Eurasian Chemico-Technological Journal 16 (2014) 319-326

Synthesis of Clay Composites of Polyacrylamide and Poly-2-Hydroxyethylacrylate and Sorbtion Ability in the Case of Cetylpyridinium Bromide

M.M. Beysebekov*, R.S. Iminova, Sh.N. Zhumagalieva,
M.K. Beysebekov, Zh.A. Abilov

Al-Farabi Kazakh National University, al-Farabi ave., 71, Almaty, Kazakhstan

Abstract

By the three-dimensional polymerization of nonionic (polyhydroxyethylacrylate and polyacrylamide) polymers and bentonite clay from Manyrak deposit (East Kazakhstan Region) and with using of process preliminary intercalation of monomers in an aqueous suspension of bentonite (polymerization in situ) the chemically crosslinked composite gels were synthesized. Optimal conditions of synthesis and physical-chemical properties of composition gels were established. It was shown, that yield of gel fraction increases with increasing contents of bentonite clay. Insignificant adding of negative charged particles of bentonite clay gives to polymer gels of nonionic type polyelectrolyte character, that comes out in decreasing of swelling degree of gels under effect of ionic strength. By using physical and chemical methods of research: equilibrium swelling, IR spectroscopy, scanning electron microscope (SEM), sorption-desorption, etc. were shown the formation of compatible, homogeneous, swelling in water polyelectrolyte gels formed via hydrogen bonds between the components of the gel, stabilized by hydrophobic interactions of the organic polymer chains. The possibility of the regulation of swelling ability of the composite gels through varying of the outside and inside factors as: consist of the composition, conditions of intercalation, pH of the environment, temperature and ionic strength was established, that is stimulus sensitivity of gels. The sorbtion capacity of polymer-clay composites in attitude surface active substance cetylpyridinium bromide were estimated. Increasing of temperature of environment and content of bentonite clay in composite promotes the process of sorbtion of surface-active substances. Considerably high sorption capacity of polymer clay composition based on more hydrophilic polymer – polyacrylamide was established. By the results of investigations one may, that synthesized polymer clay composites after suitable investigations can be recommend as sorbents of cationic surface active substances.

Introduction

Polymer-clay system based on natural and synthetic polymers are relatively affordable sorbents with improved physical and chemical, sorption-desorption and mechanical properties. Consumption of such sorbents were noticed in mechanical engineering, light industry, medicine, waste water treatment and isolation of various metals and surface-active substances in some industries. The interest in these materials was stimulated by two historically and practically important information [1]. First, the report of the research group “Toyota” about nanocomposites “nylon-6 (N6)/montmorillonite (MMT)”, for which the introduction of a small amount of the stratified silicate leads to improvement thermal and mechanical properties [2], and second, establishing by Vay and his colleagues [3] the possibility of mixing during the melting of polymers with stratified silicates without using organic solvents. Today, efforts in this direction are held more globally, using almost all types of polymer matrices. One of the ways of producing composite materials is a radical intercalation polymerization in situ monomers on the surface of the clay fillers [4]. This method has been used since 1960, and continues to exist in the mass, solution, emulsion or suspension [5]. The process of polymerization of monomer proceeds in the interlayer space of the clay structure (montmorillonite) [6]. The advantage of this method is that

---

* Corresponding author. E-mail: make1987@mail.ru

if polymerization develops inside the galleries the particles of clay will gradually swell and eventually exfoliates into discrete layers. As uninterrupted phase in the composites can be used such synthetic polymers as polyacrylamide, polycarboxylic acids, polyhydroxyethylacrilate and etc [7]. Promising as a filler are layered minerals – bentonite clays with a high content of montmorillonite [8]. The introduction of the bentonite clay in content to gel compositons gives to gel new qualities: improved mechanical and changes of collapsing properties. It should be noted huge deposits of valuable minerals in Kazakhstan, particularly in the East Kazakhstan region. [7] In this regard, a very essential and interesting is to consider creating a polymer-clay composite materials with valuable properties on the basis of domestic bentonite clay, which has a number of specific properties, such as swelling and adsorption ability.

In this paper we tried to undertake attempt to use bentonite clay from Manrak deposit (East Kazakhstan Region) as a filler in the creation of new chemically cross-linked polymer-clay composite gels based on non-ionic polymers, poly-2-hydroxyethylacrylate and polyacrylamide, and the study of their nature of the interaction, morphological structure and sorption capacity in case PEAHENS.

