SYNTHESIS AND PROPERTIES
OF INORGANIC COMPOUNDS

Synthetic Calcium Aluminosilicates and Their Sorption Properties with Respect to Sr²⁺ Ions

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Abstract—Sorption characteristics of synthetic calcium aluminosilicates (CAS) obtained in the multicomponent $CaCl_2$–$AlCl_3$–KOH–SiO_2–H_2O system are presented. The isotherms of Sr^{2+} sorption on CAS from aqueous solutions containing no additional salts were measured for Sr^{2+} concentration from 0.5 to 11.1 mmol/L and solid to liquid phase ratio S : L = 1 : 100. The maximum sorption capacity of synthetic CAS was determined, the phase distribution constants of Sr^{2+} ions at different S : L ratios were found. The recoveries of Sr^{2+} ions from solutions containing 0.01 mol/L $Ca(NO_3)_2$ and from a solution simulating water of the Mayak plant sewage pond No. 11 were determined.

The long-lived isotopes of strontium, ^{89}Sr with a half-life of 50.5 days and ^{90}Sr with a half-life of 28.9 years (with β-particle energy of 0.535 MeV), formed upon ^{235}U nuclear fission under neutron bombardment in nuclear reactors and upon nuclear explosions, are among the most hazardous isotopes spread in the biosphere. This is due to the fact that, after chemical compounds of radioactive strontium get into a human body, even at low solubility products, strontium displaces calcium mainly from the bone tissue upon cation exchange and is accumulated in the bones, resulting in continuous exposure of the body to radiation [1, 2]. Furthermore, not only radioactive strontium isotopes are hazardous for biogenic processes. The uptake of more than 0.8–3 mg of stable strontium isotope per day by the body of an adult human induces so-called "strontium rickets," which is also caused by strontium accumulation in bone tissues [3].

The issues of soil and water purification from stable and radioactive heavy metal isotopes, including Sr^{2+} ions, receive considerable researchers' attention. The range of natural and synthetic sorbents used to remove Sr^{2+} ions from aqueous solutions is fairly broad [4–12]. High efficiency toward sorption of Sr^{2+} ions was demonstrated for calcium silicates of various compositions and structures [13–18]; furthermore, effective sorbents of this class can be obtained from industrial wastes of technology-related deposits containing calcium and silicon compounds [13, 15, 18]. Despite the diversity of already studied sorbents applied for Sr^{2+}
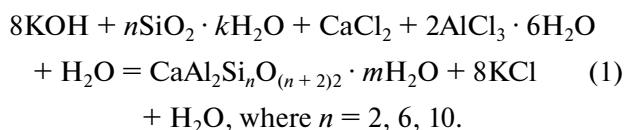
sorption, the search for new methods for the synthesis of sorbents, including calcium aluminosilicates (CAS) and investigation of the sorbent structure, composition, and sorption properties are still in progress. Previously [19–22], we studied the sorption properties of nanostructured aluminosilicates obtained from aqueous solutions in the $AlCl_3$–KOH–SiO_2–H_2O system.

The objective of the present study was to examine the composition, structure, morphology, and sorption properties of CAS with different Al : Si ratios (2 : 2, 2 : 6, or 2 : 10) prepared in the multicomponent $CaCl_2$–$AlCl_3$–KOH–SiO_2–H_2O system for the sorption of Sr^{2+} ions from aqueous solutions of strontium chloride without other salts and from solutions containing various salts.

EXPERIMENTAL

Synthesis of Calcium Aluminosilicates

The starting compounds used to prepare calcium aluminosilicates with specified Al : Si ratios of 2 : 2, 2 : 6, and 2 : 10 were high-purity grade $CaCl_2$, $AlCl_3 \cdot 6H_2O$, and $SiO_2 \cdot nH_2O$ and analytical grade KOH. The reactants were taken in stoichiometric ratios (considering the presumed composition of the anhydrous product) corresponding to the preparation of the aluminosilicates $CaAl_2Si_2O_8 \cdot mH_2O$ **(I)**, $CaAl_2Si_6O_{16} \cdot mH_2O$ **(II)**, and $CaAl_2Si_{10}O_{24} \cdot mH_2O$ **(III)** according to the equation

