INTERPARTICLE INTERACTION IN THE DILUTED AQUEOUS SUSPENSIONS OF HYDRO-MICA

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Abstract:

An influence of some compositions containing water soluble polymers on the interparticle interaction in the aqueous suspensions of hydro-mica has been investigated. Surface modification of the particles preceding adding a flocculation agent to the system causes much higher intensity of the interparticle interaction in the suspension, which results in the particle aggregation and decreasing in the sedimentation stability of the systems.

Results of this investigation can be used in some cleaning technologies to remove highly dispersed pollutants from some natural water and wastewater, raw mineral materials refining and separation process.

Keywords: *water soluble polymer, flocculation agent, sedimentation stability*

Introduction

Highly dispersed clay-like particles often should be removed in course of the mineral raw materials refining or in the wastewater treatment technologies. Some organic substances can promote better aggregation of the particles, lower sedimentation stability of the system and, therefore, increased efficiency of the clay particles removing. Mutual aggregation of small and coarse particles ensures the most effective removing [1, 2]. A smaller particle can get into the sphere of molecular attraction of a coarse one and then the both particles form a contacted associate. Stability of the associate depends on the mutual effect of the molecular, electrostatic and structuring forces.

Various organic additives can significantly influence interparticle interactions in the disperse systems. For instance, sedimentation stability of the systems can be regulated through changes in concentration and type of the admixtures.

Experimental

This investigation deals with hydro-mica – a clay-like material with general formula $K_{1-1,5}Al_4[Si_{6.5-7}Al_{1-4.5}O_{20}](OH)_4*nH_2O$. This mineral can be classified as mica with a layered structure and close to hexagonal lattice [3].

Granulometric composition of the material has been determined using a laser granulometer "GRANULOMETER-750" (see Fig. 1).

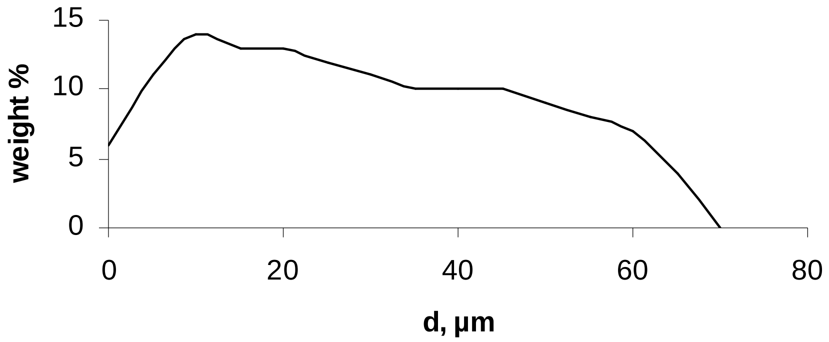
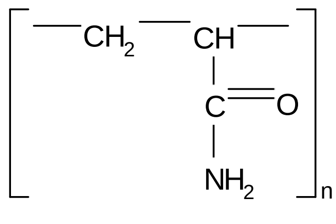


Fig. 1. Granulometric composition of the hydro-mica suspensions

Such requirements as availability, inertness in the surface interaction with hydro-mica and lower toxicity were taken into account in selection of the organic additives. Easy practical applicability of the additives has also been considered. Hence, following two substances have been selected basing on the data from [4]:

1. Polyethyleneoxide (PEO) made by Novosibirsk branch of the firm "Karbolit" (Russia). Formula of PEO can be shown as HO-[-CH_2-CH_2-O-]$_n$-H and it approximate molecular weight is about (2-3)$\cdot 10^6$ a.m.u.
2. Polyacrylamide (PAA) made by the firm "Oriana" (Kalush, Ukarine). Approximate molecular weight is about (5-6)$\cdot 10^6$ a.m.u. and formula is



An effective coefficient of adhering (C_{ef}) was calculated as a tangent of slope of the dependence of the small fraction concentration on concentration of the coarse fraction and used as a criterion of the interparticle interaction in diluted (up to 3 kg/m^3) suspensions [5].