Experimental

2-hydroxyethylacrylate (HEA) with containing 98% of the main product manufactured by “Aldrich Chemical Co.” (USA) and acrylamide (M = 152.2, T_m = 357.5 K) (AAm) of the company «Reanal» (Hungary), was used without purification. As a cross-linking agent used N, N′-methylene-bis-acrylamide (MBAA) from «Reanal», (Hungary), as an initiator potassium persulfate (PPS) grade “chemically pure” without purification. Bentonite clay (BC) from Manrak deposit (East Kazakhstan Region) was purified by repeated elutriation in distilled water by the method of D.P. Salo [9]. The chemical composition of the natural and treated bentonite clay determined by the diffraction spectral analysis (DFS-13, Russia) is presented in Table 1.

Table 1

Chemical composition of the natural and purified clays

Sample of clay	Content of components,%								
	SiO_2	A_2O_3	Fe_2O_3	CaO	MgO	Na_2O	K_2O	H_2O	Loss after anneal
Natural	65	13	1	0.5	1.5	1.5	0.5	11	6.5
Purified	60	9	0.5	0.5	1	1	0.5	7	20.3

According to the results of X-ray phase analysis (DRON-4-07, Russia) it was identified three phases in investigated bentonite clay: α-quartz SiO_2, montmorillonite $Al_2[OH]_2\{Si_4O_{10}\}$. mH_2O and amorphous phase.

Cetylpyridinium bromide (CPB) $C_{16}H_{33}NC_5H_5Br$ brand “p” (“Aldrich” USA) was used without purification.

Synthesis of Clay Composite Gels of Poly-2-hydroxyethylacrylate and Polyacrylamide

Intercalated composite gels PAAm-BC and PHEA-BC synthesized by intercalation radical polymerization of a monomer solution in water environment with including bentonite clay dispersion of different concentrations. In a glass beaker we prepared 100 ml of a suspension of bentonite clay in water mixing by magnetic stirring during 2 hours. Then to suspension added monomer and mixed during 6 hours. Then beaker with a mixture tightly closed and left for night. The next day the mixture was again mixed during 2 hours (maximum intercalation). Next, the suspension was heated to 60 ºC, and added to it a cross-linking agent, and then the initiator. The suspension poured into ampoules with a diameter of 20 mm, which were isolated from the air by laboratory film and placed in thermostat. The polymerization was carried out during two hours at 60 ºC, and then 20 hours at 25 ºC in air thermostat [10]. The content of cross-linking agent is 0.05-1 mol.% from weight of the monomer, initiator concentration in the composition is 1 mol.% from the monomer content. The content of bentonite clay varied between 0.5-3 wt.% from weight of the monomer. Obtained gels were washed from the unreacted monomers with distilled water. The completeness washing of composite gels controlled by quality reaction to amide group and a double bond (with bromine water). Obtained gel were dried under vacuum at 40 ºC to constant weight. The dried gels were ground in porcelain mortars. For tests were taken fractions with particle size < 0.1 mm.

For all the synthesized polymer-clay gels, and also for starting materials were written IR-spectrs on spectrophotometer with Fourier transformer “FT/R Satellite” of the “Mattson” company (USA) with using KBr.

Morphology and structure of bentonite clay, polymers and composite gels PHEA-BC and PAAm-BC were studied by using a scanning electron microscope JEOL JSM-6380A with EDS-detector (Japan). The samples were placed in tubes and pollinated gold in pollinator Quick Auto Coater, then studied at 15-20 kV.

Yield of gel fraction (G), the degree of crosslinking (J) and swelling of investigated polymer-clay gels and bentonite clay is calculated by common equations and formulas [9, 11].

Quantitative determination of the CPB in the solution was carried out using a UV spectrometer SF-56 (Russia) with a quartz cell thickness of 1 cm, it were written spectra of CPB with concentrations 10^{-5} -10^{-4} -10^{-3} M and defined a characteristic peak at 258 nm, where measure the optical density of the solution CPB.

