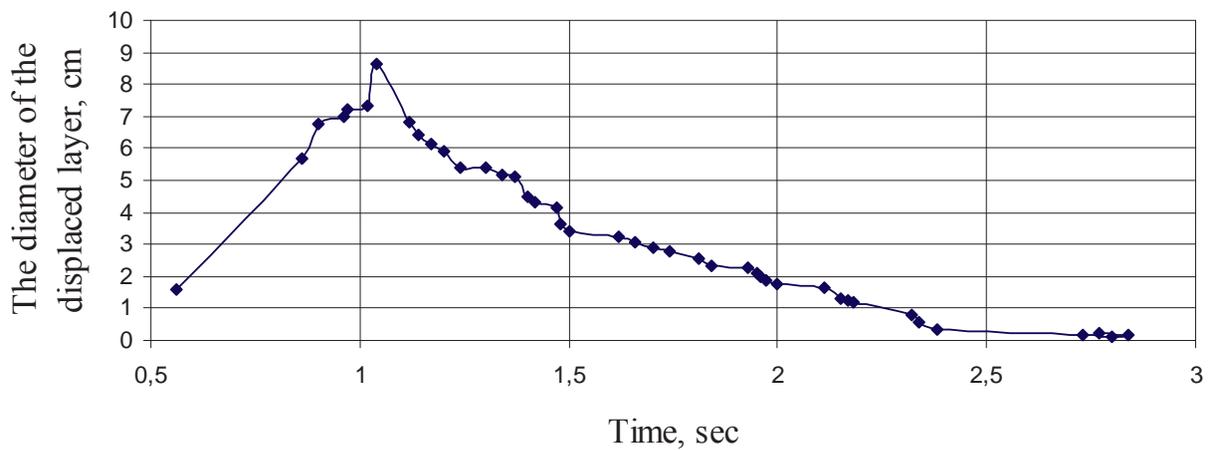


Figure 4. Change in the diameter of the displaced fluid layer

exponent (Fig. 6). From the above results, it can be seen that the performance can be considered to characterize a surfactant, wherein the range considerably exceeds the measurement range of the contact angle (0 to 180) and the range of values of the surface tension (20 to 480 [5]). This has been determined for we have studied a range of values from tens to hundreds of thousands of units [1].

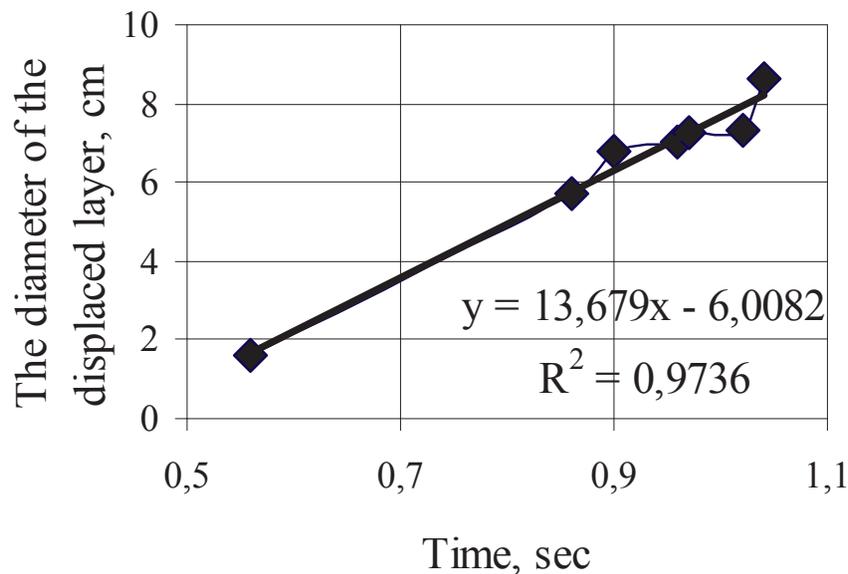


Figure 5. Increase in the diameter of the displaced fluid layer

### 3. The determination of surface properties

To study the surface properties of the liquid, the time was determined where the greatest range of movement in the number of staff from the moment of touching a drop of surfactant liquid

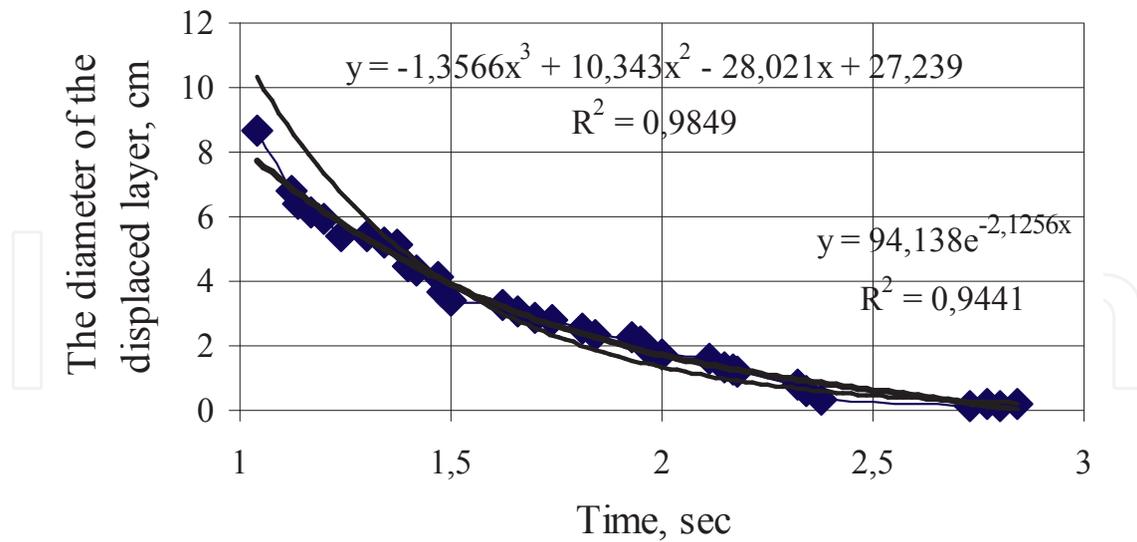


Figure 6. Reducing the diameter of the displaced fluid layer

to a frame moving with the largest radius was determined. To know the frame rate, the time between frames is multiplied by the number of frames to achieve the greatest range of fluid movement. Then, multiply the result with the time to reach the maximum displacement of the liquid, the number of displaced kilogram of surfactant liquid finding surface. The results are shown in Fig. 7.

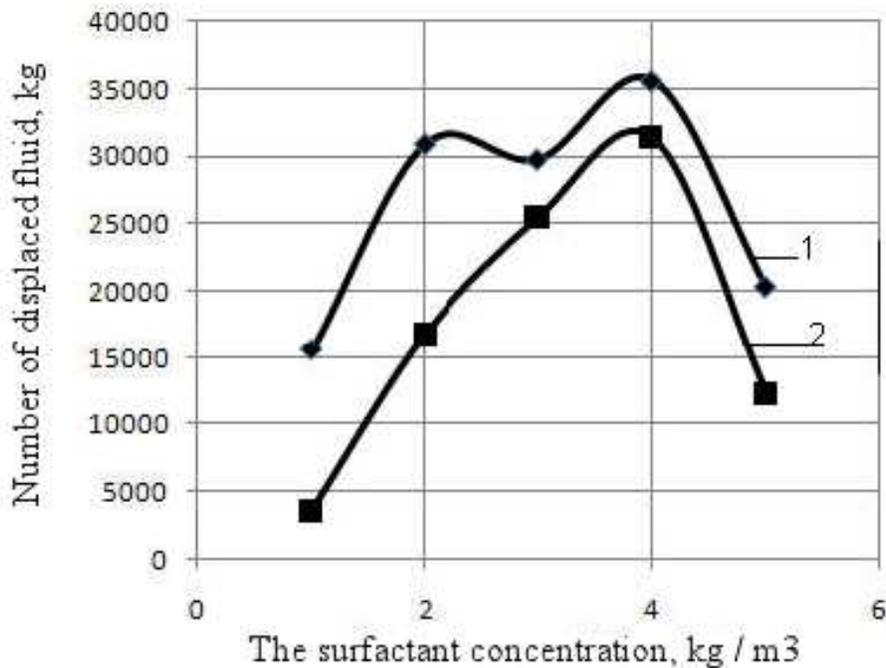


Figure 7. The change of parameters depending on the surfactant concentration: 1. The specific amount of fluid displacement (kg liquid / kg of surfactant) 2. The specific amount of fluid displacement per unit time ((kg liquids / kg surfactant) \* sec)

From these results, it is seen that the amount of fluid displaced is changed, passed through a maximum, which is a concentration of  $4 \text{ kg/m}^3$ . Perhaps, this is due to the properties of surfactant solutions, which vary significantly with increasing concentration and the formation of micellar nanostructures.

