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## A REVISIT OF SELECTION THE EFFICIENCY CRITERION FOR FLOTATION REAGENTS OF FATTY ACIDS CLASS\*

### Introduction

The collective ability and selective action of collector agents is believed to depend mainly on their sorption characteristics at the solid – liquid interface. A number of studies have demonstrated that the collective ability of reagents (carboxylic acids, amines) can be influenced significantly by their property of reducing the surface tension at the gas-liquid interface. The correlation between the surface pressure in the carboxylic acid film located on the free surface of the solution and the floatability of mineral was established empirically [1–4]. At the same time, this “surface pressure – floatability” relationship fails for long-chain saturated carboxylic acids. Quast indicated that the value of surface pressure of the reagent film does not always characterize the collective ability of a carboxylic acid. For example, the pH range of the increased recovery of hematite by tetradecanoic acid does not coincide with the pH region of high surface pressure. On that ground, the author assumed that the surface properties of this acid do not contribute to the flotation mechanism [3].

*The collective ability of desorbed species (DS species) of saturated carboxylic acids is reviewed. DS species of a reagent denote the forms capable of moving from the mineral surface to the bubble, i.e., to the gas-liquid interface, at the moment of breakout of the interlayer separating these interconnected objects. Experiments on fluorite ore in the presence of mixed cover, including physical and chemical sorption forms, and cover containing only chemical form are performed. As is shown, the removal of physical sorption form decreases recovery of fluorite in concentrate. It was determined, that physical sorption form of carboxylic acid provides specific collective function. The spreading rate of carboxylic acids on water surface is determined at pH 7 and 10. The spreading rate of carboxylic acids is comparable with flotation parameters of fluorite ore with mentioned collectors. The sequence of increasing the spreading rate of middle- and long chain carboxylic acids corresponds with the sequence of increasing fluorite recovery in foam product. A criterion for estimating the collective capacity of carboxylic acids is proposed. Advisability of its application for selection flotation reagent with required collective ability is estimated. Values of forces that influence the liquid in the interlayer at the side of the spreading film of the reagent DS species and the water flow rate from the interlayer are evaluated.*

**Key words:** flotation, criterion for selecting collector agent, saturated carboxylic acids, surface pressure  
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The correlation between the surface pressure in the reagent film and quartz floatability was identified for cationic reagents, as well [5]. Finch and Smith showed that the combination of adsorption of ion-molecular amine complexes on the mineral surface and high surface tension of “fresh bubbles” is favorable for high flotation rates [6]. The use of bubbles with reduced surface tension led to a decrease in the flotation rates of the mineral.

Dependence of the collective ability of dialkyldithiophosphates on their dynamic activity was established for the gas-liquid interface [7]. Similar to carboxylic acids and amines, the collective ability of dialkyldithiophosphates has been shown to increase with increasing dynamic surface activity. The authors proposed using dynamic surface tension of the reagent as a criterion for evaluating its collective force. It was shown in that the IMA-I207 reagent, which has the greatest surface activity (39.2 mN/m), ensures the highest extraction of silver and gold [8].

A mechanism for the influence of active (with respect to the gas-liquid interface) forms of a reagent on the flotation aggregate formation was suggested [9, 10]. According to this mechanism, flotation bubbles adsorb the surface-active forms of collectors and transport them to the mineral surface. Transition of active collectors from the bubble to the mineral enables lowering the surface tension at the mineral-gas interface. If combined with high tension at the mineral-liquid interface, this will lead to a rapid displacement of the contact perimeter of three aggregate states along the face of a mineral particle and the accelerated formation of flotation contact. Bubble-to-mineral transition of active collector implies that bubbles should have low surface tension. However, the proposed mechanism disagrees with the conclusions of the work, where the need for high surface tension of “fresh bubbles” is demonstrated.

