Food and Environment Safety - Journal of Faculty of Food Engineering, Ştefan cel Mare University – Suceava
Volume X, Issue 2 – 2011

INFLUENCE OF SOME SURFACTANTS AND FLOCCULANTS ON INTERPARTICLE INTERACTIONS IN AQUEOUS SUSPENSIONS OF HYDRO-MICA

***Sergey BORUK[1], Igor WINKLER[1] , Sonia GUTT[2]**
[1] Yuriy Fedkovych National University of Chernivtsi, Kotsiybynsky St., 2, Chernivtsi 58012, Ukraine.
E-mail: boruk_s@hotmail.com
* Corresponding author
[2] Stefan cel Mare University of Suceava, University Street nr. 13, 720 229 Suceava, Romania
Received 3 January 2011, accepted 16 May 2011

Abstract. *An influence of composition of nonionic surfactant Twin-80, and combined effect of the water-soluble surfactant polyethylene-oxide (PEO) and flocculant polyacrylamide (PAA) on interpartcile interaction in the water suspensions of hydro-mica with electrolytes have been investigated. Ions of electrolyte do not cause any changes in a character of the surfactants' influence while can result in significant changes in the concentration range for their effective action. These changes can be induced by adsorption of the electrolytes ions on the surface of the dispersed phase particles. Following consequence can be formed from the three kinds of electrolytes according to their influence on the interparticle interaction:* K^+ - Mg^{2+} - Na^+*. A combination of the cation charge and radius is a key factor governing its activity. A character of the surfactants' effect undergoes dramatic changes because of the micelle-forming processes occurring in presence of the electrolytes. Combined application of PEO and PAA results in more intense interpartcile interaction in the system. Results of this investigation can be applied to various technologies for separation of the dispersed phase from disperse media (treatment of some natural waters and wastewaters, refining and concentration of the mineral ores and other source materials, mixtures separation, etc.).*

Key words: *surfactants; electrolytes; interparticle interactions; disperse system*

1. Introduction

An intensity of interparticle interaction should be regulated within some intervals for many technological applications related to production and refining (concentration) of the highly concentrated suspensions. Some organic modifiers can change a composition of the particles surface and influence a structure of the disperse system [1, 2]. Such agents hold much promise for regulation of interparticle interactions.

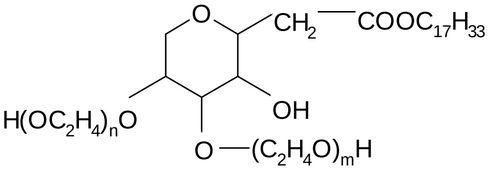
Various ion-soluble substances can be found in many industrial suspensions, which results in changes in properties of surface of the dispersed phase particles and characteristics of the disperse media. Therefore, details of influence of electrolytes on interparticle interaction in the disperse systems are of significant interest for investigation.

2. Experimental

Our investigations dealt with aqueous suspensions of hydro-mica (mineral illite). This is a layered mineral with general composition $K_{1-1,5}Al_4[Si_{6.5-7}Al_{1-4.5}O_{20}](OH)_4 \bullet nH_2O$, which can be classified as a mica and has close to hexagonal crystals with continuous layers of the SiO_4 tetrahedrons [3]. Granulometric composition of this mineral is represented in the Fig. 1.

Selection of the modifiers has been realized in respect to the following parameters: surface activity towards dispersed phase particles; no chemical interaction between the modifier and surface of the particle; availability and applicability of the modifying agent. Following substances were found [4] conforming to the above conditions:

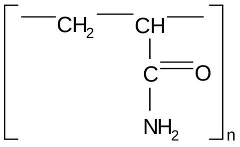
1. Nonionic surfactant Twin-80 made by the firm “TOS” (Russia). Atomic weight of this substance is about 1100 atomic mass units (a.m.u.) and formula:



where n+m=20. This substance can form micelle with critical constant of micelle forming (CCM) = 0.06 kg/m^3.