$$8KOH + nSiO_2 \cdot kH_2O + CaCl_2 + 2AlCl_3 \cdot 6H_2O$$

$$+ H_2O = CaAl_2Si_nO_{(n+2)2} \cdot mH_2O + 8KCl \qquad (1)$$

$$+ H_2O, \text{ where } n = 2, 6, 10.$$

A weighed portion of potassium hydroxide was dissolved in distilled water, and the specified amount of silica was added to the resulting solution preheated to 85–95°C. The solution was kept with continuous stirring until silica completely dissolved (solution 1). Solutions of $CaCl_2$ and $AlCl_3 \cdot 6H_2O$ to be then mixed with solution 1 were prepared in separate vessels. The solutions were mixed with vigorous stirring and maintaining the temperature at 85–95°C. The chemical reaction resulted in a voluminous white-colored precipitate. It is noteworthy that compaction of the precipitate after the synthesis is sharply decelerated with increasing SiO_2 content in the initial system. The precipitates were washed with hot distilled water. Washing was considered to be completed when the test reaction for chloride ions in the wash water was negative. The precipitates were collected on a filter using a Büchner funnel, a white-ribbon filter, and a water-jet pump. The washed precipitates were dried at 105–110°C in a drying chamber for 3 days and stored in a dessicator filled with a prepared silica gel.

Chemical Modification of Calcium Aluminosilicates

All aluminosilicates tend to be chemically modified as a result of cation exchange both during the synthesis and during the subsequent treatment in salt solutions and melts at various temperatures. In the $CaCl_2$–$AlCl_3$–KOH–SiO_2–H_2O system under study, polysilicic acid salts with a specified KOH/SiO_2 ratio were first obtained and then mixed with a solution of calcium and aluminum chlorides. The cation exchange in the system results in a thermodynamic equilibrium determined by the change in the Gibbs energy, which is equal to the difference between the energies of cations interacting with the negatively charged framework of the aluminosilicate and the difference between their hydration energies in the solution and in the aluminosilicate [23].

During this study, we also obtained aluminosilicates from the reactants taken in a stoichiometric ratio according to equation (1) with $n = 2$ but with the subsequent heat treatment in a saturated solution of calcium chloride and in distilled water. The precipitates were washed to remove potassium chloride and collected on filters. Depending on the precipitate heat treatment, the content of calcium compounds in the aluminate varied from 0.3 to 0.5, the potassium content was from 0.005 to 0.3 mol/L, and the aluminum and silicon content and ratio corresponded to the specified values. For the sorption of Sr^{2+} ions, aluminosilicates with the calcium to potassium molar ratio of 1.4 (CAS(I^1)) and 3.8 (CAS(I^2)) were prepared from this series of samples.

Sorption of Sr^{2+} Ions

A solution of strontium chloride with 40 mg/mL concentration of Sr^{2+} ions was prepared by dissolving an exact weighed portion of analytical grade $SrCl_2 \cdot 6H_2O$ in distilled water. Dilution of the resulting solution gave a series of initial aqueous solutions with Sr^{2+} ion concentration of 0.12–11.1 mmol/L.

Sorption experiments were carried out under static conditions at 20°C. To measure Sr^{2+} sorption isotherms from solutions without additional salts, 0.2-g portions of the sorbent were placed into a series of test tubes, 20 mL of aqueous solutions of strontium chloride with different initial concentrations of Sr^{2+} ions (0.5–11.1 mmol/L) were added, and the mixture was stirred on an RT 15 power magnetic stirrer (IKA WERKE, Germany) for 3 h. Then the solutions were separated from the sorbent by filtering through white ribbon filter paper, and Sr^{2+}, Ca^{2+}, and K^+ ion concentrations in the filtrates were determined.