The mechanism of performance is proposed for the active species of flotation reagent with their reverse motion, from the mineral surface to the bubble [11-13]. The possibility of the transition of dialkyldithiophosphate from galena to an air bubble is proved using the radioactive isotope method [14]. Transition of active species of collector to the bubble surface implies their desorption from the mineral surface after the local breakout of the interlayer. As is known, the sorption cover consists of several layers. The underlying layer is represented by a chemically fixed reagent [15]. This layer is well organized and is densely packed due to hydrophobic interaction of hydrocarbon chains. It gives strong hydrophobicity to the mineral surface [16]. The top layer is formed only on a mineral surface coated with a chemically or physically sorbed reagent and is represented by calcium oleates, sodium and neutral carboxylic acid molecules or ion-molecular complexes. This layer does not add to hydrophobicity of the mineral, is weakly bound to it and is easily desorbed by organic solvents or by ultrasonic treatment of the suspension [17].

Earlier studies assumed that the upper layer is desorbed from the mineral at the moment of the interlayer breakout and moves to the bubble surface. High spreading rate of the agent’s species desorbed from the mineral is feasible when using bubbles with high surface tension or “fresh” bubbles. The amount of collector passing the gas-liquid interface depends on its surface activity and sorption density

on the mineral. We will consider this part of the sorption layer fixed on the hydrophobized surface as a desorbed species (DS species) of a reagent.

Investigations of the effect of collectors from the carboxylic acids class present an inspiring challenge, since they are widely used in the flotation of non-sulfide ores. These reagents are characterized by a marked activity with respect to the liquid-gas interface.

The objectives of the present work include: to evaluate the collective activity of physically sorbed forms of saturated carboxylic acids based on the mechanism proposed; to search for evidence of the need for the reagent’s DS species on the mineral surface and their specific function in the formation of flotation contact; to determine the spreading rate of carboxylic acids along the gas-liquid interface and to estimate numerically the collective capacity of their DS species under the assumption that the said capacity is realized when the liquid is removed from the interlayer by a spreading collector; to develop a criterion that allows a comparative assessment of the collective activity of homologous reagents and its verification upon the available experimental and operational data.

### Materials and equipment

The rate of carboxylic acids spreading over the water surface was evaluated in a unit, which was presented in [12]. The cell was placed under a high-speed camera, Casio EX-LIM EX-F1 (300 fps) that would record the spreading of surface-active (with respect to the gas-liquid interface) carboxylic acids to a video file. The spreading rate was evaluated for hexanoic (technical specifications: TY 6-09-126-75), octanoic (TY 6-09-529-75), decanoic (TY 6-09-320-75), dodecanoic (TY 6-09-612-76), tetradecanoic (TY 6-09-127-75), hexadecanoic (TY 6-09-4132-75), and oleic (TY 9145-172-4731297-94) acids. The content of the target component in acids made 98%.  $CaCl_2$  (federal industry standard, GOST 450-77) was used to produce calcium oleates. Distilled water was used in these experiments. The pH value was changed by proportioning HCl and NaOH.

Sonopuls – HD 3200 V ultrasonic disperser was used to remove the physically adsorbed reagent. Ultrasonic power of exposure was 80 watts; frequency – 20000 Hz; treatment time – 1 min.

Fluorite ore from the Yaroslavl Ore Mining and Processing Plant was used in flotation trials (control and experimental options). Its chemical composition is listed in **Table 1**. Fluorite ore was subjected to flotation in a laboratory flotation machine with a volume of 0.75 l. The size of flotation material made 44 μm (88%). Decanoic acid was used as a flotation collector agent; consumption rate was 4,000 gpt. Water glass was used as a calcite depressant; consumption rate was 1,500 gpt. T-80 reagent was used as a frother. The physical form of acid sorption was removed from the mineral surface using ethyl alcohol; consumption rate was 200 ml per 200 g of ore.

**Table 1. Chemical composition of the ore**

Composition	CaF <sub>2</sub>	CaCO <sub>3</sub>	SiO <sub>2</sub>	Al <sub>2</sub> O <sub>3</sub>	MgO	Fe <sub>2</sub> O <sub>3</sub>	K <sub>2</sub> O	Na <sub>2</sub> O
Content, %	24.39	9.15	29.62	16.03	11.65	4.53	3.22	1.62

**Table 2. Parameters of fluorite flotation with decanoic acid: without and with washing the material with alcohol after agitation with reagent**