Results and Discussion

Synthesis and investigation the physica-chemical properties of chemically crosslinked composition gels of the nonionic acrylates and bentonite clay. As noted above, one of the ways of obtaining clay composites, in particular nanocomposites, is the “in situ” polymerization with intercalation [5, 6]. Intercalation – a process of the repeated “penetrating” by macromolecules of intralayer spaces of the clay particles and the achievement by this high level of interaction. The difficulty of this method is the problem of obtaining the clay structure with ability to penetrate into the space of the matrix (polymer) and link heterogeneous components – inorganic filler and an organic polymer., the polymerization conditions display the indisputable effect to the physical and chemical properties of polymer-clay compositions, especially the density of crosslinking. The type and concentration of the filler also display the considerable influence on the structure of the composite. As a result of the series of experiments and studies have established the optimal ratio of monomer-solvent, equal to 1:9 by volume. It is with such a ratio of monomer and solvent were obtained samples of composite gels with different contents of mineral components (0.5-3 wt.% of the weight of the monomer, Table 2) and studied their morphological structure, swelling and sorption ability in case of PEAHENS.

Table 2
Physical and chemical properties of composite gels
[MBAA] = 0.25 mol.%, [PPS] = 1 mol.%

H_2O:PL, %	bentonite, %	G, %	S, %	J	W_{beat}, %
[H_2O]:[PHEA] 90:10	0.5	87.8	12.4	3.6	15.52
	1	90	10	3.26	16
	2	92	8	2.95	16.44
	3	95	5	2.44	23.84
[H_2O]:[PAAm] 90:10	0.5	80	20	4.5	14
	1	81	19	4.4	14.5
	2	84	17	4.18	15
	3	85	15	3.93	17

PL-polymer: G – yield of gel fraction; S – output sol fraction; J – the degree of crosslinking; W – Beat organic residue on ignition.

In accordance with [12] the formation of the composite occurs through a series of intermediate stages. In the first stage, the formation of tactoids – polymer surrounds clay agglomerates. In the second stage, the penetration of the polymer in the interlayer space of clay, resulting in a moving displacement of the layers to 2-3 nm. In the third stage, a partial separation of layers of clay and disorientation. At the last stage – exfoliation. In fact, in the product polymer composites may be present all types of the structure, which depends on the distribution of clay in the polymer matrix. In the study of the morphological structure of the gels by using scanning electron microscopy, have been seen some interesting data on the structure of bentonite clay and polymer compositions. Thus, the elemental analysis of SEM photographs of pure bentonite clay (Fig. 1a and 1c), tells about flaky layered structure, within which, basically, are oxides of silicon, aluminum and magnesium, which is also confirmed by the diffraction spectral analysis presented in Table 1. In the picture of composition BC-PHEA, we can see the typical formation of large agglomerates of particles of clay, irregularly dispersed in the matrix. Perhaps this is due to the amorphous state of the gel PHEA which has elasticity (Fig. 1b). To track BC-PAAm (Fig. 1d) is noticeable smooth surface, indicating a uniform distribution of clay particles in the polymer matrix and penetration of monomers in the interlayer space of clay. The dimension of the structural units is in the range 1-20 mm. Polyacrylamide chains not only penetrate the layers of clay, extending the interlayer space, but also contribute to the partial dispersion of the particles with the separation of tactoids layered package of plates, resulting in a composition with an ordered intercalated and exfoliated structure.