The dependence of the strontium distribution constant (K_d) on the solid to liquid phase ratio (1 : 40, 1 : 100, 1 : 400, 1 : 1000, 1 : 2000, or 1 : 5000) in the sorption of Sr^{2+} ions on CAS from solutions containing no additional salts or 0.01 mol/L $Ca(NO_3)_2$ and from solutions simulating water of the Mayak plant sewage pond No. 11 was elucidated by placing specified weighed portions of the sorbent into a series of test tubes and adding 20 mL of the required solution with initial Sr^{2+} concentrations ranging from 0.12 to 0.33 mmol/L (depending on the particular experiment). To obtain data on the sorption of Sr^{2+} ions under static conditions, solutions simulating water of the Mayak plant sewage pond No. 11 were prepared from aqueous solutions containing a complex mixture of ions. Solution composition, mg/L: Sr^{2+}, 10–12; Ca^{2+}, 100; Mg^{2+}, 75; Na^+, 132; K^+, 15; Cl^-, 82; SO_4^{2-}, 650 [24].

Each series of experiments included a control run in which distilled water and the sorbent were used.

The sorption capacity (A_c, mol/g) of the samples was calculated from the formula

$$A_c = \frac{(C_{init} - C_{eq})}{m} V, \qquad (2)$$

where C_{init} is the initial concentration of Sr^{2+} ions in the solution, mmol/L; C_{eq} is the equilibrium concentration of Sr^{2+} ions in the solution, mmol/L; V is the solution volume, L; m is the sorbent mass, g.

The recovery of ions (α, %) was calculated from the formula

$$\alpha = \frac{(C_{init} - C_{eq})}{C_{init}} \times 100\%. \qquad (3)$$

The phase distribution constant (K_d, mL/g) was determined in the following way:

$$K_d = \frac{(C_{init} - C_{eq})V}{C_{eq}m}. \qquad (4)$$

Methods of Analysis

The elemental composition of CAS was determined by energy dispersive X-ray fluorescence spectroscopy on an EDX-800HS spectrometer (Shimadzu, Japan). Analysis neglecting light elements was carried out using the spectrometer software. The relative composition determination error was ±2%.

The content of water of crystallization in the obtained calcium aluminosilicates was determined from the difference between the sample masses after drying to a constant mass at 110°C and after annealing up to 900°C.

The X-ray diffraction patterns of the samples were collected in a D8 ADVANCE automated diffractometer with sample spinning in CuK_α-radiation. Powder X-ray diffraction analysis was carried out using the search software EVA and the powder diffraction data bank PDF-2.

IR spectra were measured in the 400–4000 cm^{-1} range on a Shimadzu FTIR Prestige-21 FT IR spectrometer at room temperature. The samples were triturated in an agate mortar down to a finely dispersed state and were applied on a KRS-5 glass substrate as mineral oil mulls.

The specific surface area of CAS samples was determined by low-temperature nitrogen adsorption on a Sorbtomer-M instrument.

The morphological characteristics and the elemental composition of samples in local volumes were investigated using a Hitachi S5500 high-resolution scanning electron microscope equipped with an attachment for scanning transmission microscopy and a Thermo Scientific energy dispersive spectrometer.

The contents of Sr^{2+}, Ca^{2+}, and K^+ ions in the filtrates after sorption were determined by atomic absorption method on an AA-Solaar Samsung spectrometer in flame using the analytical lines at 460.7, 422.6, and 766.5 nm, respectively. The limits of detection in aqueous solutions were (μg/mL): 0.002 for Sr, 0.0005 for Ca, and 0.002 for K.

The sorption of strontium from solutions simulating water of the Mayak plant sewage pond No. 11 was investigated by the method of radioactive indicators. The activity of solutions containing ^{90}Sr was 3×10^4 Bq/L. The degree of decontamination was determined from the difference between the ^{90}Sr concentrations in the solution before and after sorption. The content of radionuclides in the solution was found by β-spectrometry using a TRI-CARB, model 2910 TR, liquid scintillation spectrometer (Germany). With known V/m ratio, the distribution constant was calculated from t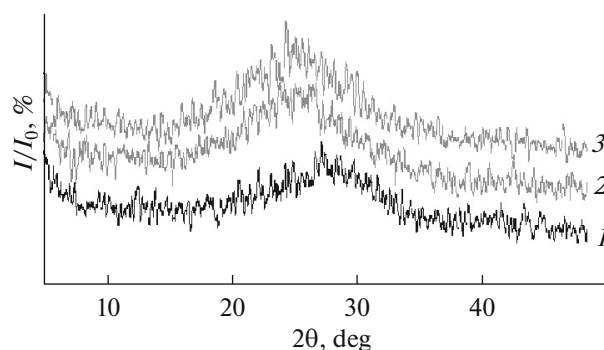he distribution of radionuclides between the solid and liquid phases by the formula $K_d = (A_S/A_L)(V/m)$, where A_S and A_L are the radionuclide contents in the solid and liquid phases, respectively; V is the volume of the liquid phase, mL; m is the sorbent mass, g.