Product type	Yield $\gamma$ , %	CaF <sub>2</sub> content, %	CaF <sub>2</sub> recovery, %
<i>Standard flotation</i>			
Froth product	47.5	41.43	81.1
Cell product	52.5	8.75	18.9
Total	100	24.27	100
<i>Washing the material with alcohol after agitation with reagent</i>			
Froth product	31.6	35.16	42.5
Cell product	68.4	21.98	57.5
Total	100	26.15	100

**Table 3. Parameters of fluorite flotation by decanoic acid following the standard scheme and with ultrasonic treatment after agitation with the reagent**

Product type	Yield $\gamma$ , %	CaF <sub>2</sub> content, %	CaF <sub>2</sub> recovery, %
<i>Standard flotation</i>			
Froth product	53.17	39.78	87.1
Cell product	46.83	6.73	12.9
Total	100	24.3	100
<i>Decantation, washing with water after agitation with reagent</i>			
Froth product	55.82	39.34	89.3
Cell product	44.18	5.96	10.7
Total	100	24.6	100
<i>Ultrasonic treatment of suspension, decantation and washing with water</i>			
Froth product	28.4	39.4	43.2
Cell product	71.6	20.61	56.8
Total	100	25.96	100

**Table 4. Recovery of fluorite in depending on length of hydrocarbon chain**

The length of the hydrocarbon chain	C8	C10	C12	C14	C16
Recovery, %	66.50	85.30	80.50	38.70	21.80

**Experimental part**

To determine the values for the flotation of physically sorbed forms of reagents, experiments on fluorite flotation with decanoic acid were performed following the standard (in the presence of physical and chemical species of sorption) and the experimental (with removing the physical species of sorption) schemes. Physical form of reagent's sorption was removed from the mineral surface by two methods: washing with alcohol and processing the suspension with ultrasound. In both schemes, the ore was agitated with the collector for 15 minutes; flotation time was 16 minutes. Under the experimental scheme, the ore was agitated with the reagent, decanted and then the solid residue was washed with alcohol. The pH value of the pulp during flotation made 7.5. Results of flotation performed by both the standard scheme and with washing of physical reagent's sorption with alcohol are presented in **Table 2**.

Under the second variant of the experimental scheme, the physical form of sorption was removed by ultrasound. Ore was agitated with the reagent, after that the suspension was treated with ultrasound for 1 minute and then decanted.

Water was added to the solid residue, up to the required flotation volume (0.75 l) and flotation was carried out for 16 minutes. Flotation results are presented in **Table 3**.

Thus, it has been shown that the DS species of the collector perform a certain function in establishing of flotation contact and their absence in the sorption layer leads to a significant degradation in flotation parameters: recovery decreases from 81.1÷87.1 to 42.5÷43.2%.

The rate of spreading carboxylic acids and calcium dioleate over the water surface was determined in the unit. In case of carboxylic acids, the spreading rate was determined for two values of water pH in the cell: 7 (**Fig. 1a**) and 10 (**Fig. 1b**). The initial spreading rate of oleic acid and calcium dioleate was estimated at pH 9.5 and made 24 and 25.5 cm/s, respectively.

The experimental evidence indicates the possible spreading of carboxylic acids along the gas-liquid interface and the spreading rate of their homologues is determined. As is shown, the spreading rate of products of interaction between carboxylic acids and calcium salts is comparable with that of acids.

Experiments on fluorite flotation with carboxylic acids with different length of the hydrocarbon chain were performed (**Table 4**). As the length of hydrocarbon chain increases more than 10 atoms of carbon, the flotation recovery of fluorite decreases.

**Results and discussion**

The author of the study has noted the correlation between the surface tension of octanoic, decanoic and dodecanoic acids and the hematite recovery. The correlation is broken for long-chain reagents: tetradecanoic, hexadecanoic and octadecanoic acids. The lack of correlation between the specified parameters for long-chain acids allowed the author make an assertion that the value of the equilibrium surface pressure is not always a good indicator of the flotation collector efficiency. According to the operation mode of flotation reagent the pressure (calculated as the difference between the surface tension of water and the reagent solution) does not reflect the physics of forming flotation aggregate. In this process, important factors are the local value of the surface pressure, which was formed briefly at the moment of interlayer breakout and the spreading rate of the agent's derivatives. Therefore, in the case of long-chain agents, decrease in the spreading rate associated with the cohesion of their hydrocarbon fragments should be accounted for.