#### 4. Defining the properties of the fluid

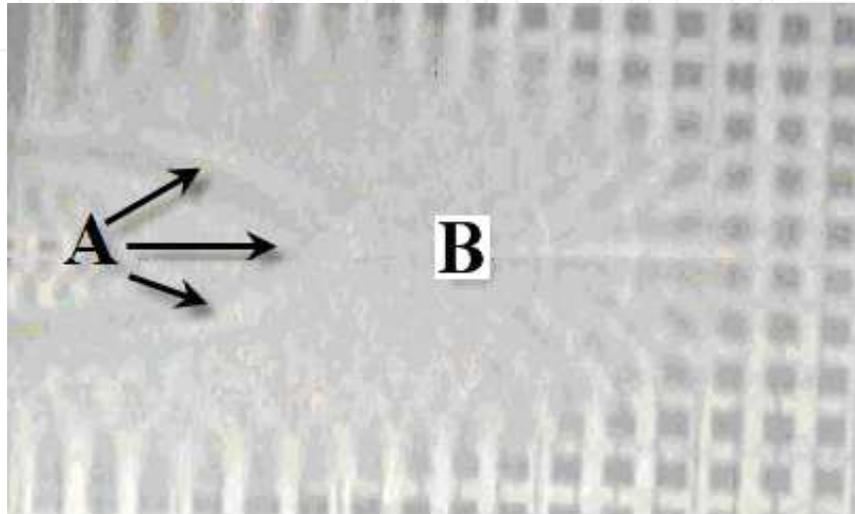
The liquid can be characterized by the methods given above. At the same time, we observed the regularity of occurrence and propagation of microwaves, which can also be used to characterize the surface properties of the fluid [6].

To determine the distribution ranges of microwaves, reflection display grids were used, which is clearly seen on the surface of the liquid in the video. The excitation of the surface of the liquid carried the water droplets drop at a height of  $0.02 \text{ m}$  on the surface of the water and poured in a circumscribing circle on the paper surface. The different amount introduced into the circle bounded the fluid to change the thickness of the layer from  $0.0002 \text{ m}$  to  $0.001 \text{ m}$  on the surface of the flooded paper.

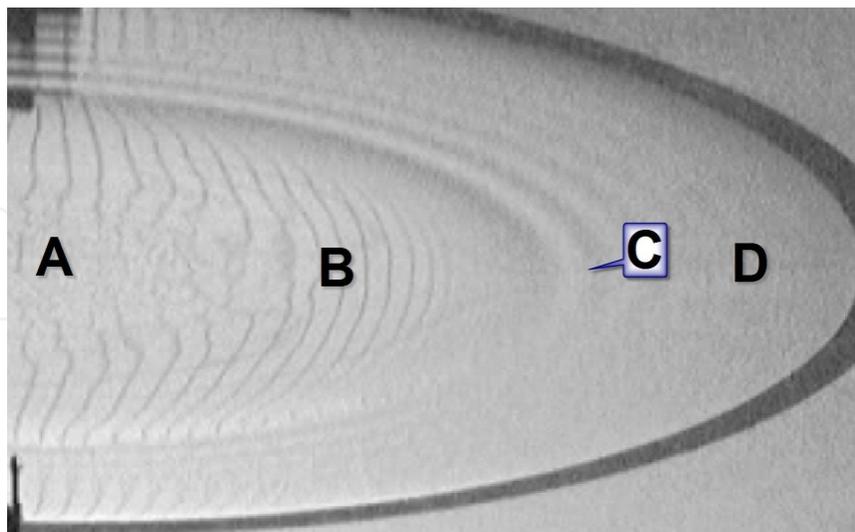
Changes occurring in the interaction of water droplets to the surface layer of water were recorded with a video camera. Then, on a frame scan, selected images in which measurements were recorded changed. For this purpose, standard computer programs were used. Similarly, the effect of surfactant concentration on the velocity of the waves was included in the study. It has been shown that the water droplets in contact with the surface of the water formed microwaves first (see Fig. 8) and then moved over the water surface substantially at a constant speed  $(70 - 75) \cdot 10^{-2} \text{ m/s}$  (see Figure 10). With the passage of the microwave image, the grid display disappears. The resulting large waves then move on to the liquid surface at an average rate of  $32 \cdot 10^{-2} \text{ m/s}$  (see Figure 8). The increase in the thickness of the water layer in area C increases the distance of propagation of the microwaves. Considering the studies of American astronauts, it can be assumed that microwave oscillations are produced by the surface film having a thickness of  $0.00015 \text{ m}$  [7]. Their height (amplitude of oscillation) may not exceed the double thickness of the film but interaction of the drops of surfactant solution with the water also causes the appearance of these two types of waves. However, the larger wave, starting from the center of the dropping, and then moved to the edges of the bounding circle is already under the action "move fluid wave". (See fig. 9 mark C).

She seemed to be pushed in front of the wave, and the trailing edge of the wave becomes steeper. This wave slows down when approaching the edge of the bounding circle and its movement initially opens the surface of the liquid (see Fig. 9. mark A) and the "boundary layer" of liquid (see Fig. 9). In the notation, the line indicating the mesh is clearly visible, under the influence of a force field where the liquid surface is. Moreover, at low concentrations of surfactants and a strong interaction with the liquid lying below the surface of the "wave motion of the liquid", the "boundary layer" is rolled on the surface. It was great all the time and zone A was determined to have an observed free liquid. The introduction of surfactants somewhat reduces the velocity of the propagation of large capillary waves (Without the surfactant

average speed is  $32 \cdot 10^{-2} \text{ m/s}$  capillary wave and with surfactants, it is  $20.5 \cdot 10^{-2} \text{ m/s}$ ). Moreover, the microwaves are observed on the surface of large waves because the indicator on the surface of the liquid keeper is not visible (Figures 8 and 9). A large wave of "moving fluid" slows down when approaching the edge of the circle to this limit:  $(13-15) \cdot 10^{-2} \text{ m/s}$ . The speed of microwaves remains almost constant at the range of  $65 - 75 \cdot 10^{-2} \text{ m/s}$ . This speed can be detected only two times during the passage of the microwaves on the investigated surface. Furthermore, microwaves quickly reach the circle limit.



**Figure 8.** Microwaves (area B) and capillary movement (area A) on the surface of the liquid. In the area of microwave indicator net disappears.



**Figure 9.** View of the water layer after exposure to drops of surfactant.

The effect of opening the boundary layer fluid wave motion can be used to estimate and visually observe the thickness of the boundary layers. Also, the properties of microwaves to

increase the range of the spread with increasing thickness in the liquid layer can be used to estimate the thickness of the layer of water associated with the surface on which the liquid is present and to evaluate the interaction energy of the liquid with the surface [6]. In the method of the moving fluid, a surfactant is proposed for use due to its characteristics and surface properties in surfactant identification, including metrology and nanomaterials.