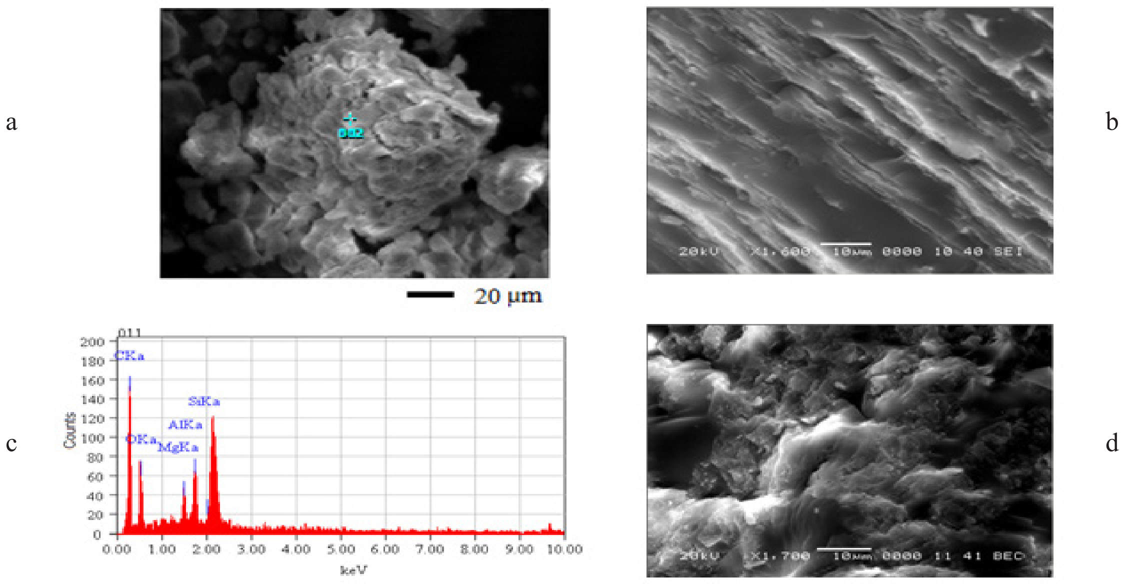
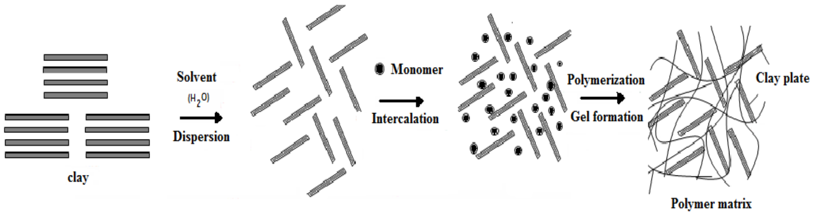


Fig. 1. SEM pictures of surfaces of bentonite clay (a), the composite BC-PHEA (b), spectra of elemental analysis (c) and composite BC-PAAm (d).

In general, the orderly distribution of clay dispersion in the polymer for the study of polymer-clay composite gels BC-PAAm and BC-PHEA can be explained by the fact that the increase in the distance between the silicate platelets (galleries) in the synthesis takes place mainly due to the penetration into the space between the growing polymer chains formed in the synthesis of monomer intercalation. Regarding the composition of the clay poly-2-hydroxyethylacrylate, suggests a weak interaction the polymer macromolecules with intralayer surface of the clay particles and large enveloping their by the polymer chains. Schematically the formation of polymer-clay composite gel can be represented as follows (Scheme 1):



Scheme 1. Formation of polymer-clay composite gel.

Penetrating of the clay component can achieve high permeability and elasticity of polymer composite gels with preservation of adsorption properties and swelling [11]. These attractive properties of polymer-clay composites have been successfully used to create absorbent, stabilizing, and ion-exchange materials. Thus, according to the dependence of the swelling of the BC-PAAm gels with different contents of BC (Fig. 2), the increasing of the mineral content in the initial mixture in the range of 1-9 wt.% reduces the swelling of the gel in water from 30 to 22 g/g. The presence of dispersed clay particles probably favors the deviation from the ideal grid, which, however, does not preclude compliance with the basic laws of the influence of CA on the swelling ability of the compositions. It should be noted that the swelling ability of the composition is intermediate between pure BC and PAAm (with the same amount of crosslinking agent) position. The maintaining of the strength and a relatively small difference in the swelling of the polymer component and composite creates an opportunity to round out the feasibility of the using it as adsorbents and implants in medicine [12]. Stronger contraction of the

BC-PAAm gels observed in saline, i.e. from ~ 22 in water to ~ 13 in saline. Response of compositions to change of conditions of the environment, occurring under the influence of ionic force, no other than the proof of acquisition by gels of polyelectrolytic character at the expense of negatively loaded particles of Si-O of group on a surface of the bentonite clay [19], neutralizing mobile antiions. Approach of extent of swelling of gel testifies to it values of swelling of a composite with not loaded particles at the expense of weakening of osmotic pressure of antiions at addition of chloride of sodium.