As follows from Fig. 1, the initial spreading rate of tetradecanoic acid is less than that of decanoic acid by ~ 2.5 times. If the surface pressures of these acids are equal, we can expect that the collective ability of tetradecanoic acid will decrease ~ 2.5-fold, as compared with that of decanoic acid. Experiments on hematite flotation have shown that its recovery by decanoic acid exceeds that performed by tetradecanoic acid by ~ 2.5 times.

Short-chain carboxylic acids with a hydrocarbon chain length of less than 8 carbon atoms have high spreading rate over the water surface (Fig. 1). Their water solubility exceeds considerably that of long-chain acids; therefore, sorption of short-chain carboxylic acids on the mineral surface is insignificant. The surface tension gradient formed at the moment of the interlayer breakout is rather small; the surface pressure of the reagent film is also moderate, which limits the rate and mass of desorbed forms of the reagent.

On the basis of the data obtained, we propose a criterion that allows us to evaluate numerically changes in the collective ability when a carboxylic acid with the specified length of a hydrocarbon fragment is replaced with another one, with differing length of the hydrocarbon chain. The surface flow capacity of the agent's DS species can act as a criterion characterizing the collective ability of carboxylic acids' DS species. Here, by the surface flow capacity in a given cross-section we mean the total energy carried by the flow via this section per time unit. Associates of desorbed species of the reagent have different energies at different points of the flow cross-section, since part of it goes to the adjacent layers of the liquid. The flow capacity can be expressed as the product of the surface flow energy at a given point by its mass flow rate:  $N = \pi_0 Q_m$ . Here,  $\pi_0$  is the surface pressure, N/m;  $Q_m$  – surface flow of the reagent's desorbed forms, m<sup>2</sup>/s. In addition to the surface pressure value, this criterion can account for the spreading rate of the film of reagent's desorbed species along the water surface. It can be used for a comparative evaluation of other collectors belonging to the same homologous series of chemical compounds.

Changing the pH of the flotation system will modify the surface flow capacity, due to the decreased spreading rate of the reagent and reduced mass of its desorbed species located on the mineral surface. The spreading rate of carboxylic acid films at pH ~ 10 is demonstrated in Fig. 1b. For decanoic acid at around pH 10, it declined 1.8-fold, as compared with the spreading rate within the neutral pH range. We also need to remember that in the alkaline region, there exists a possibility of washing the physical sorption of carboxylic acids off the mineral surface with an alkaline solution. As revealed in the earlier study, part of the reagent's desorbed species is washed with water [18]. At pH 6.3, up to 20% of the oleate is desorbed from the hematite surface and up to 35% – from the magnetite surface; whereas at pH 10, desorption makes 45 and 65%, respectively. The total effect of the reduced spreading rate of carboxylic acid and removed DS species of the reagent from the mineral surface will lead to the depressed flotation process in the alkaline pH region (Fig. 2) [19]. The similar results were obtained in flotation of magnetite, hematite, goethite, fluorite, sheelite and also are in review article [20–22].

As demonstrated above, the sorption coating of a mineral consists of two layers: the lower one with a chemically

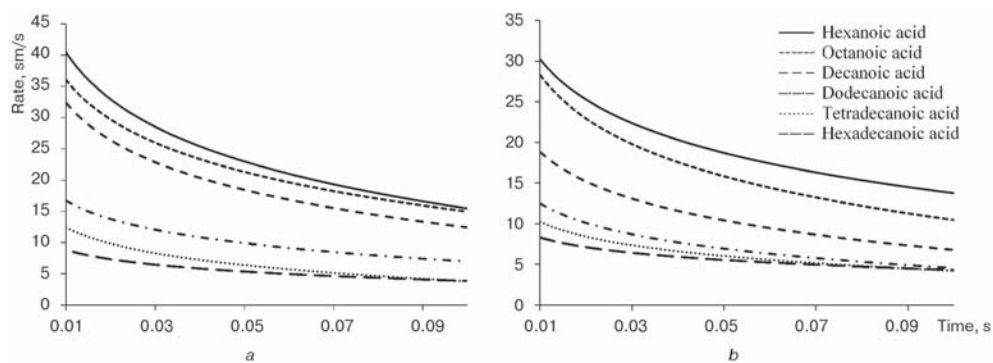


Fig. 1. Spreading rate of film of carboxylic acids on water surface versus time: a – pH = 7,0; b – pH = 10