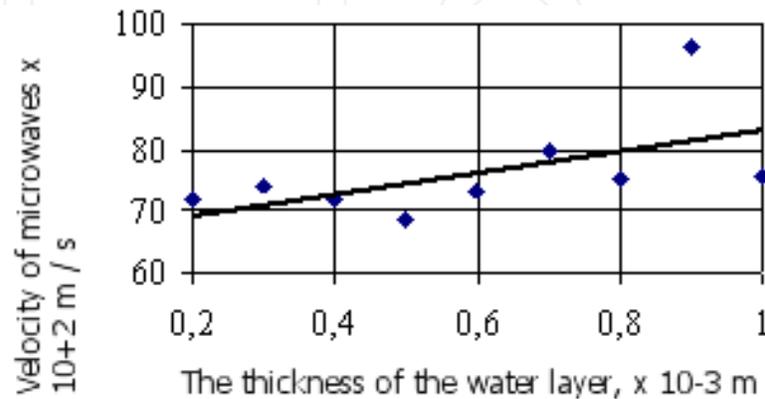


Figure 10. The changing speed of microwaves on the surface from the impact of a drop of water.

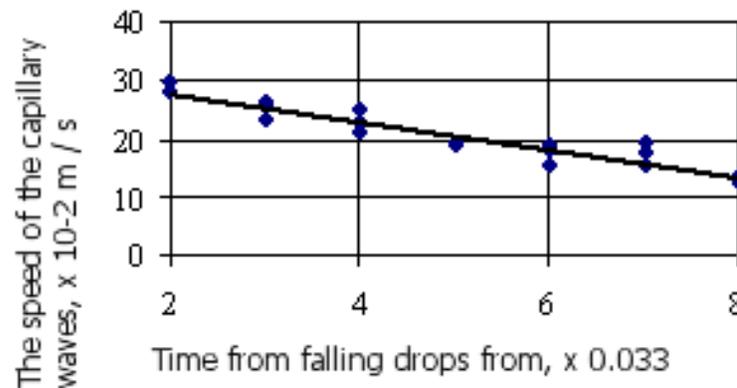
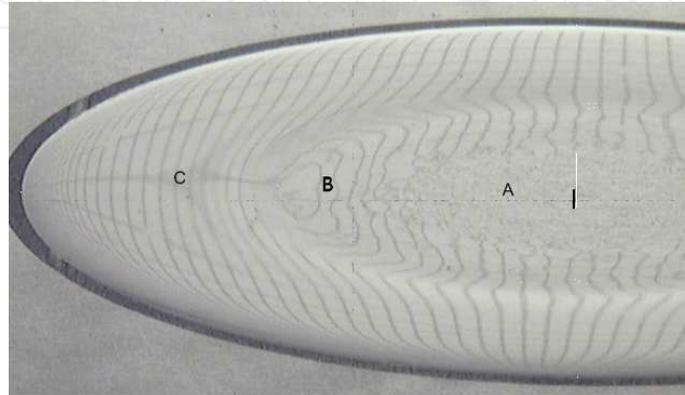


Figure 11. The change in the speed of the capillary wave action due to the drops of surfactant. The water depth is 0.0005 m.

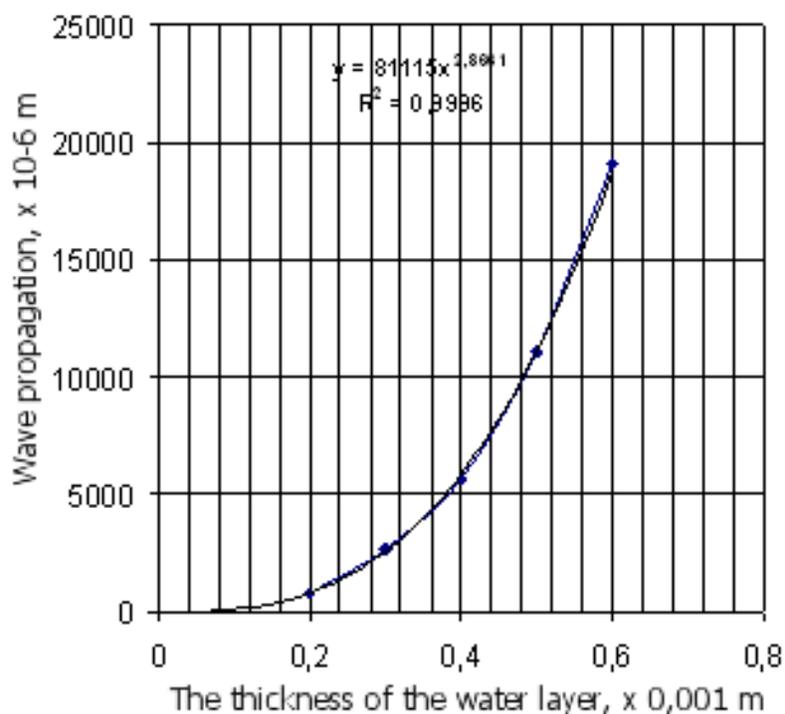
Studies have shown that in a limited space, microwaves do not change their speed, while the larger capillary waves significantly reduce its speed when approaching the limiting barrier. This can serve as a basis for concluding that occurs due to fluctuations in the microwave surface of the liquid film. A wave of migration has a pulsating speed like bumping and the surfacing of the boundary layer, slowing down and crashing "surfacing" acceleration.

Microwaves can be used to determine the thickness of the boundary layers created on the surface, study the increasing the thickness of the layers of water, and expose small water droplets on the surface dropping them from a small height.

After recording a video, defined images, in which the measurements of the amount of liquid transfer and the range of wave propagation, which are the characteristics of the surfactant properties of liquids and surfaces, can be seen frame by frame. At the same time, the images can determine the thin, visible layer of liquid. Figure 12 shows a view of the exposed surface of the surfactant layer of liquid. Figure 12 shows three clearly visible that are staggered. Zone A - is the surface (substrate) excepted from the liquid, zone B – is the tampering surfactant interfacial layer of liquid, and zone C – is free (not bound to the substrate) and fluid displacement.

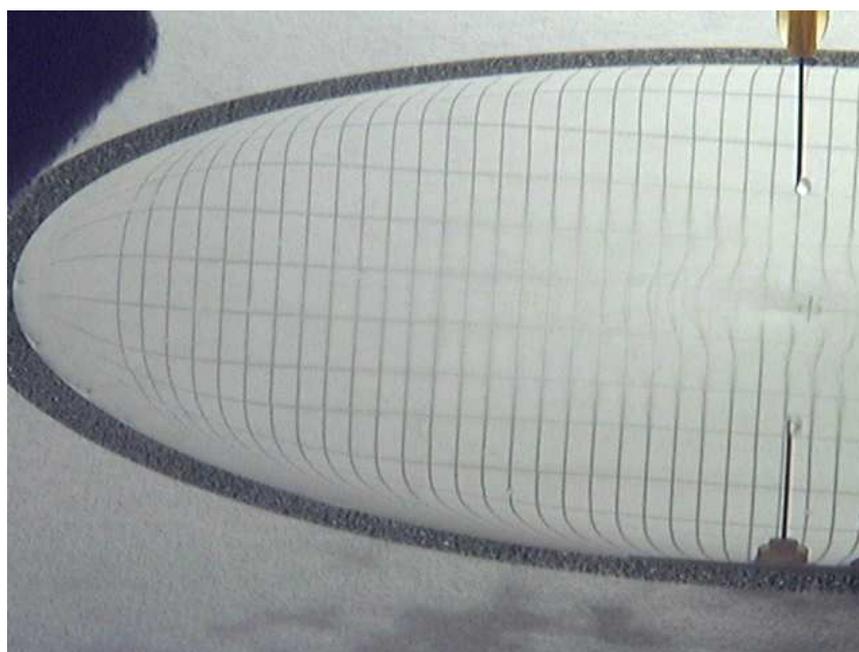


**Figure 12.** Three zones. Surfactant - "equalizer" with a concentration of 3 kg/m<sup>3</sup>. The diameter of the circle bounding 0.144 m: A - surface freed from water; B - surface boundary layer; C - moving layer of fluid