Fig. 1. X-ray diffraction patterns of calcium aluminosilicates: (*1*) CAS(**I**), (*2*) CAS(**II**), (*3*) CAS(**III**).

Characteristics of the Synthesized Potassium Aluminosilicates

As mentioned in the Experimental, the reactants in the $CaCl_2$–$AlCl_3$–KOH–SiO_2–H_2O system were initially taken in a stoichiometric ratio calculated for the specified calcium aluminosilicate: $CaAl_2Si_2O_8 \cdot mH_2O$ (**I**), $CaAl_2Si_6O_{16} \cdot mH_2O$ (**II**), or $CaAl_2Si_{10}O_{24} \cdot mH_2O$ (**III**). Determination of the elemental composition showed the following contents of elements in the obtained CAS, wt % (mol):

CAS(**I**): Si, 31.4 (1.12); Al, 29.3 (1.08); Ca, 22.5 (0.56); K, 16.8 (0.43);

CAS(**II**): Si, 61.2 (2.18); Al, 20.0 (0.74); Ca, 5.8 (0.14); K, 13.0 (0.33);

CAS(**III**): Si, 63.1 (2.25); Al, 12.7 (0.47); Ca, 8.2 (0.2); K, 16.0 (0.41).

It follows from the obtained data that the Al : Si ratio in the samples corresponds to the specified ratio (2 : 2; 2 : 6; 2 : 10) but the total amount of the calcium and potassium cations (their total charge) indicates that calcium aluminosilicates are not a single phase. They can contain both aluminosilicates and calcium and aluminum silicates. Water of crystallization was found in the CAS: $3H_2O$ for CAS(**I**) and $4H_2O$ for CAS(**II**) and CAS(**III**).

According to powder X-ray diffraction data, the obtained CAS contained only X-ray amorphous phases (Fig. 1). It follows from the presented X-ray diffraction patterns that the interplanar spacing (*d*, Å) for aluminosilicates varies in the series: **I** < **II** < **III** (3.2200 < 3.5344 < 3.5432), which is indirect evidence for the formation of compounds with different unit cell parameters depending on the Al : Si ratio. The X-ray
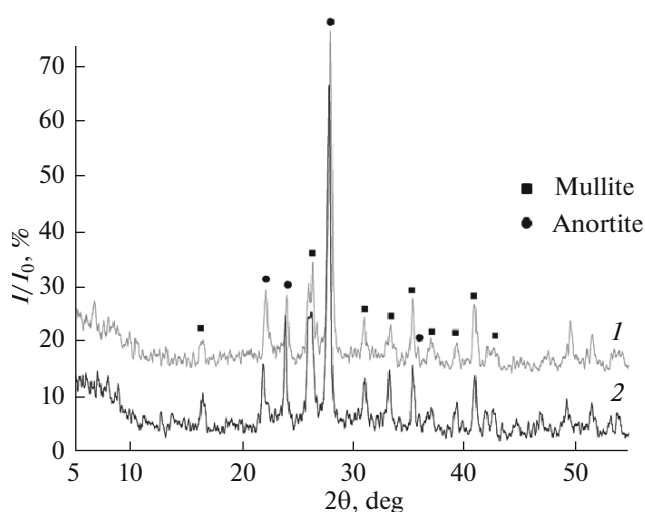
Fig. 2. X-ray diffraction patterns of calcium aluminosilicates after annealing at 1100°C for 5–6 h: (*1*) CAS(**I**), (*2*) CAS(**I^1**).