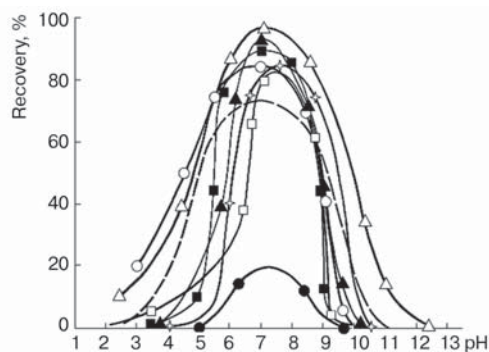


Fig. 2. Floatability of —□— columbite, —◇— zircon, —▲— tantalite, —■— ilmenite, —○— rutile, —△— garnet and tourmaline, —●— albite, — — perovskite as a function of pH. Consumption of oleic acid 1kg/t

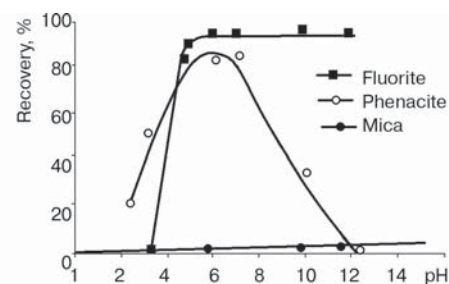
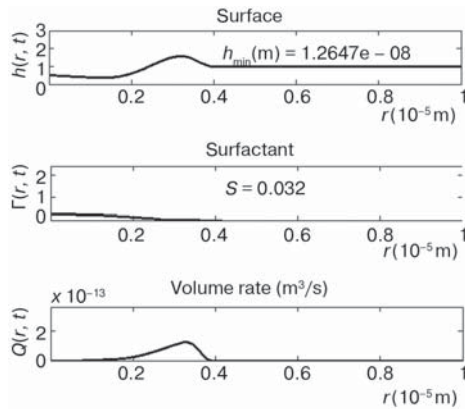


Fig. 3. Floatability of fluorite, phenacite and mica as a function of pH. Consumption of oleic acid 33 mg/l

fixed agent and the upper one represented by calcium oleate, sodium and neutralcarboxylic acid molecules. According to Abramov's experimental data, ethyl alcohol removes oleic acid molecules with ease, while it practically does not remove the chemisorbed oleate [23]. Therefore, after decantation and washing the collector-treated ore with ethyl alcohol, only the chemical form of the reagent's sorption is presumably located on the mineral surface. Recovery of fluorite with one (chemical) form of the collector's sorption differs significantly from that containing both sorption forms (chemical and physical, fixed through the hydrophobic mechanism). Our experiment has revealed that high flotation parameters are only achieved if both physical and chemical forms of the reagent's sorption are present on the mineral surface and are sharply reduced if any one is absent. Taking into account the obtained experimental results and other data, we can assume that easily desorbed derivatives of octanoic, decanoic and dodecanoic acids at the time of formation of the flotation contact can captivate the liquid and remove it from the interlayer that separates the mineral particle and the gas bubble. Removal of the interlayer liquid by tetradecanoic, hexadecanoic and octadecanoic acids is hampered by their low spreading rate over the water surface.

The dependence of fluorite recovery on pH is presented in Fig. 3. In the alkaline region, floatability of this mineral remains high up to pH 12. High fluorite floatability can be associated with



**Fig. 4. Results of numerical calculation of the flow of liquid from the interlayer caused by spreading of the DS species film of carboxylic acid forms with 10 carbon atoms in the hydrocarbon chain: a – is the profile of the free surface of the liquid interlayer; b – concentration of DS forms of carboxylic acid; c – flow rate depending on the radial coordinate at time  $t = 4.0 \cdot 10^{-5}$  s;  $\sigma_m = 40.3 \cdot 10^{-3}$  N/m**

the formation of calcium dioleates or calcium dioleate associates with acid anions. Fluorite belongs to the class of sparingly soluble minerals and therefore calcium cations can interact in solution with oleic acid anions. The emerging derivatives are released on the hydrophobized mineral surface and can eventually serve as the reagent's DS species. The products indicated above have a sufficient spreading rate (that exceeds the spreading rate of oleic acid) to get the liquid interlayer removed.