A coefficient of sedimentation instability (C_{si}) was calculated as a tangent of slope of the dependence of changes in the optic density (D_0–D_c) during the experiment on concentration of the dispersed phase and used to determine a character of the additives effect on sedimentation stability [6].

A product of coefficients *mβ* from the Einstein equation was used to characterize intensity of the contacted interaction in the highly concentrated systems.

These coefficients describe functional relationship of the parameter α in the equation with shifting forces ratio [7, 8]:

$$\eta = \eta_0 \exp(\alpha\varphi),$$

where:
η, η_0 – viscosity of suspension and disperse medium respectively;
α – a parameter, which describes interparticle interaction.

Viscosity of the system has been investigated using a rotation viscosimeter "Rheotest-2" at high shifting speed values. This condition ensured suspension state of the particles.

Parameter α was found dependent on the dimensionless parameter γ, which can be calculated through the shifting speeds ratio: $\gamma = D/D_{max}$, where D_{max} is the maximal shifting speed and D – given shifting speed. Then α can be obtained as $\alpha = \beta(\gamma)^{-m}$ [4, 9].

Parameters β and m are constant in each individual experiment and α depends on the shifting speed. Therefore, an intensity of the interparticle interaction can be characterized as a systems' response to an external disturbance.

It is known [1, 4] that some high-molecular additives (for instance, PEO) can modify surface of the disperse phase particles, which results in the primary structuring of the system.

The structuring significantly influences the bonding force between PAA functional groups and the particles. That is why it was needful to determine how preliminary modification of the disperse phase particles using PEO can influence the system's stability in presence of the flocculation agent (PAA).

First modification stage implied modification of the solid phase particles with PEO then we used PAA. Concentration of the flocculant was kept constant through all the experiments and concentration of the modifier was variable.

Results and Discussion

It is found that preliminary modification of the hydro-mica particles with PEO (C_{PEO} = 0.01 kg/m^3) causes rise in C_{ef} value comparing to the value after modification with individual PAA. Aggregation of the particles results in the decrease of sedimentation stability of the suspensions (see Fig. 2).

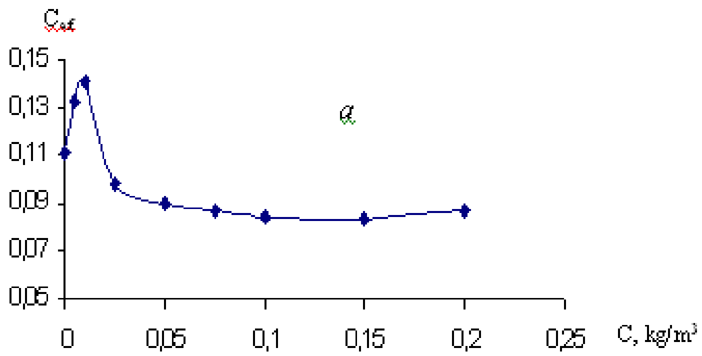
A range of the PEO concentrations ensuring effective flocculation is narrowed if a system contains PAA.

Low concentration of PEO (under 0.02 kg/m^3) causes formation of the particles associates, which decreases aggregation and sedimentation stability and increases absolute values of C_{ef} and C_{si}. Adding of PAA causes intense flocculation of the particles associates, which reveals itself through intense clarification of the suspensions containing only coarse or a mixture of coarse and small particles (Fig. 2).

Basing on the results of this investigation we can recommend a composition of PEO and PAA for clarification of various natural waters, wastewaters and some technological solutions from the hydrophilic suspended particles.

Previously aggregated small particles can cohere with the coarse ones forming big floccules, which rapidly precipitate. This process of precipitation can be registered through decrease of optical density of the suspensions.

Another effect of the preliminary modification of the particles is reducing of the sediment's volume. This phenomenon can be caused by some hydrophobisation of the clay particles surface, which reduces amount of the liquid captured between structural components of the floccules.



