



Fig. 10. Ready-assembled oil filter (on the left) and filter element

#### REFERENCES

1. Evstigneev V.V., Isaeva Zh.M., Prolubnikov V.I., Tubalov N.P. Estimating the efficiency of using cermet filters for technical liquid purification // Polzunovskii Vestnik. – 2005. – № 1. – P. 322.
2. Evstigneev V.V., Novoselov A.A., Prolubnikov V.I., Tubalov N.P. Simulation of treatment process of exhaust gases of chemical industries and diesel aggregates from solid particles by SHS-filters // Bulletin of the Tomsk Polytechnic University. – 2005. – V. 308. – № 1. – P. 138.

2. To unify cylindrical filters they are recommended to be produced with wall thickness of 10...12 mm and to complete different filters both in chemical industry and in transport only of dimension sizes of filter cermet catalytic blocks depending on consumption of exhaust gases.
3. Cylindrical filter elements made of SHS-materials possess sufficient filtering properties. The carried out analysis allowed selecting samples of porous materials which trap solid particles with the size from 5 mkm and larger possessing specific capacity equal to  $10^{-3} \text{ m}^3/(\text{m}^2\cdot\text{s})$ . These samples may be used for fine purification of both water and oil liquids from solid impurities. Change of thickness of filter element walls from 4 to 7 mm results in increasing hydraulic resistance of porous samples from 8 to 14,2 kPa at specific liquid consumption  $4\cdot 10^{-3} \text{ m}^3/(\text{m}^2\cdot\text{s})$ .

3. Evstigneev V.V., Kolesnikov D.V., Prolubnikov V.I., Tubalov N.P., Schetinkina N.Yu. The technique of determining hydraulic resistance of porous SHS-materials // Polzunovskii Vestnik. – 2005. – № 2. – P. 277.
4. Tubalov N.P., Lebedeva O.A., Vereschagin V.I. Porous composition ceramic materials obtained by self-propagating high-temperature synthesis in the system  $\text{F}_2\text{O}_3\text{-Al}_2\text{O}_3\text{-Al}$  // Novye Ogneupory. – 2003. – № 9. – P. 40.

Received on 14.11.2006

UDC 54.058:553.611.6

### EFFICIENCY OF USING EAST KAZAKHSTAN NATURAL SORBENTS IN WATER PURIFICATION FROM IONS OF HEAVY METALS ( $\text{Cu}^{2+}$ )

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*Sorption properties of bentonite clays of East Kazakhstan have been studied by the example of model solutions containing ions of copper ( $\text{Cu}^{2+}$ ). The mechanism of exchange and degree of ion extraction from solutions were established.*

It is known that the efficient sorbent for heavy metal ions is synthetical resin ions (cations) possessing high exchange capacity of sorption. However, there is no industrial production of ionites in Republic of Kazakhstan and their import from foreign countries is non-value-added. Natural materials possessing considerably lower exchange capacity in comparison with cations but rather cheaper than ionites may be the alternative. It is in East Kazakhstan where there are rich deposits of bentonitic clays (Taganskoe deposit) which are useful for extracting ions of heavy metals and production of which does not require great material costs as their accessibility and comparatively low price (local material) are not the least of the factors.

Bentonitic clays consist of minerals of montmorillonite group divided into alkaline and alkaline-earth differences. Minerals of montmorillonite group form bentonitic formations characterized by presence of montmorillonite minerals and minerals close to them by crystal structure such as beidellite; high dispersity of mineral particles, exchange complex and high colloidal properties are typical for them. Bentonites were formed as a result of volcanic ash decomposition at change of micas, chlorites and rockforming minerals in the process occurring in hydrothermal conditions. Depending on composition of exchange complex there are alkaline (sodium and calcium-sodium) and alkaline-earth (calcium, magnesium-calcium, calcium-magnesium) ben-

tonites. This difference is conditioned by features of crystal structure of smectites owing to which bentonites possess many specific properties the most valuable of which is ion-exchange ability [1].

Bentonite refers to clay natural materials possessing high sorptive ability relative to metal cations and may be used for developing barrier insulant in places of burial of toxic wastes including radioactive ones as well as for purification of drinking and waste waters. The keyword parameter determining possibility of using bentonite as filter material is concentration of heavy metals in water after filter and diffusive properties of bentonite. By scientific literature data these characteristics depend both on heavy metal solubility and bentonite sorptive properties. There are scientific literature data on mechanisms of cation sorption, role of different binding sites, equilibrium constants of proper reactions. The aim of this work was to study sorption of ions of metal Cu(II) by bentonite.

Thorough investigations showed that clays meet all requirements and they are unique in high content of exchangeable ions of Na, fineness and swelling capacity in water.

Bentonites of Taganskoe deposit are divided into alkaline and alkaline-earth by their chemical composition that is cations of sodium and calcium serve as exchangeable cations [2].

Bentonite of 14<sup>th</sup> horizon of Taganskoe deposit EKR (Kazakhstan) was used in the experiments; its basic mineral composition was determined by the method of RFA. It was ascertained that the base of mineral composition of preparation is montmorillonite – clay mineral of layer structure. Roentgen-phase analysis was carried out by ASTM file for preparation diagnostics. Among the obtained experimental values of interplanar spacing  $d_i$  the strongest were selected by line intensity and compared by values  $d_i$  of substances (compounds) put out by the program of ASTM identification. After specified approximate chemical composition of samples the program of ASTM put out information on these elements. Among the compounds those ones were selected whose intensive lines coincided with lines of our samples.