**The collective force of carboxylic acids**

To reach the objectives of this research, we determined the force exerted by the film of the spreading reagent on the liquid in the interlayer. We used a known solution of removing the liquid from the interlayer under conditions of surface tension gradient at the gas-liquid interface. For this purpose, we assumed that physically sorbed DS species of the reagent are present on the mineral surface. The reagent's DS solution has low surface tension. Following the local breakout of the interlayer, this species of the reagent's sorption gets access to the gas-liquid interface, where the surface tension is almost equal to the surface tension of water ("fresh" bubbles). In conditions of the surface tension heterogeneity, the emerging capillary forces act on the reagent film tangentially to the free liquid surface and induce its spread [24]. The reagent film involves the adjacent layers of liquid in its motion and generates a convective current, the so-called Marangoni convection.

A thin layer of viscous incompressible (true) fluid, i.e., the interlayer, is bounded from below by a solid surface  $z = 0$  and by a free boundary  $z = H(r, t)$  – from above. To describe the axisymmetric flow, we used the Navier-Stokes equations in a cylindrical coordinate system  $(r, \theta, z)$

$$\rho \left( \frac{\partial v_r}{\partial t} + v_r \frac{\partial v_r}{\partial r} + v_z \frac{\partial v_r}{\partial z} \right) = -\frac{\partial p}{\partial r} + \mu \left[ \frac{1}{r} \frac{\partial}{\partial r} \left( r \frac{\partial v_r}{\partial r} \right) - \frac{v_r}{r^2} + \frac{\partial^2 v_r}{\partial z^2} \right]. \quad (1)$$

$$\rho \left( \frac{\partial v_z}{\partial t} + v_r \frac{\partial v_z}{\partial r} + v_z \frac{\partial v_z}{\partial z} \right) = -\frac{\partial p}{\partial z} - \rho g + \mu \left[ \frac{1}{r} \frac{\partial}{\partial r} \left( r \frac{\partial v_z}{\partial r} \right) + \frac{\partial^2 v_z}{\partial z^2} \right]. \quad (2)$$

$$\frac{1}{r} \frac{\partial v_r}{\partial r} + \frac{\partial v_z}{\partial z} = 0. \quad (3)$$

**Table 5. Surface pressure  $S$ , flotation reagent force  $F$ , interlayer thickness  $h$  and the maximum flow rate at  $r = 0.2 \cdot 10^{-5}$  m for some saturated carboxylic acids**

Parameters	Saturated carboxylic acids			
	Hexanoic	Octanoic	Decanoic	Dodecanoic
$S = \sigma_w - \sigma_m$ (mN/m)	3.0	15	32.0	28.0
$h$ (m)	$2.68 \cdot 10^{-8}$	$1.62 \cdot 10^{-8}$	$1.26 \cdot 10^{-8}$	$1.3219 \cdot 10^{-8}$
$F$ (N)	$7.57 \cdot 10^{-6}$	$4.57 \cdot 10^{-5}$	$9.78 \cdot 10^{-5}$	$8.6896 \cdot 10^{-5}$
$Q_{max}$ (m <sup>3</sup> /s)	$1.6 \cdot 10^{-14}$	$6.8 \cdot 10^{-14}$	$1.2 \cdot 10^{-13}$	$1.097 \cdot 10^{-13}$
$t_m$ (s)	$4.0 \cdot 10^{-5}$			

Here,  $\mu$  is the coefficient of kinematic viscosity;  $\rho$  – liquid density;  $p$  – pressure;  $g$  – gravitational acceleration directed along the negative  $z$  axis; flow velocity vector has components  $(v_r, 0, v_z)$ . Equations (1) – (3) were simplified to the equations of the theory of lubrication. Simplification was performed under the assumption that the ratio of characteristic vertical dimension (thickness of the liquid layer on the mineral at the initial instant,  $H_0$ ) to characteristic horizontal dimension (e.g., the initial radius of the surface-active substance spot,  $R_0$ ) is much less than 1.