diffraction patterns of samples after annealing at 920°C for 4 h were found to contain peaks for aluminum hydroxide and aluminum silicate Al_2SiO_5 against the background of amorphous peak in the 15°–35° range of angles. After annealing of samples (whether or not they contained an alkaline metal) at 1100°C for 5–6 h, the X-ray diffraction patterns exhibited peaks for the crystalline phase of anortite ($CaAl_2Si_2O_8$) of the triclinic system (with unit cell parameters: $a = 8.173$, $b = 12.869$, $c = 14.165$, $\alpha = 93.13°$, $\beta = 115.913°$, $\gamma = 91.261°$) and peaks corresponding to the mullite phase ($Al_{2.4}Si_{0.6}O_{4.8}$) of the orthorhombic system (with the crystal cell parameters: $a = 7.583$, $b = 7.681$, $c = 2.6854$, $\alpha = \beta = \gamma = 90°$) (Fig. 2).

Figure 3 presents the IR spectra of CAS(**I**), CAS(**II**), and CAS(**III**). According to [25–27], the intense IR absorption bands at 850–1100 cm^{-1} refer to Si–O–Si and Al–O–Al stretching vibrations, while the low-frequency bands at 450–600 cm^{-1} are due to the Si–O–Si and Al–O–Si bending vibrations. As the Si/Al ratio in aluminosilicates increases, the absorption maximum assigned to the Si–O stretching mode shifts to higher frequencies: 1010.7 cm^{-1} for CAS(**I**), 1056.99 cm^{-1} for CAS(**II**), and 1064.71 cm^{-1} for CAS(**III**) (Fig. 3). This shift can be a consequence of increasing lattice energy of calcium aluminosilicates following increase in the Si/Al ratio [28]. The presence of water in CAS is confirmed by fairly intense absorption peak in the frequency range of 3000–3800 cm^{-1} typical of stretching vibrations involving hydrogen [26]. The absorption bands at 1600 cm^{-1} are caused by bending modes of water.

The specific surface areas of the CAS samples (**I**, **II**, **III**) determined by multipoint BET method were 83 ± 5.0, 90 ± 5.0, and 121 ± 5.0 m^2/g, respectively; i.e., the increase in the Si/Al ratio leads to increase in the specific surface area of the synthesized samples.

According to scanning electron microscopy data (Fig. 4), there are no morphological differences between the samples; they all are nanostructured systems analogous to synthetic aluminosilicate synthesized and studied previously [19] and have a multilevel porous structure with pore sizes of up to hundreds of nm and block size of up to ten nm.

Sorption of Strontium on CAS

Figure 5 shows the sorption isotherms of Sr^{2+} ions from strontium chloride solutions without additional salts. As can be seen from Fig. 5, the sorption capacity decreases on going from sample **I** to sample **III**. However, it should be noted that the recovery of Sr^{2+} ions from aqueous solutions at low concentration (below 1 mmol/L) remains constant (95–99.7%) to within the measurement error.
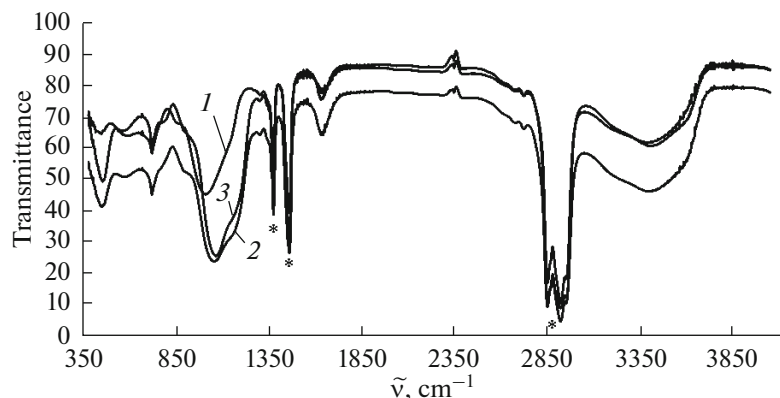