2. Polymer polyethyleneoxide made by the firm “Carbolite” (Russia). Its atomic weight is about (2-3)•10^6 a.u.m. and chemical formula HO-[-CH_2-CH_2-O-]$_n$-H.

3. Polymer polyacrylamide made by the firm “Oriana” (Ukraine). Its atomic weight is about (4-6)•10^6 a.u.m. and formula:



Solutions of electrolytes KCl, NaCl and $MgCl_2$ with equal ionic strength have been used as disperse media.

3. Results and Discussion

An Einstein’s equation

$$\eta = \eta_0 \exp(\alpha\varphi), \qquad (1)$$

can be used to calculate viscosity of such systems.

Here η and η_0 denote viscosity of the suspension and disperse media respectively; α is a parameter, which describes intensity of the interparticle interaction.

A wide variety of particles with different sizes were present in the source mineral suspension (see Fig. 1). There were also some coarse-dispersed particles, which can sedimentate in the aqueous media very fast. That is why all viscosity measurements have been carried out using a rotation viscosimeter “Rheotest-2” working at a high shifting velocity. This mode enables to keep the coarse-dispersed particles suspended.

The parameter α in (1) depends on the dimensionless parameter γ, which can be calculated as a ratio between the shifting velocities $\gamma = D/D_{max}$, where D_{max} is the maximal shifting velocity of the viscosimeter. α can be calculated as $\alpha = \beta\ (\gamma)^{-m}$. Since β and m stay constant for each individual measurement, a value of α depends solely on γ. In such manner an intensity of the interparticle interaction can be evaluated through reaction of the system on the external mechanical disturbance [5, 6].

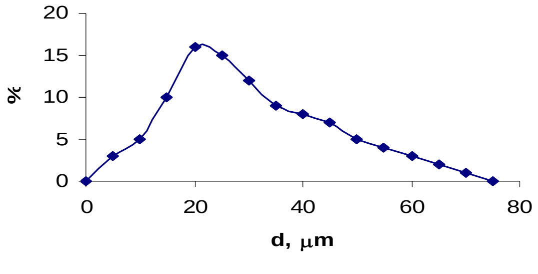


Figure 1. Granulometric composition of the hydro-mica suspensions

An influence of electrolytes on the interparticle interaction is caused by adsorption of the electrolyte ions on the dispersed phase particles, which changes properties of the phase. The particles charge is a key factor governing bonding strength between functional groups of the surfactants and polymers with the dispersed phase particles. On other hand, changes in the particles electrokinetic potential induced by the electrolytes can affect a character and magnitude of effect of the organic substances on intensity of the interparticle interaction.

Following ‘aggregation activity’ sequence can be formed from the electrolytes under this study according to their effect on the interparticle interaction in the hydro-mica suspensions:

$$\text{KCl } (m\beta = 4{,}45) > \text{MgCl}_2\ (m\beta = 4.0) > \\ > \text{NaCl } (m\beta = 3{,}9). \qquad (2)$$