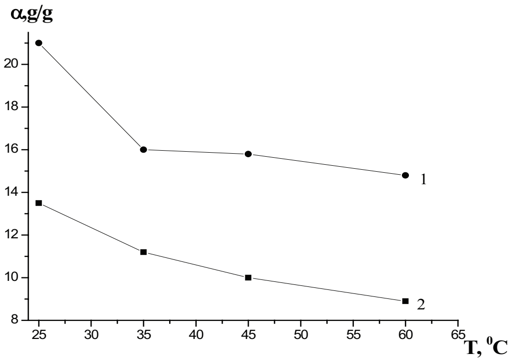


Fig. 2. The relationship between the degree of swelling of composites BC-PAAm content of bentonite clay: 1 – in the water; 2 – in saline; [MBAA] = 0.1 mol.%.

As it appeared, investigated polymer-clay gels of the PAAm and PHEA possess some thermo – and pH-sensitivity (Table 3, Fig. 3). Temperature sensitivity of composition of BC-PHEA is expressed in gel compression at increase in temperature (Fig. 3). In case of composite system of BC-PAAm significant growth in extent of swelling of BC-PAAm gels with increase in temperature is observed. Reduction in the degree of swelling in the case of clay compositions PHEA indicates the prevalence of hydrophobic interactions, in the case of polyacrylamide-clay composition is stabilized mainly by intermolecular hydrogen bonds between the proton-donor groups and proton- acceptor COOH,-C(O) NH_2, PAA and OH groups of bentonite clay, since heating leads to the weakening and breaking of hydrogen bonds, which in turn contributes to the swelling of the polymer network PAAm. Of course, only the hydrogen bonds can not significantly affect the state of the gel, so you should take into account the inherent composition of the cooperative ties.

Table 3 also shows the results of the study the effect of pH and ionic strength of the medium on the swelling of the gomogels PAAm and PHEA and clay compositions. As the table shows, the degree of swelling of PAAm and gomogels PHEA subjected to any change at different pH. For polymer clay compositions observers a decrease of the swelling degree when the pH changes from acid to alkaline medium. Thus, for BC-PAAm gel composition (10:1) ([MBAA] = 0.25 mol.%) the swelling is $\alpha = 22$ g/g at the pH = 1 and $\alpha = 15.9$ g/g at pH = 9. It just goes to show the large contribution of bentonite clay in the formation of the composite gel and its influence on the swelling ability.

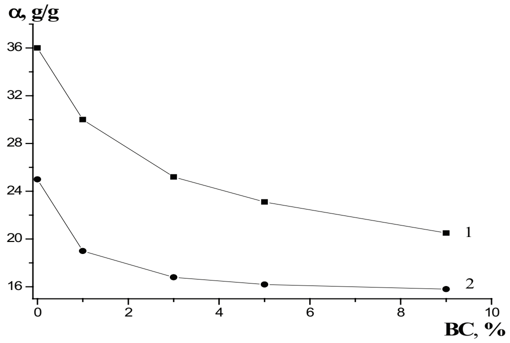


Fig. 3. The relationship between the degree of swelling of composite gels BC PHEA (1:10) on the temperature: 1 – in the water; 2 – in saline; [MBAA] = 0.1 mol.%

Table 3

The dependence of the swelling degree of the gomogels and clay composition of the PHEA and PAAm on the temperature, pH and ionic strength of the medium

H_2O:PL, %		pH				T, ºC				NaCI, M			
		1	3	7	9	25	36.6	45	60	0.1	0.15	0.5	1
[90:10]	PAAm pure	26.2	25.7	25.1	24.7	24.3	25.2	27.1	29.2	27.4	25.6	15.3	11.9
	BC:PAAm, 1:10, %	22.1	17.2	16.8	16.1	22.2	23.5	24.3	25.3	26.9	24.9	14.1	11.3
[90:10]	PHEA pure	22.1	21.6	21.3	20.9	17.3	19.2	22.6	25.4	18.2	17.1	15.2	11.3
	BC: HEA, 1:10, %	21.7	18.3	16.9	15.4	16.2	17.9	21.3	23.6	17.1	16.2	13.3	10.6