Fig. 3. IR spectra of CAS samples: (*1*) CAS(**I**), (*2*) CAS(**II**), (*3*) CAS(**III**). * Are vaseline peaks.
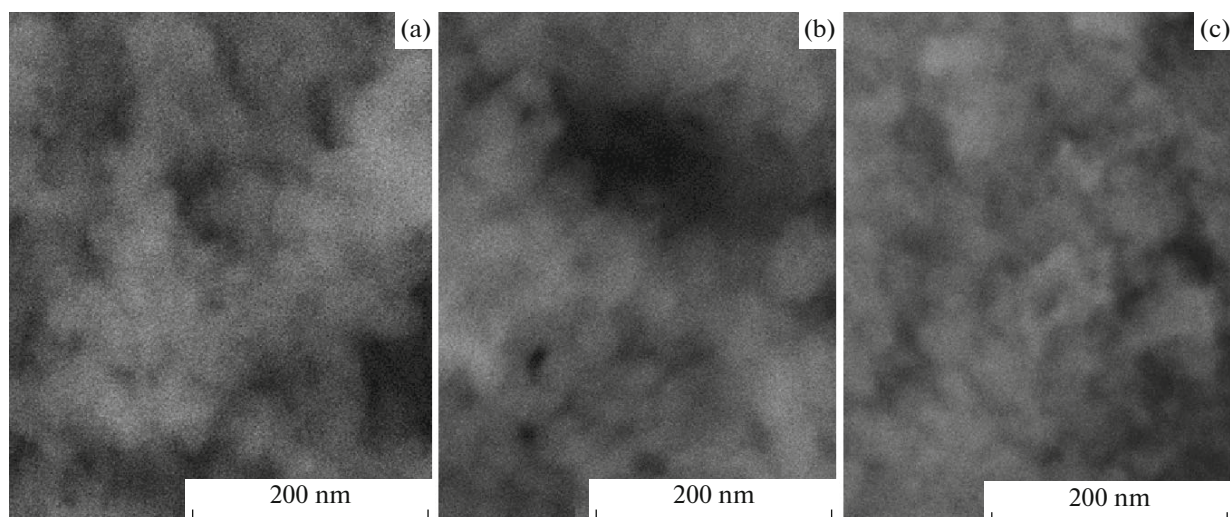
Fig. 4. Scanning electron microscopy images of microparticles of CAS samples recorded using the scanning transmission microscopy attachment: (a) CAS(**I**), (b) CAS(**II**), (c) CAS(**III**).

For evaluating the sorption properties of the CAS samples, the isotherms were analyzed in the corresponding coordinates of the Langmuir equation

$$\frac{C_{eq}}{A_c} = \frac{1}{A_m k} + \frac{C_{eq}}{A_m}, \text{ (I)}$$

where C_{eq} is the equilibrium concentration of Sr^{2+} ions in the solution, mmol/L; A_m is the maximum sorption capacity, mmol/g; k is the Langmuir constant, L/mmol.

The parameters of the Langmuir equation were found to be: $k = 2.85$ L/mmol for all samples and the maximum sorption capacity A_m of 0.22 for CAS(**I**), 0.18 for CAS(**II**), and 0.13 mmol/g for CAS (**III**).

From the obtained data, it can be concluded that increase in the SiO_2 content in the aluminosilicate (for CAS(**III**), Al : Si = 2 : 10) leads to a slight decrease in the sorption capacity.
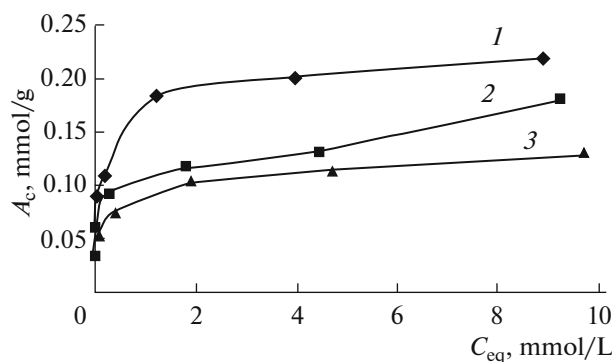
As in the case of synthetic nanostructured potassium aluminosilicate [22], the equilibrium concentration in the sorption of Sr^{2+} ions from chloride solutions on CAS at 20°C under static conditions is achieved in several minutes.