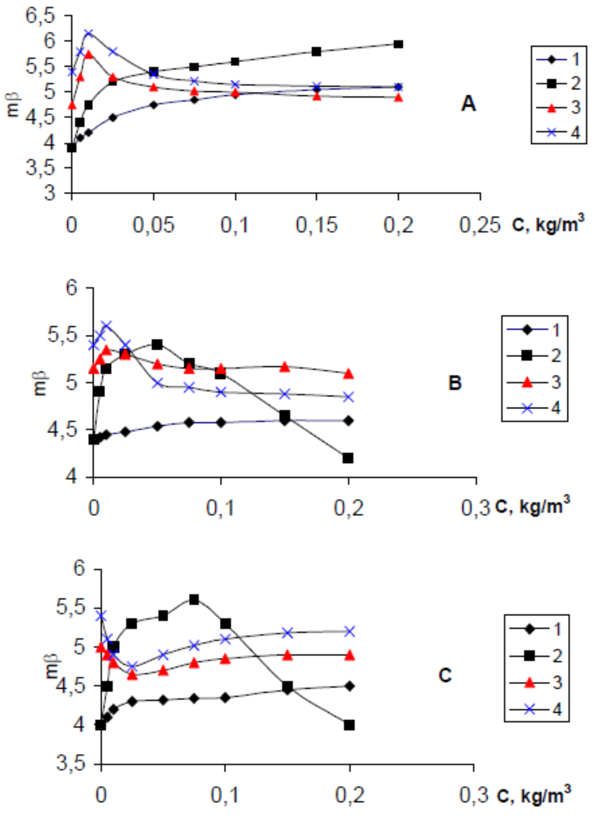


Figure 2. Dependence of a value of parameter mβ in the hydro-mica suspensions on concentrations of surfactants and flocculants in aqueous solutions of NaCl (A); KCl (B) and MgCl$_2$ (C).
Ionic strength of all the solutions i = 1. Admixtures: Twin-80 (1); PAA (2);
Twin-80 + PAA (C=0.01 kg/m^3) (3); Twin-80 + PAA (C=0.05 kg/m^3) (4).

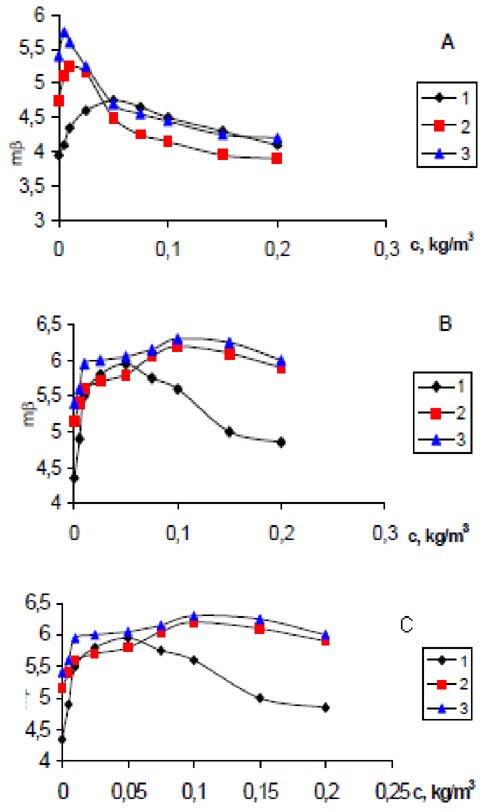


Figure 3. Dependence of a value of parameter mβ in the hydro-mica suspensions on concentrations of the polymers in aqueous solutions of:
NaCl (A); KCl (B) and MgCl$_2$ (C).
Ionic strength of all the solutions i = 1. Admixtures: PEO (1); PEO + PAA (C=0.01 kg/m^3) (2); PEO + PAA (C=0.05 kg/m^3) (3).

Higher efficiency of potassium ions is caused by their bigger radius, which results in a deeper perturbation in a structure of the surface adsorbed water layer.

Hydration ratio of the potassium ion is lower than that of sodium and magnesium and the surface adsorbed water layer disruption by potassium is comparatively significant, which promotes more intense interaction between the particles of hydro-mica. A value of mβ for the magnesium ions is smaller than value for the sodium ions and higher charge of the magnesium ions should be taken into consideration to account for stronger disruption of the boundary water level on the particles. This layer plays an important role in the structural forces of repulsion and its disruption promotes better aggregation of the dispersed phase particles.

Electrolytes do not change a principal character of influence of PAA in the hydro-mica suspensions. A concentration range of the effective structures formation in the suspensions can slightly widen (see lines 2 in Fig. 2). It is known [7] that the PAA concentration range of the effective structures formation in the water suspensions is quite narrow. However, this range undergoes significant widening in the solutions of the electrolytes under investigation. For example, concentration dependencies either flatten out (Fig. 2a, line 2) or pass through a maximum (Fig. 2b and 2c, line 2) near the concentration 0.08-0.1 kg/m^3.