Formation of chemically crosslinked compositions BC-PHEA and BC-PAAm by physical bonds was also confirmed by IR spectroscopy (Fig. 4). IR spectrum of the clay as the results of SEM, indicates a low degree of crystalline perfection of the structure. So, at 470-526 cm^{-1}, a rather strong doublet, characteristic of montmorillonite. Absorption band at 915 cm^{-1} is characterized by vibrations of Al-OH. Maximum at 1038 cm^{-1} are due to the asymmetric stretching vibrations of Si-O. The stretching vibrations of structural OH groups are observed in the form of a broad absorption band at 3629 and 3447 cm^{-1}, characteristic OH – groups octahedron and tetrahedron crystalline grate of BC, accordingly. The spectra of the polymer-clay tracks clearly visible characteristic bands related to the original components. Thus, the polymers contain PHEA and PAAm are prone to hydrogen bonding ester and hydroxyl groups (PHEA) and NH_2-groups (PAAm). In the spectrum of composite gels PHEA-BC in the 3600-3000 cm^{-1} are prescribed flat, broad, slightly intense bands characteristic interactions of OH groups of the polymer and bentonite clay, OH groups shifted hydrogen, chelate bonds are written in 2874 and 2921 cm^{-1}. The stretching vibrations of the ester group are written in 1726 cm^{-1} vibration deformational Al-OH groups of clay observed at 916 cm^{-1}, spectra are also characterized by the presence of the absorption bands of asymmetrical bonds Si-O-Si in the 1037 cm^{-1} and bending vibrations Si-O at 671, 585, 475 cm^{-1}. The IR spectra of PAAm-BC tracks a broad band absorption in the 2785 cm^{-1} and 3700 cm^{-1}, characteristic of the stretching vibrations of NH_2 groups of PAAm, shifted to shorter wavelengths as a result of disturbance by hydrogen bonds (Fig. 4). The stretching vibrations of urea bonds are also displaced and are written in 1671, 1490, 1417, 1452 cm^{-1}, C-N bond at 1356 cm^{-1}, C-C aliphatic at 1172, 1119 cm^{-1}. Appear asymmetric vibrations Si-O-Si bonds at 1042 cm^{-1} with a hypsochromic shift of the deformation vibrations of OH and Si-O bonds at 712, 670 cm^{-1}, respectively.

Thus, the results of studies of the swelling capacity, morphology and structure of the obtaining compositions BC-PAAm and BC-PHEA combine the properties of the original components and are characterized by interoperability and uniformity. The mechanism of interaction between the polymer phase system and the filler is very complex and not completely understood, since the formation of such materials is due to compaction of low molecular weight oligomers in the presence of the filler. It turns a strong influence on the supramolecular and the molecular structure of the polymer and the formation of the polymer. The above characteristics of clay compositions PHEA and PAAm provided non-Coulomb nature of their interaction and the formation of polymer-clay composition by hydrogen bonds are stabilized by hydrophobic interactions.

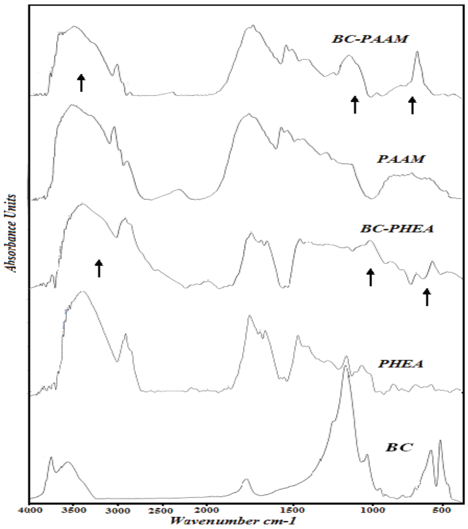


Fig. 4. IR spectra.

Investigation the Laws of Interaction of the Cetylpyridinium Bromide with the Composite Gels

Acquisition by received composition the polyelectrolyte character through the clay mineral and thermally sensetive transferred from polymer components can be regarded as sorbents surfactants. For this purpose, the interaction cetylpyridinium bromide (CPB) with the reviewed composite gels was investigated. Results of the study of swelling behavior of gels in solutions of different concentrations of CPB and temperatures are presented in Table 3. Not difficult to see that low concentrations of CPB increases swelling, that is at a concentration of $1 \cdot 10^{-5}$ M has the highest, and when the concentration of CPB $1 \cdot 10^{-3}$ M the lowest degree of swelling. The cause of this phenomenon, apparently, is to strengthen the Coulomb interaction between charged sorbate and the compositional gel of polyelectrolyte nature. With decreasing the temperature in the solution CPB hydrogen bonds between the composite became weaker, but at the same time it is possible strengthening of hydrophobic interactions, which generally results in an increase in swelling. For example, the swelling ratio of the gel PAAm-BC (10:1 wt.%) at 25 ºC in a solution of the surface-active substance with $C_{CPB} = 1 \cdot 10^{-4}$ mol is 17.6 g/g, and at 60 ºC is 26 g/g twice more.