The data on sorption of Sr^{2+} ions on aluminosilicates containing different amounts of calcium and potassium ions, CAS(**I¹**) and CAS(**I²**), are summarized in Table 1. It follows from the table that, irrespective of the calcium and potassium ratio in calcium aluminosilicates, the recovery of Sr^{2+} ions is high, being at least 92−97% for Sr^{2+} concentration of up to 1 mmol/L. The sorption capacity of aluminosilicate with elevated calcium content (CAS(**I²**)) is higher than that of CAS(**I¹**) at Sr^{2+} concentrations in the solution of >2.5 mmol/L (Fig. 6). For the aluminosilicate with a higher content of potassium ions, note an increased ratio of the concentrations of potassium ions to cal-
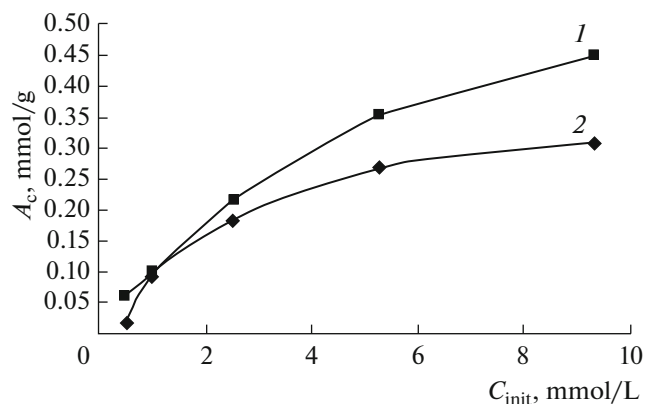

Fig. 5. Sorption isotherms of Sr^{2+} ions on synthetic aluminosilicates: (*1*) CAS(**I**), (*2*) CAS(**II**), (*3*) CAS(**III**).

Fig. 6. Sorption isotherms of Sr^{2+}: (*1*) CAS(**I²**), (*2*) CAS(**I¹**).

Table 1. Sorption capacity of CAS(I^1, I^2) samples as a function of Sr^{2+} concentration in the solution (H_2O stands for control solutions without the strontium salt)

No.	Sr^{2+} concentration in the initial solution, mmol/L	Sr^{2+} equilibrium concentration in the solution, mmol/L	Ca^{2+} concentration after sorption, mmol/L	K^+ concentration after sorption, mmol/L	A_c, mmol/g	Recovery, %
			CAS(I^1)			
1	0.52	0.01	0.17	1.2	0.05	98.1
2	1.01	0.08	0.44	1.5	0.1	92.1
3	2.56	0.72	0.61	1.94	0.18	71.9
4	5.29	2.62	1.4	2.24	0.2	50.5
5	9.32	6.16	3.03	2.42	0.3	33.9
6	H_2O	0.006	0.02	0.39		
			CAS(I^2)			
7	0.52	0.02	0.4	0.57	0.05	96.2
8	1.01	0.07	0.8	0.75	0.1	93.1
9	2.56	0.49	1.8	0.98	0.2	81.0
10	5.29	1.81	3.1	1.13	0.35	65.8
11	9.32	4.71	4.1	1.34	0.45	49.5
12	H_2O	0.05	0.1	0.29	–	–

Table 2. Distribution constant K_d for the extraction of Sr^{2+} ions from aqueous and salt solutions on CAS (**I**, **II**, **III**) as a function of the S : L ratio

S : L	No salts			In the presence of salts		
	Sr^{2+} equilibrium concentration, mmol/L	K_d, mL/g	recovery, %	Sr^{2+} equilibrium concentration, mmol/L	K_d, mL/g	recovery, %
	CAS(**I**), Sr^{2+} concentration of 0.31 mmol/L; 0.32 mmol/L for solutions with additional salts					
1 : 40	0.018	639	94.2	0.11	74	62.5
1 : 100	0.021	1405	93.2	0.16	103	50.0
1 : 400	0.047	2249	84.8	0.27	80	15.6
1 : 1000	0.095	2232	69.4	0.3	73	6.3
1 : 2000	0.131	2552	57.7	0.31	94	3.1
1 : 5000	0.19	3017	38.7	–	–	–
	CAS(**II**), Sr^{2+} concentration of 0.33 mmol/L; 0.34 mmol/L for solutions with additional salts					
1 : 40	0.001	16348	99.7	0.174	60	48.8
1 : 100	0.004	7645	98.8	0.199	72	41.5
1 : 400	0.032	3702	90.3	0.254	137	25.3
1 : 1000	0.097	2431	70.6	0.291	177	14.4
1 : 2000	0.147	2513	55.5	0.298	293	12.4
1 : 5000	0.189	3622	42.7	0.296	792	12.9
	CAS(**III**), Sr^{2+} concentration for both solutions of 0.30 mmol/L					
1 : 40	0.001	12477	99.7	0.06	163	80.0
1 : 100	0.002	14122	99.3	0.122	147	59.3
1 : 400	0.004	27454	98.7	0.212	165	29.3
1 : 1000	0.014	20176	95.3	0.259	163	13.7
1 : 2000	0.043	11909	85.7	0.268	235	10.7
1 : 5000	0.084	13176	72.0	0.295	117	1.7