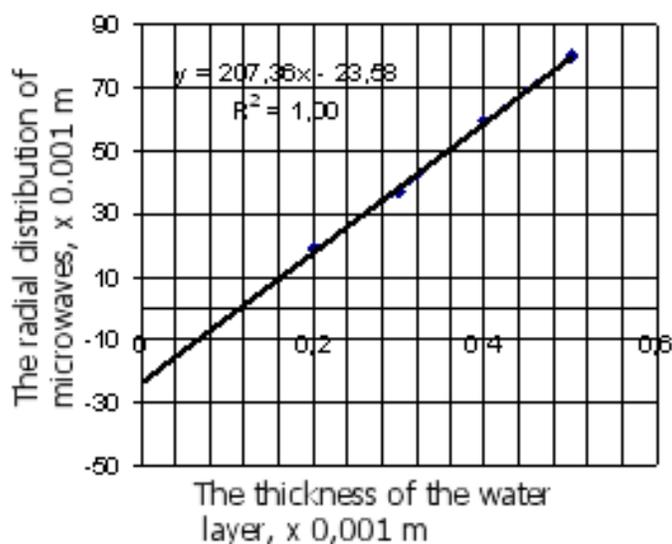
**Figure 13.** Izmnenie microwaves spread on the water surface depending on the thickness of the substrate - the paper

Since there is liquid on the surface layer bordering the air and the volume of liquid, it is possible to conclude that the thickness of the liquid on any surface exceed the total thickness of the surface layers and that the interfacial layer of the rest of the liquid will be "free". US astronauts conducting experiments in space determined that a double layer of water in the air interface when there is no free liquid is equal to 300 microns (0.0003 m). Consequently, a single layer is equal to 0.00015 meters, and the thickness of the liquid layer above the value property of this layer should undergo changes. We believe that the easiest way to define these changes is that it can serve as a distance propagation of microwaves on the surface of the liquid layer of known thickness. In this paper, we change the thickness of the liquid layer from 0.0002 to 0.0006 m.



**Figure 14.** The dependence of the radial propagation of the microwaves on the surface of its layer thickness.

The determination of microwave range is carried out by the disappearance of the indicator grid lines on the surface of the water (see Fig. 15). The results of the measurements are shown in Figure 13, which illustrates the sharp increase in the area of microwave propagation beginning with 0.0003 mm. Perhaps, this is the thickness of the water layer in which the surface layer and the boundary layers start to move away from each other. Then, when the surface layer has a thickness of 0.15 mm, the boundary layer will have a thickness of 0.3 minus 0.15 = 0.15 mm. Approximately, the same value is obtained when considering the radial distribution of microwaves (see Fig. 4). Direct drawn through the experimental points intersects at the horizontal axis at 0.12 mm. In other words, given the zero value of the radius of the microwaves on the propagation of the liquid layer with 0.12 mm thickness, the liquid layer is bonded to a substrate.



**Figure 15.** The type of surface water layer with a thickness of 0.4 mm. The distribution of microwaves on the surface is observed by the disappearance of the grid display.

Thus, the method for moving the liquid surfactant can be used to characterize the boundary layer thickness.

## 5. Contactless displacement liquid surfactants

In the study of fluid displacement, it was observed that microwaves begin to form when the surface of the water droplet is at a small distance in drip surfactants. Consequently, using surfactant with high volatility can cause a slide on the surface layer of water from the gas phase surfactant [8].

For the experiment, in the method described above, the only investigated material were a small square and a thickness of 1 mm. They were placed in the center of the bounding shape (a circle) and the amount of water is taken. Having regard to the volume of the test material, a layer of water with a predetermined thickness was generated on it. The objects of the study used were duralumin discs, silicon hereinafter - the "silicon", and LiNbO<sub>3</sub> of the "Lithium". The capillary pipette was placed at different heights (from 1.5 to 4mm) from the surface being studied, on which the fluid (water) was located. Also, there was a change the thickness of the liquid layer from 0.3 to 0.6 mm. The measurement results are shown in Table 1.

Observations have shown that a decrease in the height of the capillary over the studied surface purifying it from the liquid is more intense. The surface on which the liquid was, is cleared of the water layer quickly. A thickness of 0.3 mm in the water displaces the surfactant on the surface being studied for 6-7 seconds. Table 1 with a reduced thickness of the liquid cleansing surface is faster. The greatest speed of moving liquid is observed on silicon, and the smallest on the paper. One can assume that the communication between the water surface and the paper

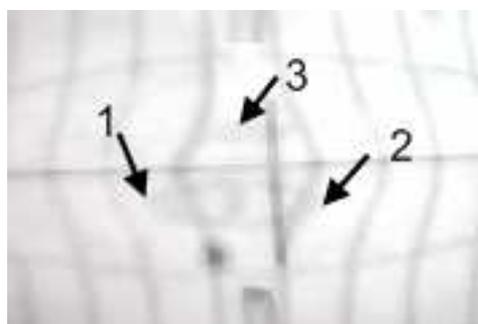
is higher than the surface of lithium and silicon wafers. At the same time, the thickness of the water layer, which can still be displaced under the action of the surfactant, is less in paper plates than to silicon and lithium. The paper limited the thickness of the water layer at 0.4 mm, silicon between 0.5 to 0.6 mm, and lithium. This effect is used to evaluate the thickness of the boundary layer of water on the surface of the materials investigated [9]. However, there is a contradiction. Lower speed happens in thin layers of water, which may be due to surface roughness. The average value of surface roughness in micron samples obtained on the instrument "Profilers - 296" is : paper - 4.55 ; Li - 1.16 ; and silicon - 0.75. The physical nature of this indicator is that the larger the value, the greater the difference between the highest and the lowest point on the surface (vertical drop), therefore, the greater roughness. Consequently, the roughest paper will then be lithium and silicon. In the reverse speed of the fluid buildup, with a correlation coefficient of - 0.999 and the same parameters (height above the surface of the capillary pipette and the thickness of 3.5 mm to 0.3 mm) fluid velocity of the liquid will move: paper - 2.62; Li - 16.49 ; and silicon - 18.9 mm<sup>3</sup>/sec. At first glance, these results confirm the conclusion about the effect of roughness on the velocity of the fluid. However, this aspect requires a more detailed study. For example, if one adopts the hypothesis about the impact on the speed of the fluid, the strength of the molecules of the liquid from the surface under study, it turns out that the paper bond strength liquid is higher than the surface of silicon wafers and lithium. Therefore, the rate of fluid movement across the paper surface is less than the surface of the silicon wafer and lithium. But, as we have noted above, the movement and penetration of the liquid occurs on the investigated surface with a liquid layer of different thicknesses. For the paper, the value of the minimum thickness of the fluid at which there is a breakthrough of the liquid layer is 0.4 mm to 0.6 mm, and lithium-silicon is 0.5mm [9]. This means, lithium and silicon binds more water than paper. According to fluid handling associated with more water and logically, paper - the stronger of the coupling, the smaller will move liquid per unit of time (for more details see below).

Object	The height above the surface of the object, mm	The water depth, mm	Breakthrough time the total thickness of the water layer, sec	The diameter of the layer of fluid displaced by 20 frames (4 seconds), mm	The volume of the displaced fluid mm <sup>3</sup>	Time from onset of exposure, sec	The speed of movement through fluid 20 frames (4 seconds), mm <sup>3</sup> /s	The speed of movement from the start of exposure, mm <sup>3</sup> /s
lithium	3,5	0,3	1,4	16,7	65,99	5,4	16,49	12,22
	3,5	0,4	6,8	17,05	91,32	10,8	22,83	8,45
	2,0	0,5	0,6	13,12	67,61	4,6	16,90	14,69
silicon	3,5	0,3	2,0	17,91	75,61	6,0	18,90	12,60
	2,5	0,5	0,8	17,05	114,15	4,8	28,53	23,78
	2,0	0,5	0,8	17,52	120,55	4,8	30,13	25,11
paper	3,5	0,3	8,2	6,67	10,51	12,2	2,62	0,86
	3,0	0,3	5,0	9,74	22,36	9,0	5,59	2,48