Table 4

The dependence of the degree of swelling of gomo - and clay composite gels of PAAm and PHEA ([MBAA] = 0.25 mol.%; [PPS] = 1 mol.%) in CPB solution on temperature and the different concentration of the surface-active substance

H_2O:PL, %		C_{CPB}			T, ºC, (C_{CPB} = $1\cdot10^{-4}$ mole)			
		$1\cdot10^{-5}$ mole	$1\cdot10^{-4}$ mole	$1\cdot10^{-3}$ mole	25	36	45	60
[90:10]	PAAm pure	26	24.9	21	24.9	26	28	31
	BC:PAAm, 1:10, %	18.2	17.6	16.9	17.6	22	24	26
[90:10]	PHEA pure	13.5	11.5	9	11.5	12	12.6	13.4
	BC: HEA, 1:10, %	11	8.2	7	8.2	9.5	10.2	11.3

The immobilization of CPB on composite gels was carried out by sorption method and using UV spectroscopy the means of quantitative sorption were obtained (Figs. 5 and 6). With increasing concentration of CPB sorption capacity of composite gels is reduced. If to compare the PAAm gels and PHEA, can be seen that sorption capacity of PHEA less than PAAm. Sorption data are consistent with the swelling. Thus, at a concentration of CPB of $1\cdot10^{-5}$ M, for which there is a higher degree of swelling of the gel the adsorption of surfactant by composites BC-PAAm and PHEA-BC is 68 and 34%, respectively. And at a concentration of CPB of $1\cdot10^{-3}$ M, the same values of sorption – 12 and 6%, respectively. Figure 6 shows the sorption of composition gels on temperature. With decreasing the temperature of the environment and bentonite clay in the composite the sorption capacity is increased. As the temperature increases from 25 to 60 ºC sorption CPB composites PAAm-BC and BC-PHEA from 68.7 and 33.44%, respectively, increased to 75.3 and 42.11%, respectively. Another important point that should be noted according to the study is that the inclusion of bentonite particles and increase of its content in the composites positively contributes sorption ability of composite gels. For example, if the quantitative value of sorption of the composition PAAm-BC (10:1 wt.%) at normal temperature is 68.7%, the sorption of CPB by composite of PAAm-BC (10:3 wt.%) is equal to 74.5%. It and is clear if to consider that in itself bentonite clays are effective adsorbents at the expense of unique structure and to the contents as a part of the active cation-exchange centers. Thus, quantitative characteristics of occluding ability of composites concerning molecules of CPB testify to prospects of these gels as sorbents of cationic surface-active substances.

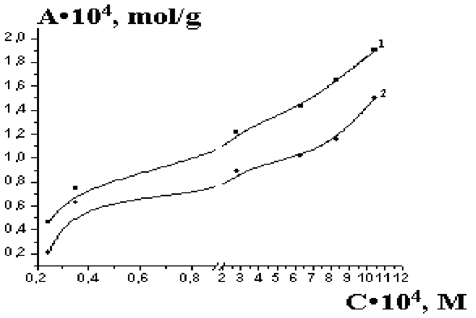


Fig. 5. The dependence of sorption CPB by composite gels on different concentrations of CPB: t = 25 ºC; [MBAA] = 0.25%; [PPS] = 1 mol.%; C_{CPB} = $1\cdot10^{-4}$ mole; BC:PAAm = 10:1 (1); BC:PHEA = 10:1 (2).

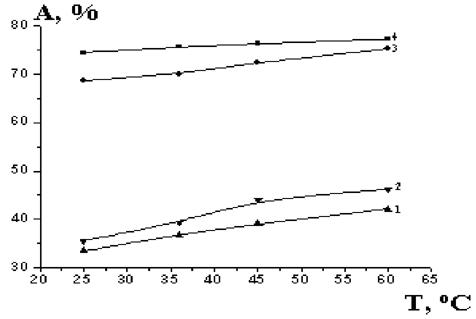


Fig. 6. Dependence of sorption CPB by composite gels on temperature: [MBAA] = 0.25%; [PPS] = 1 mol.%; C_{CPB} = $1\cdot10^{-4}$ mole; BC:PAAm = 10:3 (4); 10:1 (3); BC:PHEA = 10:3 (2); 10:1 (1).