* The $Ca(NO_3)_2$ concentration is 0.01 mol/L.

Table 3. Distribution constant K_d for sorption of Sr^{2+} ions from solutions simulating water of the Mayak plant sewage pond No. 11 on CAS (**I**, **II**, **III**) on the S : L ratio

No.	S : L	Sr^{2+} equilibrium concentration, mmol/L	K_d, mL/g	Recovery, %

No.	S : L	Sr^{2+} equilibrium concentration, mmol/L	K_d, mL/g	Recovery, %
CAS(**I**), Sr^{2+} concentration of 0.12 mmol/L				
1	1 : 40	0.018	221	85.0
2	1 : 100	0.04	206	66.7
3	1 : 400	0.079	199	34.2
4	1 : 1000	0.06	246	50.0
5	1 : 2000	0.114	106	5.0
CAS(**II**), Sr^{2+} concentration of 0.139 mmol/L				
6	1 : 40	0.032	132	77.0
7	1 : 100	0.052	166	62.6
8	1 : 400	0.074	344	46.8
9	1 : 1000	0.1	379	28.1
10	1 : 2000	0.107	570	23.0
CAS(**III**), Sr^{2+} concentration of 0.144 mmol/L				
11	1 : 40	0.019	262	86.8
12	1 : 100	0.032	353	77.8
13	1 : 400	0.066	471	54.2
14	1 : 1000	0.092	559	36.1
16	1 : 2000	0.11	671	23.6

cium ions displaced to the solution. The distribution constants K_d for S : L ratios of 1 : 40 and 1 : 100 were 176 and 838 mL/g, respectively, for CAS(**I**[1]) and 176 and 745 mL/g, respectively, for CAS(**I**[2]); i.e., no substantial differences were observed. For the calcium aluminosilicates CAS(**I**[1]) and CAS(**I**[2]), the recovery of Sr^{2+} ions from a solution simulating water of the Mayak plant sewage pond No. 11, at S : L = 1 : 100, determined by radioactive indicator method was 90–90.5% and K_d = 980, which was twice as high as the values for the extraction of these ions by natural aluminosilicates [24].

For CAS (**I**, **II**, **III**), data on the dependence of K_d for the extraction from aqueous solutions with Sr^{2+} concentration in the range of 0.3–0.33 mmol/L with no additional salts and in the presence of 0.01 mol/L $Ca(NO_3)_2$ in the solution are summarized in Table 2. As can be seen from the table, the presence of 0.01 mol/L $Ca(NO_3)_2$ reduces the degree of Sr^{2+} extraction approximately twofold when S : L = 1 : 100 and severalfold for higher S : L ratios. The CAS(**III**) sample is inferior to CAS(**I**) or CAS(**II**) in the maximum sorption capacity but provides higher K_d values.

Table 3 presents the data on the recovery of Sr^{2+} ions on CAS(**I**), CAS(**II**), and CAS(**III**) from a solution of complex ionic composition simulating water of the Mayak plant sewage pond No. 11 and the distribution constants K_d depending on the S : L ratio for Sr^{2+} concentration in the 0.12–0.14 mmol/L range, calculated from the results of atomic absorption spectroscopy measurements of Sr^{2+} concentrations before and after sorption. As can be seen from the table, sorption of Sr^{2+} ions from solutions with a complex salt composition is characterized by lower recovery of Sr^{2+} ions and lower distribution constants K_d.

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