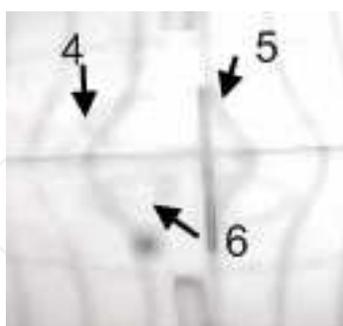
Object	The height above the surface of the object, mm	The water depth, mm	Breakthrough time the total thickness of the water layer, sec	The diameter of the layer of fluid displaced by 20 frames (4 seconds), mm	The volume of the displaced fluid mm <sup>3</sup>	Time from onset of exposure, sec	The speed of movement through fluid 20 frames (4 seconds), mm <sup>3</sup> /s	The speed of movement from the start of exposure, mm <sup>3</sup> /s
	2,5	0,3	1,6	7,86	14,54	5,6	3,64	2,6
	2,0	0,3	1,0	7,54	13,41	5,0	3,35	2,68
	1,5	0,3	0,4	8,32	16,34	4,4	4,08	3,71

**Table 1.** The influence of parameters on the movement of water surfactants from the gas phase.

During the experiment, it was observed that erodible ring structure appear at the surface layer of the water, which later disappears. (see Figs. 16 and 17)



**Figure 16.** Position of the edges forming a ring structure.



**Figure 17.** Position of the edges of the ring structure formed from structure.

In Figure 16, arrows 1 and 2 indicate that the position of the edges formed a ring structure. Arrow 3, on the other hand, shows the emergence of a new ring structure. In Figure 17, arrows 4 and 5 show the position of the edges of the ring structure formed, which is marked by the arrow 3 in Figure 16. Arrow 6, then, shows the emergence of a new ring structure. There are several explanation of this effect:

1. This stratified destruction layer are associated with the studied surface water, thus, water layers in the associated liquid layer have varying degrees of communication between them.
2. The impact of the electric potential between the capillary pipette and the surface is being studied.
3. This "microdroplets" evaporating surfactants spreads over the surface of water.

The first explanation is the most acceptable. In previous studies on the movement of a drop of liquid surfactant, the free liquid displacement is observed on the surface of the water bound to the gelatin layer and then destroys the boundary layer. Below are the data from this work.

The movement to the peripheral areas of liquid drug is slow and comes in two stages. The first stage is under the influence of highly concentrated surfactant solution (80 kg / m<sup>3</sup>) "sulphonol" located above the moving fluid bed bound. After a while, the fluid begins to move associated with the gelatin layer of water, freeing the surface and causing it to become dull. (see Figs. 18-20)

The time taken for the movement of fluid may be determined by the number of frames from the starting points. Since the beginning of the movement, it is necessary to frame up to № 10. The movement of "free" liquid ends at frame 43 (Fig. 18). At a frequency of shooting 24 frames per second on the move, 1.375 sec have been spent. Without noticeable changes in the layer, "bound" water was up to the frame number 60 in 0.7 seconds. Further movement of the associated layer to frame 215 occurred within 6.45 sec.

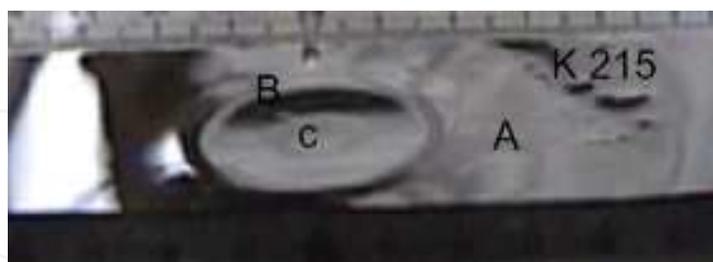


**Figure 18.** View of the water surface after movement of the "free" liquid on the surface of the water associated with gelatin frame 43. A - bound fluid layer; B - bound (shaft) move "free" liquid.



**Figure 19.** The start of the movement associated with the liquid layer on the surface of the gelatin block 81. A - bound fluid layer; B - bound (shaft) move "free" liquid; C - free gelatin surface.

Bound liquid layer on the surface of the gelatin is not destroyed by the surfactant concentration of  $5 \text{ g / cm}^3$ . Movement of the "free" liquid only occurred on the surface of the "bound".



**Figure 20.** The type of surface bound gelatin layer of water moving frame 215. A - bound fluid layer; B - bound (shaft) move "bound" liquid; C - matt exempt from bound water surface layer of gelatin.

The surface of the paper layer of bound water is destroyed under the action of a surfactant and a small concentration of  $5 \text{ kg/m}^3$ .

It is possible that ring structures will form in a contactless displacement fluid given a scenario similar to the one above. The observed circular formations change their dimensions slowly. Therefore, we assume that this is the most likely scenario of the destruction process of boundary layers.

The second assumption about the nature of electricity does not exclude, but rather complements the first scenario. More so, only after grounding the tripod holding capillary dropper measurement results in our experiments stabilized.

The third assumption, in principle, is unlikely, as it implies a rapid condensation of the evaporated molecules in microdroplets. Evaporation or not molecular, and cluster. We are assuming that the surfactant molecules at the water surface form a monomolecular film that is moved by the water. The highest measured diameters of the annular formations (see Fig. 16 and 17) are calculated using the table data area and the height of surfactant molecules on their surface. Measurements and calculations showed that the diameter of the "microdroplets" with the observed size of the circular formations may be within  $0.00020245 \text{ m}$ .  $2,82743\text{E} + 13$  contains more than molecules. The droplet size is large enough. Therefore, it can be assumed that the surfactant molecules at the surface either does not fit into a continuous film upon evaporation or is the molecules and the clusters containing few molecules are detached from the total weight. The first assumption is most likely because the calculations carried out the work of Karbainova, A.N. [4] It was shown that one molecule surfactant can move 3.5 million molecules of water. If you use this value to calculate the number of surfactant molecules needed to move the volumes of liquid, which are shown in Table 1, it turns out that the greatest number of molecules that moved will be equal to  $1,15233\text{E}+15$  and the smallest is  $1,00465\text{E}+14$ . A number of the above-mentioned droplet size must be delivered to the first surface 41 in the second case 4. Naturally, the number of droplets is significantly larger and significantly smaller in droplet size, possibly approaching nanoscale.

The measurement of the contact angle (wetting angle) showed that the contact angle of water droplets on lithium (45°) is lower than silicon (55°) (See drawings on the left and right). That is, lithium is more hydrophilic than silicon and accordingly, the rate of water movement on lithium is less than silicon. Water molecules bind more strongly to the surface of lithium, so it is necessary to expend more energy for their movement and other things being equal, the amount of water transferred will be smaller. For example, when the height of the capillary is 2.0 mm, the volume rate of water transferred to lithium is 67.61 mm<sup>3</sup>, 16.9 mm<sup>3</sup>/sec and silicon is at 120.55 mm<sup>3</sup>, 30.13 mm<sup>3</sup>/sec (Tab. 1). When the value of the difference in contact angle is 10° between silicon and lithium, the volume rate of water movement between the surfaces is practically twice of that of the silicon. Consequently, new hydrophilic indicators give a more differentiated picture.

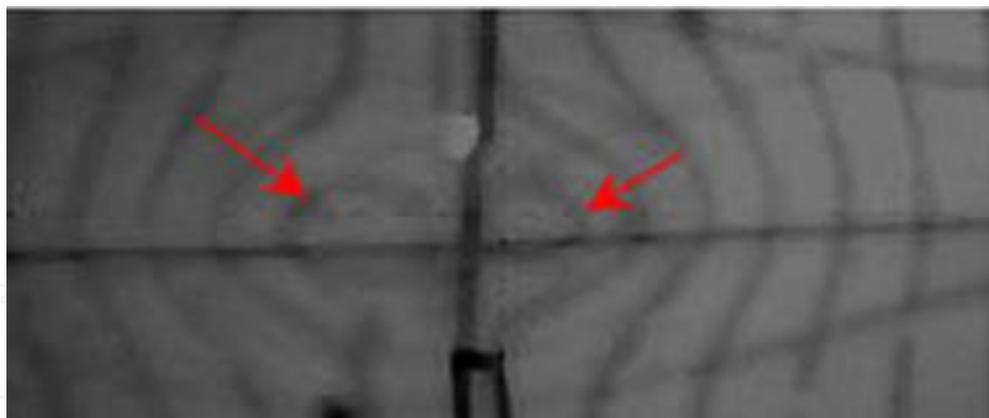
The change in the surface properties of the skin treatment processes was also investigated. A sample size of 4x4 cm was glued to a sheet of paper, coated thereon the limit line as a circle, and treated sequentially with water, aqueous acids and salt, an aqueous solution of a chromium tanning agent. After completing these processes, the speed of the movement of the water layer with thickness of 0.2 mm on the surface of the samples is determined. After exposure to water, the travel speed was found to be - 2.05 mm/sec for samples after exposure to acid and salt; 3.37 mm/sec after exposure to chrome tanning agent; and 6.86 mm/sec. The results showed that during the treatment, there is an increase in the velocity of the fluid, i.e. water-repellency at the surface of the skin as a consequence of reducing the surface water connection and therefore increases the speed of movement. This corresponds to the theoretical concepts of the science of skin.