A structures formation influence of PEO undergoes intensification in presence of the electrolytes (see Figs. 3, line 1).

It can be assumed that a spatial conformation of the adsorbed macromolecules of PEO can be changed by the electrolytes, which results in more intense interparticle interaction. The sequence (2) remains unchanged even in presence of PEO. However, a maximum in the dependence of mβ on PEO concentration in the system with ions of manganese is shifted towards higher concentrations of PEO (Figs. 3, line 1). This effect can be caused by formation of the coordination bond between an ion of manganese and oxygen from the molecule of PEO. This bond weakens efficiency of the PEO effect. A value of mβ decreases as concentration of PEO raises that can be caused by better aggregation in the system and decreasing of amount of the structural elements in a volume unit of the disperse system.

A character of the influence of the nonionic surfactant Twin-80 undergoes dramatic changes in presence of the electrolytes. A characteristic minimum related to this surfactant has not been registered in a graph mβ versus concentration in presence of the electrolytes (see Figs. 2, line 1). This can be caused by formation of the surfactant micelles under the effect of the electrolytes and decrease in the disperse efficiency of Twin-80, which does not provide any effect on the interparticle interaction in hydro-mica suspensions containing the electrolytes. The sequence (2) also remains unchanged in presence of this surfactant.

An intensity of the interparticle interaction and values of mβ rise as a result of combined application of PEO and PAA to the electrolyte-containing systems. This process also manifests itself through a shift of a peak in the diagram mβ vs concentration of PEO (Figs 3, lines 2-3). This peak shifts towards higher concentrations in presence of potassium and sodium ions and in the opposite direction in presence of magnesium ions.

Combined application of Twin-80 and PAA to the electrolyte-containing systems does not cause any significant changes in the relation mβ – surface active agents concentration, which remains almost similar to the relation for the solitary application of PAA (Figs 2, lines 3-4). However, values of mβ for the combined application are slightly higher than for the solitary ones because of more intense interparticle interaction in the first case.

4. Conclusion

The electrolytes do not result any significant changes in a character and intensity of the high-molecular surfactants and flocculants effect on the interparticle interaction in the hydro-mica suspensions. On other hand, significant changes in activity of the low-molecular surfactants have been registered after adding an electrolyte to the disperse system. This effect is caused by changes in the CCM value because of the electrolytes action. Radius and charge of the electrolyte ion govern an intensity of its effect. Three electrolyte ions can be placed in the following sequence according to the decreasing activity: potassium-magnesium-sodium.

5. References

1. CHURAEV N. V., SOBOLEV V. D. *Contribution of the structural forces in the processes of quartz humectation by electrolytes solutions.* (2000). Coll. J., 62. 278-285.

2. GONCHARUK E. V. et al. *Role of the structure-mechanical barrier in the mixed aqueous dispersions of hydrophilic and hydrophobic silica.* (2001). Ukr. J. Chem., 67, 36-39.

3. TARASEVICH Yu. I. *Composition and surface chemical properties of the layered silicates.* (1988). Naukova dumka. Kiev. 248 p

4. SURFACTANTS. ED.: ABRAMSON A. A. (1979). *Chemistry*. Leningrad. 302 p

5. SLIPENIUK T. S. et. al. *Mutual flocculation in suspensions.* (1996). Ukr. J. Chem., 62, 97-100.

6. GAMERA A. V. et. al. *Interaction between various sized particles in the hydro-suspensions of an artificial diamond. (1999).* Superhard Mater., 2, *59-62.*

7. BORUK S., WINKLER I. *Influence of some non-ionic surfactants and flocculants on stability of diluted dispersions of kaolin and hydro–mica.* (2010). Proceedings of the international conference Biotechnologies, present and perspectives. Suceava.