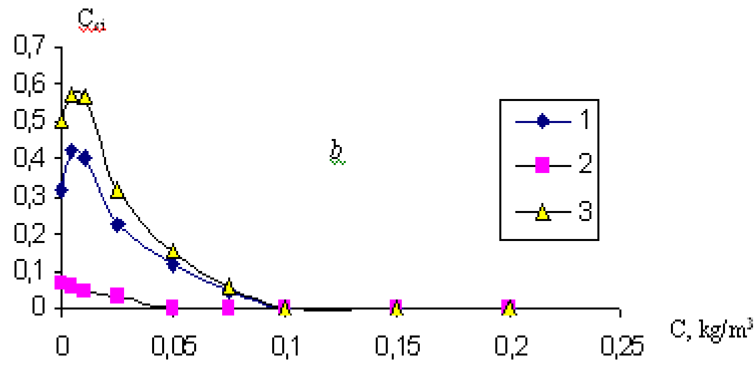


Fig. 2. Dependence of effective coefficient of adhering C_{ef} (a) and coefficient of sedimentation instability C_{si} (b) for the hydro-mica suspensions on concentration of PEO at C_{PAA} = 0.01 kg/m^3. 1 – suspension of the coarse particles; 2 – suspension of the small particles; 3 – suspension of the both particles.

Results of this investigation have been applied to improve the technology of clarification of the clay-containing wastewater from the mineral fertilizers production.

Data of Table 1 prove that joint adding of PEO and PAA ensures 1.5-2.3 faster separation of the suspensions. C_{PEO} : C_{PAA} = 1 : 100 is the most effective ratio of the components concentration [10].

Table 1

Influence of PAA : PEO ratio on the clay-salt suspensions clarification rate

Reagent	**Concentration, g/kg$_{solid\ phase}$**	**Ratio C_{PAAA} : C_{PEO}**	**Clarification rate, m/h**
PAA PEO	0.36 0.0009	400	3.00
PAA PEO	0.36 0.0018	200	4.61
PAA PEO	0.36 0.0036	100	5.62
PAA PEO	0.36 0.09	40	3.60
PAA PEO	0.36 0.018	20	3.21
PAA PEO	0.36 0.022	16	2.86

The suspensions become more unstable and a spatial structure forms in the disperse phase as a result of raise in the PEO concentration. This process also causes decrease in the values of C_{ef} and C_{si}. Raise in the PAA concentration to 0.02 kg/m^3 also causes decrease in C_{ef} and C_{si} and formation of a spatial structure (or strengthening of the previously formed one) (see Fig. 3).

Joint adding of PEO and PAA ensures stronger interparticle interaction in the concentrated suspensions, which can be described through a product of two rheological constants *m* and β (see Fig. 4). This product shows strong rise at initial increase of the additives concentration (up to 0.005 kg/m^3) followed by leveling and flattening of the dependence at further increase of the concentration. A pattern of the concentration dependence is similar for the dependence, which describes an individual effect of PEO. Only values of the *mβ* product are different for these two cases.

On other hand, joint adding of the polymers additives results in substantially stronger interparticle interaction. The "joint" *mβ* values are higher than the individual ones. This fact proves that exactly PEO governs a character of the interparticle interactions in the highly concentrated systems nevertheless another strong flocculant PAA is also present in the system.