Thus, studies have shown the possibility of estimating the properties of different surfaces by the use of non-contact displacement fluid. It is shown that the movement of the liquid surfactant influences the surface roughness and the strength of molecular interaction with the surface of the liquid.

The study of fluid motion on the surface of duralumin has shown that there are several features that can be seen only on light reflecting surfaces. Studies were therefore conducted as set forth above.

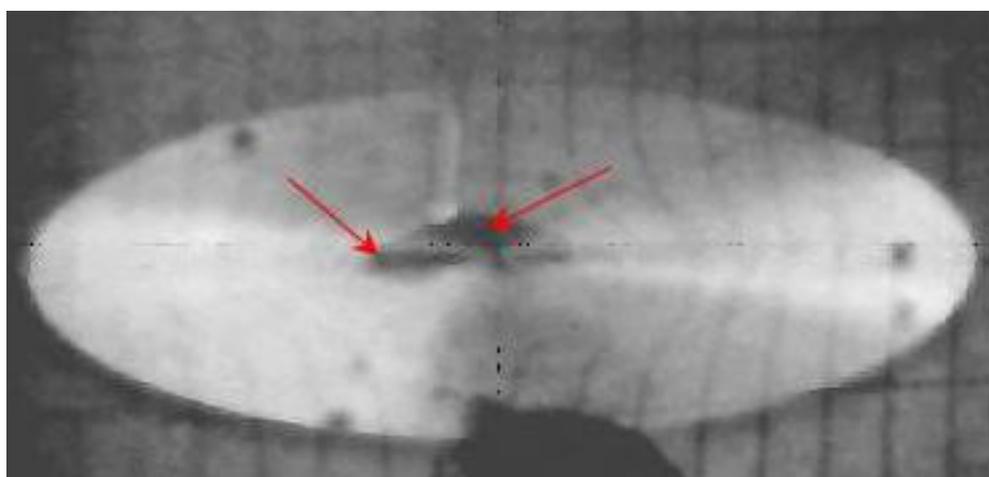
The process of moving the non-contact liquid surfactant consists of several stages. At the beginning of travel, a surfactant element removes water from the surface layers of the molecules that are fixed in this layer due to the interaction with the molecules of air between them. During the experiment, it was observed that erodible ring structures appear on the surface layer of water, which disappears over time (see Fig. 21).

In our opinion, this layering destruction of water is bound to the surface under the study. Therefore, the layers of bound water in the liquid layer have different degrees of communication between them. Furthermore, the water layer is structured on one side with air on the other side of the surface where the liquid is located. With the structure status stored in the interaction of the surface of the water with a surfactant, which is embedded in the layer structure and the stability limit is exceeded, new created surfactant molecules embedded structure begins its destruction and the movement of the liquid layer. This altered state



**Figure 21.** The formation of the ring structures (arrows) in the water layer of 0.4 mm thickness on a paper surface.

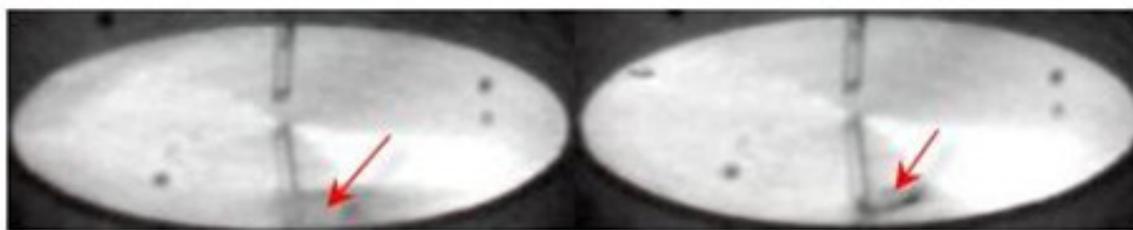
structures, with embedded surfactant molecules, are maintained long enough, which, according to our measurements, is more than 20 seconds.



**Figure 22.** Formation of dark spots.

It is possible that the formation of dark spots before the breakthrough of the liquid layer on the duralumin becomes a specific interest (see Fig. 3). We assume that this is due to a decrease in the thickness of water for up to 3 - 5 nm or less than the wavelength of light [10]. And the moving layer of water can "roll" in the study water to the surface film thickness of the dark spots. Figure 14 shows the formation of a water film (marked by an arrow) which is then collected in the droplet.

It is possible that the formation of a dark film was due to depressions in the surface of duralumin. Then, this effect can be used to assess mechanical defects on surfaces with almost nanometer thickness. The figure also shows the optical transition to deepen or to a defect or when not to manifest itself. At any rate, the reflection capillary is not changed. To detect this defect by optical methods, a special instrument base and an increase in size is required.



**Figure 23.** The sequence of frames showing the formation of a thin film of water at dark moving surfactant-ohm, which is later collected in a drop (marked by an arrow).

The method of moving the liquid surfactant was used to assess the particulate materials, including water-soluble measurement results that are shown in Table 2. For studies, particulate materials are mixed with water and were made into a pattern in which the material surface is leveled. The template was placed in the center of the bounding figure and above the layer of water creating a thickness of 0.2 mm. Capillary with isobutyl alcohol surfactants are over the patterns. The camcorder was then turned on. It was then seen that the capillary was fed vertically to the surface of the template.

Fluid movement speed, mm / sec	Disperse powder and granular						water-soluble	
	SiO <sub>2</sub>	Fe <sub>2</sub> O <sub>3</sub>	CaOH <sub>2</sub>	ZnO	MgO	CuO	NaCl	NaHCO <sub>3</sub>
	58,50	7,64	10,69	12,06	17,29	85,1	74,18	57,0

**Table 2.** The speed of the liquid (water) on the surface of particulate materials.

The table shows that the velocity of the liquid material on the surface can serve to characterize the extent of water interaction with the material. For example, the reaction of water with the surface of the copper oxide is insignificant as the moving speed of 85.1 mm / sec is much greater than on the surfaces of other materials - sand, iron oxide, lime, and others, but is very close to the speed of movement over the surface of table salt. Therefore, their surface is more hydrophobic [10, 11].

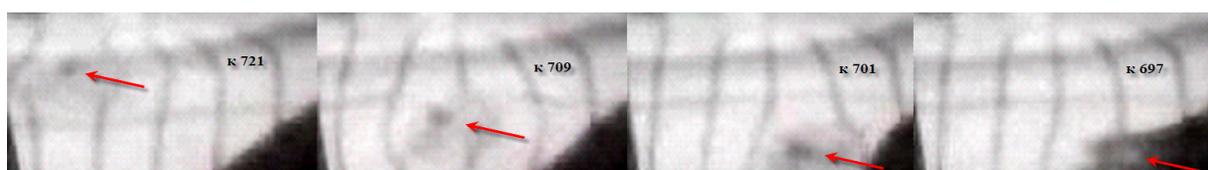
## 6. Moving particles [12]

Studies of particulate materials by fluid displacement are possible to detect moving objects using silicon oxide.