Calculations were performed for the following parameters' values:  $\mu = 1.052 \cdot 10^{-3}$  Pa·s;  $\rho = 10^3$  kg/m<sup>3</sup>;  $g = 10.0$  m/s<sup>2</sup>;  $D_s = 10^{-8}$  m<sup>2</sup>/s;  $\sigma_w = 72.3 \cdot 10^{-3}$  N/m;  $\sigma_m$  varied depending on the hydrocarbon fragment length of carboxylic acid molecules and were estimated both upon the study data and experimentally.

**Fig. 4** shows the interlayer surface profile  $h(r, t)$ , surface concentration of the reagent  $\Gamma(r, t)$ , and the volume flow of liquid from interlayer, as a function of the radial distance at an instant  $t = 4.0 \cdot 10^{-5}$  s.

Comparison of thickness  $h$  of interlayers located behind the front of spreading reagent film and the liquid flow rates reveals that the rate of its removal from the interlayer increases in the following sequence: hexanoic, octanoic, dodecanoic, and decanoic acid (**Table 5**). The collective ability of these carboxylic acids increases in the same sequence. The calculated values of the collective force  $F$  for desorbed species of carboxylic acids are estimated upon the assumption that these forces act when the liquid is removed from the interlayer and characterize adequately their collective ability.

The proposed mechanism clarifies the conclusions of the earlier study. The  $pH$  region of high surface pressure of tetradecanoic acid does not coincide with the region of the maximum hematite floatability. Relying on this comparison, concludes that the surface pressure of the reagent film does not always characterize the collective ability of carboxylic acid. According to the proposed mechanism, precipitation of DS species of tetradecanoic acid (ion-molecular complexes) leads to an increased density of its sorption on the mineral surface, and after the interlayer breakout – to the emergence of high-gradient surface tension. Therefore, creating conditions for recovery of agent forms (active with respect to the gas-liquid interface) from the solution and their deposition on the mineral refers to primary conditions for high flotation rates. According to the proposed criterion "capacity of the DS agent's species surface flow", the collector, apart from the high surface pressure, should have the ability to spread along the gas-liquid interface with high velocity. As follows from Fig. 1, the spreading rate of tetradecanoic acid is lower than

the initial spreading rate of decanoic acid. Hence, the collective ability of tetradecanoic acid is inferior to the collective ability of decanoic acid. The assertion that the surface pressure of the reagent film does not always characterize the collective capacity of carboxylic acid indicates an incorrectly selected criterion for assessing the collective ability of the flotation agent.

The mechanism proposed in [11–13] confirms conclusions of the study [6] on the need of “fresh” bubbles in flotation process. High surface tension of “fresh” bubbles and low surface tension of the solution of ion-molecular complexes or the agent’s DS species promote building-up of high local surface pressure at the moment of breaking out the liquid interlayer. High rate of agent’s DS spreading results in a rapid liquid removal from the interlayer and formation of a flotation aggregate.

### Conclusion

The local value of the surface pressure developed at the moment of the interlayer breakout is important in forming flotation aggregate. The equilibrium pressure calculated as the difference between the surface tension of water and the agent solution does not always reflect the physics of forming flotation aggregate. For long-chain reagents, decrease in the spreading rate associated with the cohesion of their hydrocarbon fragments should be accounted for.

We propose a criterion that enables a comparative evaluation of the collective activity of homologous reagents: “capacity of the surface flow of flotation reagent’s desorbed forms”.

Flotation capacity of the DS species for saturated carboxylic acids is calculated under the assumption that the major limiting factor that prevents formation of flotation contact is the presence of a liquid interlayer remaining between the mineral particle and the gas bubble after its local breakout. The sequence of changes in the calculated values of the collective force  $F$  of desorbed forms of carboxylic acids was found to coincide with the sequence of changes in their flotation activity.

The mechanism of liquid removal from the interlayer by spreading DS species confirms the conclusions of the study [6] on the need of using “fresh” bubbles in flotation. High surface tension of “fresh” bubbles and low surface tension of the solution of ion-molecular complexes or the agent’s DS species promote building-up of high local surface pressure at the moment of breaking out the liquid interlayer.

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