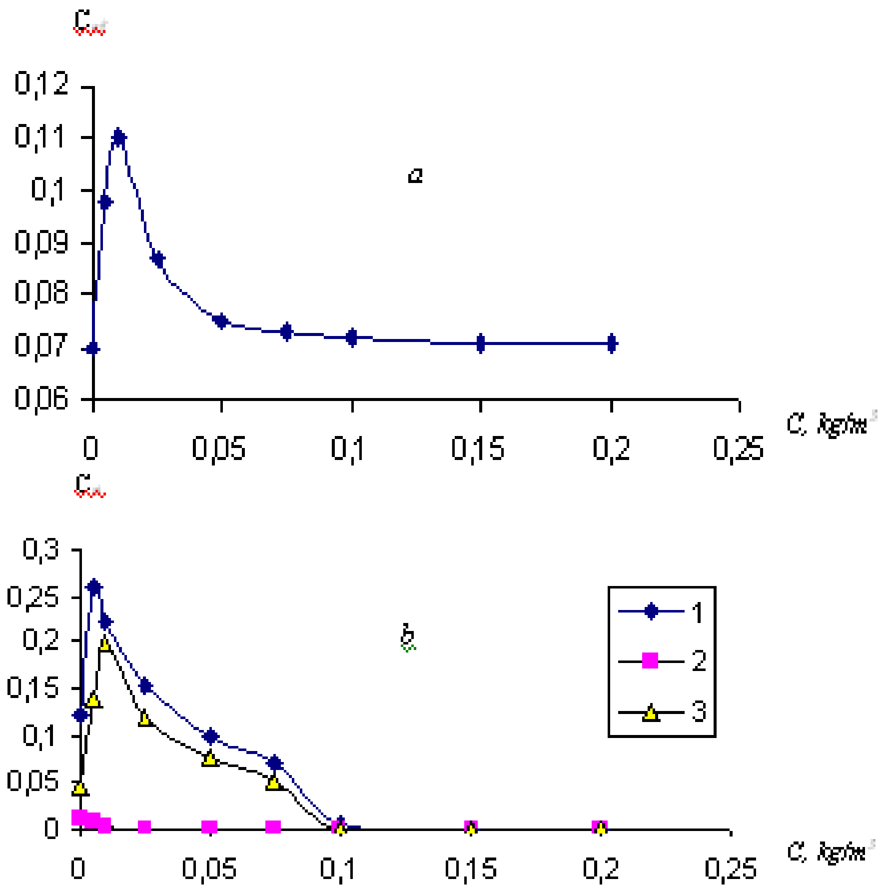


Fig. 3. Dependence of effective coefficient of adhering C_{ef} (a) and coefficient of sedimentation instability C_{si} (b) for the hydro-mica suspensions on concentration of PEO at C_{PAA} = 0.05 kg/m^3. 1 – suspension of the coarse particles; 2 – suspension of the small particles; 3 – suspension of the both particles.

Conclusion

A value of the interpartcile interaction can be substantially intensified through the surface modification of the disperse phase particles prior to adding a flocculant. This process ensures lower aggregation and sedimentation stability of the system.

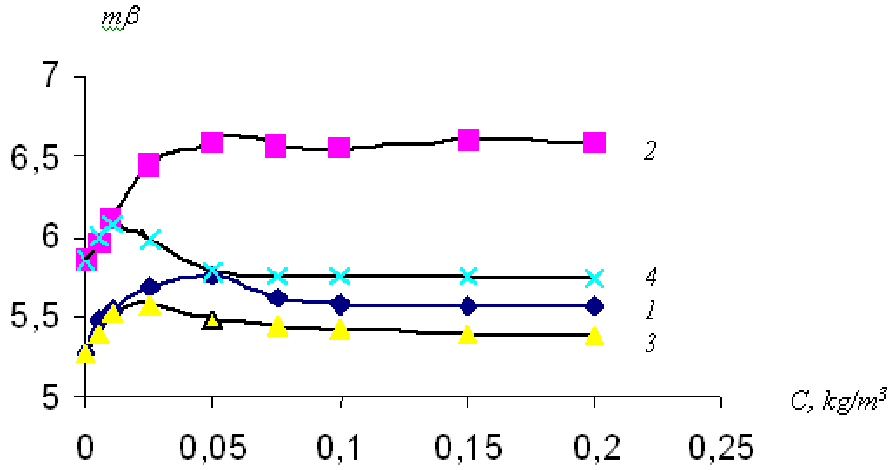


Fig. 4. Dependence of *mβ* for the hydro-mica suspensions on concentration of the additives: PEO + 0.01 kg/m^3 PAA (1); PEO + 0.05 kg/m^3 PAA (2); Twin-80 + 0.01 kg/m^3 PAA (3); Twin-80 + 0.05 kg/m^3 PAA (4).

Moreover, a modification of the hydrophilic surface of the particles with water soluble polymers and surface-active additives results in hydrophobisation of the surface, faster sedimentation of the particles and their aggregations and reduction in volume of the sediment because of decreased in amount of the liquid captured between structural elements of the floccules.

Results of this work can be utilized in enhancement of the water treatment technologies applied to the cleaning of some natural waters, technological wastewaters as well as in some raw mineral materials refining and separation processes.

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