We explored the possibility of estimating the surface properties of powder and granular materials, without determining the surface tension and wetting angle [4]. We found that with the interaction of the surfactant with the liquid layer above the surface of the sand and after bringing the surfactant in the sand into contact the camcorder recorded self-propelled objects of different types.

Conventionally, these are the six types:

1. Large objects resembling a UFO (Fig. 24)
2. Underwater objects (Fig. 25); Fast-moving underwater (Fig. 30)
3. Large objects resembling agglomerates particle (Fig. 26)
4. Objects to perform cyclic motion picture (Fig. 29)
5. The rod-shaped figure. (Fig. 29)
6. Point black.



**Figure 24.** The first type of moving objects. Large objects resembling a UFO. Getting traffic frame 698, continued frames 708 - 718. The arrows marked the position of the object. The speed of movement of the object is 10-15 mm/sec. Its size is larger than 5 mm. (moving from right to left, top) In the shade (to 698), a bright object is seen on a dark background. And on a light background is a dark object (to 708 and 718). This can be interpreted as the illumination object. Similar changes were observed for the other types. See Fig. 29. Frames 178, 189, 198, 276, 292, 328.

From Figure 24, the movement of the object causes display grid lines curves to be reflected from the surface of the water. This indicates that the object is moving on the water surface. But, there are objects moving in the water beneath the surface. (see Fig. 25).



**Figure 25.** Underwater object. Changes in the display grid lines (moving from right to left, top). Movement is seen beneath the surface. The speed of movement of the object is 10-15 mm/sec. Its size is approximately 4 mm.

From figure 25, the object moves from left to right and slightly upwards. Speed estimation is approximately 10 - 15 mm/sec. It is sufficient, in principle, to quickly notice the object with an unaided eye movement.

Given that the thickness of the surface layer of water on the air interface is 0.15 mm [7], it can be assumed that the object moved at least at this depth. It follows that the movement of the objects does not only affect surface forces. In principle, there were hopes to explain the observed motion of the objects.

Large objects, in the form of agglomerates, obviously also moves under the water surface (see Fig. 26) as reflected by the changes in the surface mesh of the indicator observed.

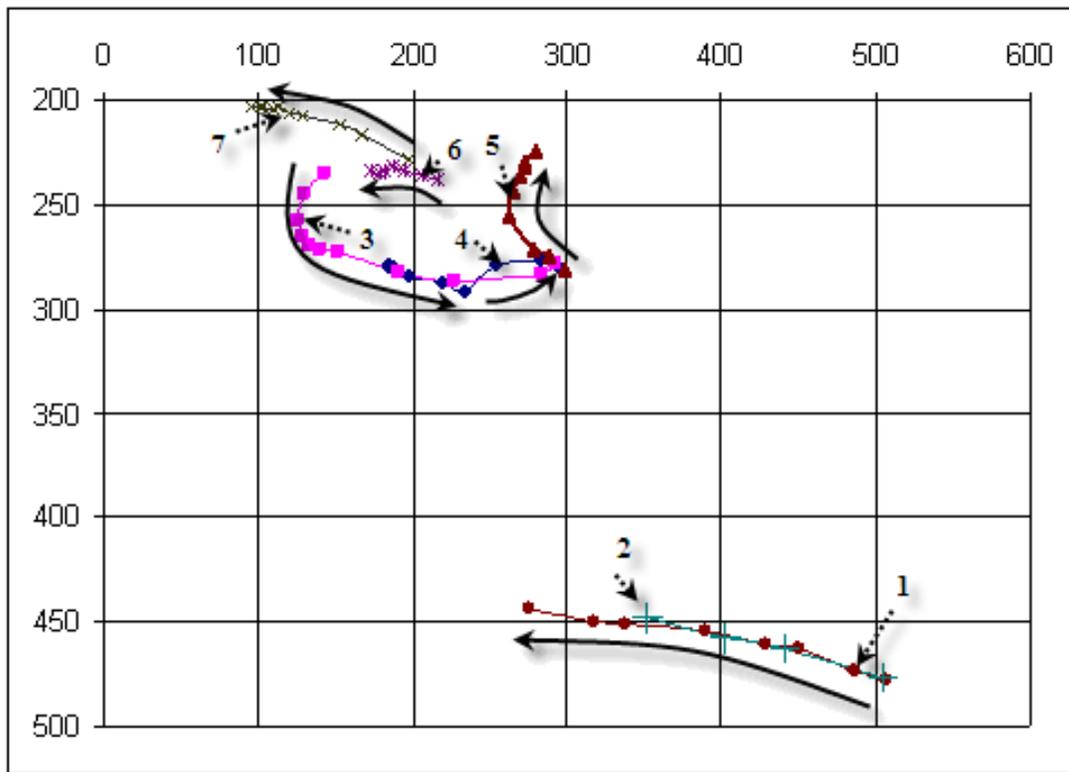


Figure 26. The third type of moving objects - shapeless aggregates. The speed of movement of the object is about 35 - 40 mm / sec (the trajectory 3 in Fig. 27).

For the experiment, the recorded moving agglomerates were characterized by the emergence of many objects. Fig. 27 shows the trajectories of some objects.

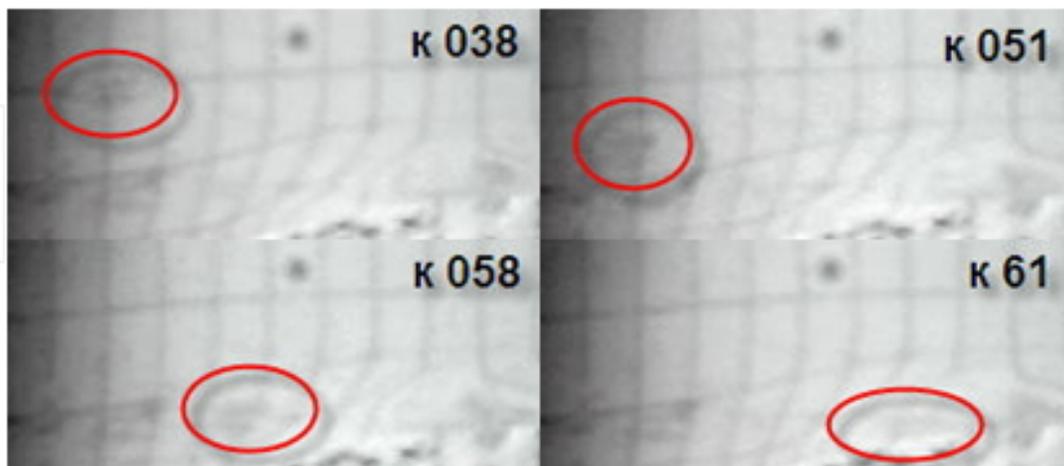


Figure 27. The trajectories of the objects

From the observation of the movement of objects, it was noted that in the beginning, a moving black circular object in shots 17 - 39 (path 4) has initiated. Then, it continues to become an

agglomerate (path 3) and, following the black object, both come to a single point (see Fig. 26) (Frame 34 - 84). At this point, there is intense movement of the objects in a small volume. From this point, after a while, the new black object starts to move quickly (frames 85 - 100 trajectory 5). Along with the sinter, a noticeable movement was produced but in reverse, which was showed by the dark object in frames 64 - 74 (milestone trajectory 6). Another dark object (path 7 shots 69 - 78) was seen moving together with other large agglomerates. Initially, the agglomerate is not noticeable and suddenly appears near this point object and continues to move together. At the bottom, starting with frame 58, two objects are substantially on the same trajectory at first and then a large object is shown(1 and 2 of the trajectory).

Moving objects change their size and position. It can be assumed that this is due to the addition and elimination of particles that make up the objects or the rearrangement of it. Before the experiment, the sand used in the experiment was sifted through a sieve with 1 mm openings. The observed objects have the same parameters, significantly exceeding this size. Consequently, the objects, themselves, are formed during the experiment.