Conclusion

Like this, in the result of synthesis polymer gels PAAm and PHEA with adding domestic bentonite clay by intercalation radical polymerization in presence cross-linked agent, and investigation swelling and sorption characteristic received composites PAAm – BC and PAAm – BC we may distinguish following moments. The process of intercalation promotes forming homogenous composition with scattering clay particles to all volume of polymer gels. However, in dependence from nature of polymer possibly and adhesion particles of clay to tactoids due to surrounding them by hydrophobic polymer (first stage formation of composite), as it observed partly in case composition PHEA – BC and vice versa penetrating of polymer in interlayer space and moving apart layers of clay (second or third stage formation of composite) as in case clay composite more hydrophilic polyacrylamide. Relatively swelling ability present composites one may mark congeniality their with character swelling gomo gels just with several conservative values of swelling degree and presence with polyelectrolyte character, due to presence opposite charged particles of bentonite clay. May expect, that formation of complex occurs because of system of hydro bonds between components of gel, stabilized hydrophobic interactions polymer chains of organic polymer. Possibility of regulation swelling ability of composition gels by changing factors as, compound of composition, condition of intercalation, pH, temperature, ionic strength. Presence and increasing contents of mineral component in composite also increasing temperature of environment considerably improves sorption ability of composition gels in attitude cationic surface active substance cetylpyridinium bromide. Should mark considerably high sorption ability PAAm – BC (~ 80%), apparently, due to high hydrophility. Results of investigations testify about possibility using of composites as sorbents cationic PEAHENS.

References

[1]. Kun Xu, Jihua Wang, Sheng Xiang, Qiang Chen, Wende Zhang and Pixin Wang, Applied Clay Science. 38 (1-2) (2007) 139–145 .

[2]. D.L. Vander Hart, A. Asano and J. W. Gilman, Macromolecules. 34 (2001) 3819–3822.

[3]. R.A. Vaia, W. Liu, J. Polym. Sci., Part B: Polym. Phys. 2002 (40) 1590–1600.

[4]. Se-Hoon Kim, Sang-Hyun Park and Sung-Chul Kim, Polym. Bull. 53 (2005) 285–292.

[5]. Lisa M. Stadtmueller, Kyle R. Ratinac and Simon P. Ringer, Polymer. 46 (23) (2005) 9574–9584.

[6]. Wei'an Zhang, Yu Li, Luo Wei and Yue'e Fang, Mater. Lett. 57 (22-23) (2003) 3366–3370.

[7]. A.M. Akimbaeva Successes and challenges in the polymerization of the monomers on the surface of layered silicates disperstnyh. Trudy Nacional'noj akademii nauk Kazahstana. Himicheskij bjulleten' [Proceedings of National Academy of Sciences of Kazakhstan. Chemical Bulletin] (in Russian). 3 (2003) 84–96.

[8]. S.N. Chvalun, Nature 2007 (2) 25–30.

[9]. D.P. Salo. The use of clay minerals for the preparation of drugs. Doc. Pharm. Sciences. Moscow., 1968. P.38.

[10]. O.V. Evsikova, S.G. Starodubtsev and A.R. Khokhlov. Synthesis, swelling and adsorption properties of composites based on polyacrylamide gel and sodium bentonite. Vysokomolekuljarnye soedinenija [Macromolecular compounds] (in Russian). 44 (5) (2002) 802-808.

[11]. N.I. Avakumova, L.A. Budarina, S.M. Divgun, A. Zaikin, V.E. Kuznetsov and V.F Kurenkov. Workshop on the chemistry and physics of polymers. Chemistry. 1990. P. 304.

[12]. A.K. Mikitaev, A.A. Kaladzhyan, O.B. Lednev and M.A. Mikitaev. Nanocomposit materials based on organoclay. Electronic Journal "Investigated in Russia". 2004. P. 912–921.

[13]. M. Alexandre, P. Dubois, Mater. Sci. Eng. R., 28 (1-2) (2000) 1–63.

[14]. E.K. Lavrentiev, S.G. Starodubtsev, A.R. Khokhlov, V.V. Volkov and K.A. Dembo, Colloid J. 70 (5) (2008) 650–655.

Received 3 March 2014