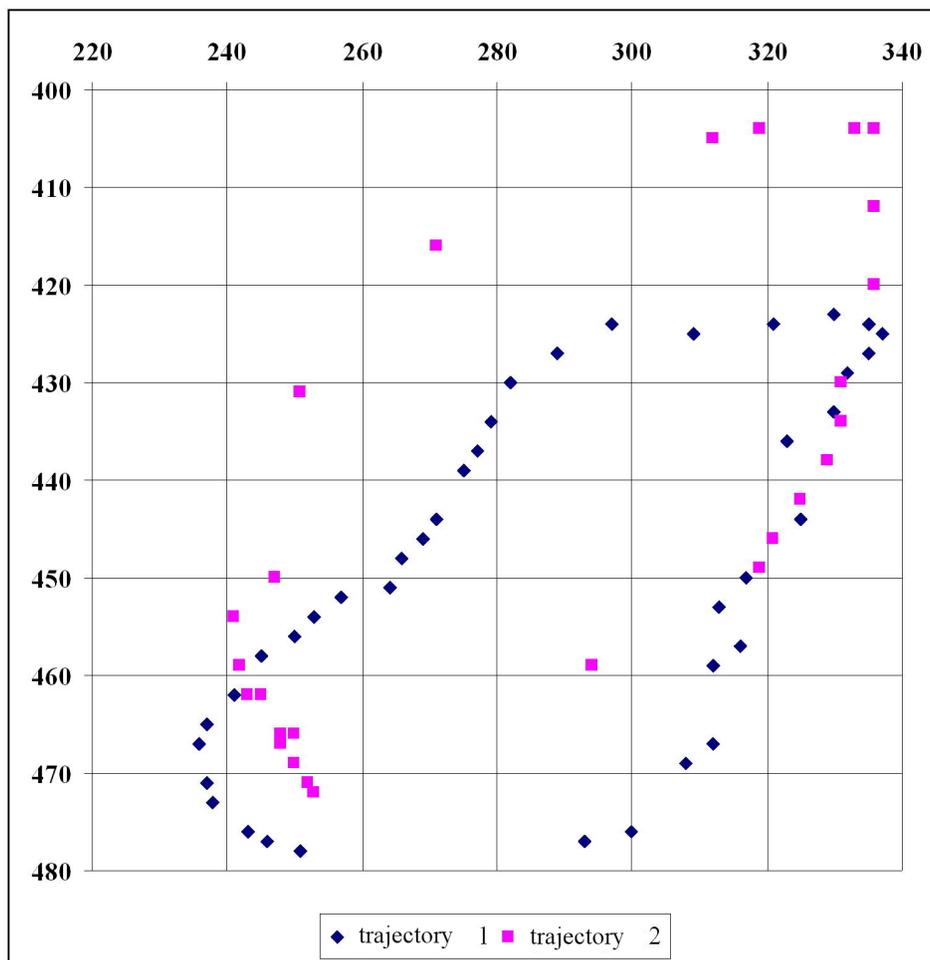
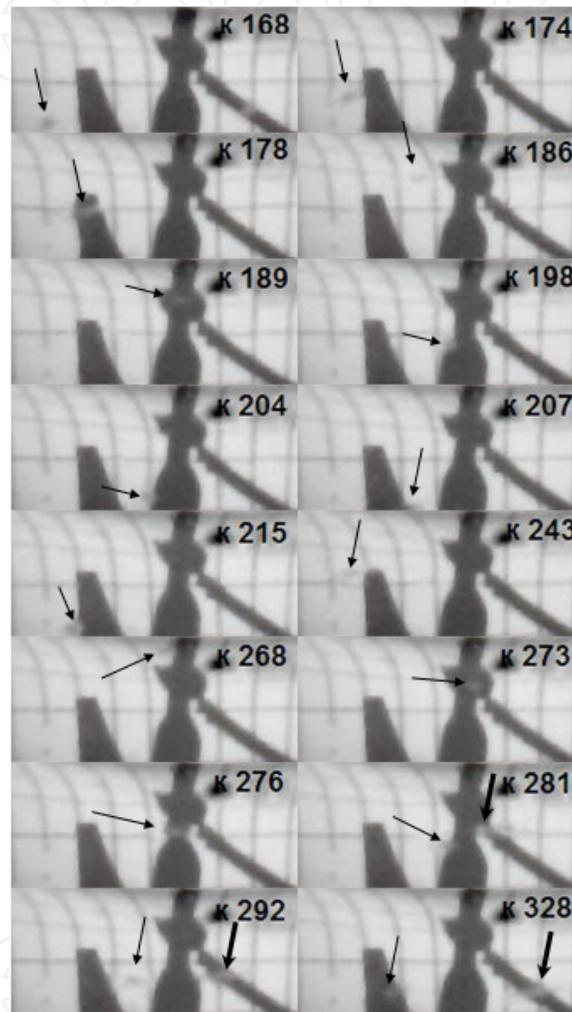


Figure 28. The trajectories of the cyclic objects. The direction of movement is indicated by the arrows.

In our point of view, the time of passage of the objects in the shadow of the device unit is important. In general, the moving objects appear darker than the surrounding background (there is light merging with the general background). However, objects remain visible and lighter than the shade behind the shadow of the devices. In our opinion, this indicates that the objects glow. Indeed, the cyclically moving objects in the original frames show that the objects marked by the arrows in Figure 28 had a yellow gold color (like light).



**Figure 29.** The successive frames of the cyclic movement of objects (path 1 frames 168-207. Trajectory 2 frames 215-328 Fig. 28)

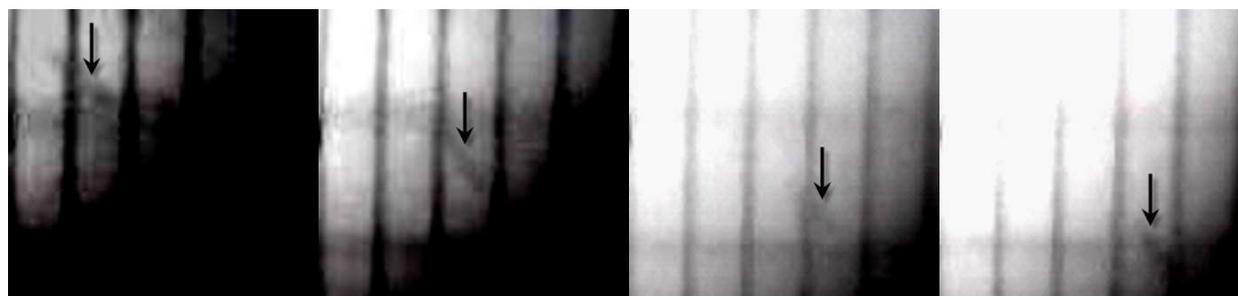
It is believed that the water in the seas and lakes by chemiluminescence illuminates during the oxidation of organic substances with oxygen. Moreover, the luminescence observed depends on the ultrasound and the purity of the water that can be suppressed. The purer the water, the less intense is the glow [13]. Possibly, the ultrasound destroys the self-organizing structure of the particles, leading to a decrease in the luminescence. In purer water, the smaller particles can be united and pushed downward for the oxidation of organic substances. With regard to our experience, these facts suggest that the association of the particles into larger agglomerates

causes the acceleration of the oxidation reaction. Any association and creation of complex structures in itself contribute to the acceleration of electrons, which causes the glow and helps create movement. At the same time, it can be assumed that the particles are oxidation catalysts and as a result, have a visible glow.

The fourth type of moving objects performs cyclic movements (Fig. 29). On the frames 281, 292, and 328, large arrows labeled objects rod type 5. In frames 178, 189, 198, 204, 273, 276, 281, 292, and 328, moving objects are in the shade and have a bright appearance that may shine.

We also recorded fast-moving underwater objects (see Fig. 30). Their speed is 100 - 150 mm/sec. A total of four frames recorded the motion of this particle.

It is possible that there are particles moving with an even higher speed. But they could not be fixed, due to the technical capabilities of the equipment.



**Figure 30.** A fast-moving underwater object.

These results show that research in this area are the prospects in the creation of sufficiently large, even visible to the naked eye, objects moving independently of nanoparticles in water. It is then necessary to understand the principles that unite and move the newly created objects.

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