Laminated and laminated-belt aluminum-iron-magnesium silicates are divided into minerals with expanding and hard structure. The first ones (vermiculite and montmorillonite) are the base of bentonitic clays. They have primary microporous structure conditioned by structure of silicate microcrystal composing them, and secondary «lamellar microporous», transition- and microporous structure occurring due to the space between microcrystals. At sorption the secondary porous structure is capable of expanding owing to increase of micropore sizes. These sorbents possess significant capacity relative to polar substances (water, alcohols, amines) which achieves double value of cation-exchange capacity [3].

Montmorillonite turns out very often to be the most efficient clay material for water purification from different organic impurities. Montmorillonite surface area reaches 766...833 m<sup>2</sup>/g.

Mechanism of impurity sorption from water on clay minerals is rather complicated and includes wandervals interactions of hydrocarbon chains with the developed surface of silicate microcrystals and electrostatic interaction of charged and polarized molecules of sorbate with positively charged areas of sorbent surface containing ions of H<sup>+</sup> and Al<sup>3+</sup>.

All sorption experiments were carried out in glass containers. To study sorption of Cu(II) the thermal activation at 200 °C and acid one by 20 % solution of sulfuric acid were preliminary carried out. Before sorption experiment the preparations were left in acid solution for 4 h at repeating stirring for activation.

To segregate mother solution from bentonite the compact filter paper with blue band was used.

Bentonite treatment with 20 % sulfuric or hydrochloric acids gives partial removal of magnesium, calcium, aluminum and iron oxides. Similar treatment increases active area of surface in 2...10 times while in this case an average efficient size of sorbent pores increases in 2...4 times. Acid properties of the surface of activated bentonite clays promote chemical adsorption of nitrogen-, oxygen-, sulfur-containing compounds on it. The higher the cation-exchange capacity of a mineral the more efficient, as a rule, its use for water clarification and purification.

Clay minerals possess ability to sorb cations in exchangeable manner. The exchangeable ions usually remain at external parts of base units [4].

Vermiculite and montmorillonite possess the highest absorptive capacity of all clay materials (8...150 mg-equ/100 g), hydrated halloysite (40...50 mg-equ/100 g), the lowest – coaginite (3...15 mg-equ/100 g).

Usually, ions of calcium, magnesium, sodium, potassium, aluminum, hydrogen may occur as exchangeable ions. The ability of retaining in adsorbed state is the higher the more the valence and radius of ion and the less the degree of its hydration. Clay minerals are capable of containing in them rather large quantity of water [5].

Cation sorption by bentonite occurs both by the mechanism of ion exchange (exchange with cations being in inter-packet spaces of montmorillonite) and by formation of complex compounds. Depending on mechanism of cation binding both sorption kinetics and its dependence on pH and ionic strength should differ considerably. It was ascertained that sorption equilibrium in alkaline medium is achieved more rapidly in comparison with acidic medium.

To achieve the aim the investigations with model solutions were firstly carried out and after positive results the experiments with sewage waters were carried out. After adding batch of thermal-acid-activated sorbent (TAAS) with mass 1 and 2 g into 250 ml bulbs with 100 ml of model solutions, the solutions were settled 4 h till achieving sorption equilibrium and were filtered through folded filter. The obtained filtrate was tested at atomic-adsorption spectrometer «KVANT-AFA».

The object of investigation is to study the possibilities of using bentonitic clay of different modification for purification of sewage water of GKP «Øskemen-Vodokanal» from heavy metal ions in static mode. Alkaline bentonite of the 14<sup>th</sup> horizon of Taganskoe deposit of VKO was tested as a sorbent. The best results were obtained at use of preliminary thermally treated acid-activated bentonite (Table 1–3).

**Table 1.** The results of investigation of model solution  $\text{Cu}(\text{NO}_3)_2$

Batch mass, g	$\text{Cu}^{2+}$ concentration in a sample, mg/dm <sup>3</sup>		The degree of extraction, $\alpha$ , %
	In model solution	After contact with TAAS	
1	0,005	$1,15 \cdot 10^{-3}$	77,00
2	0,005	$0,8 \cdot 10^{-3}$	84,00

**Table 2.** The results of investigation of sewage water contacting with TAAS before purification at GKP «Øskemen-Vodokanal»

Batch mass, g	$\text{Cu}^{2+}$ concentration in a sample, mg/dm <sup>3</sup>		The degree of extraction, $\alpha$ , %
	In model solution	After contact with TAAS	
1	0,21	0,04	80,95
2	0,21	0,02	90,47

The results given in the Table before and after purification of sewage waters at GKP «Øskemen-Vodokanal» from heavy metal ions ( $\text{Cu}^{2+}$ ) with bentonitic clay

in thermal-acid-activated form show that at batch mass of 1g the degree of copper extraction amounts to 77...95 % and at mass of 2 g – 84...96 %.

**Table 3.** The results of investigation of sewage water contacting with TAAS after purification at GKP «Øskemen-Vodokanal»

Batch mass, g	$\text{Cu}^{2+}$ concentration in a sample, mg/dm <sup>3</sup>		The degree of extraction, $\alpha$ , %
	In model solution	After contact with TAAS	
1	0,006	0,0054	90,00
2	0,006	0,0057	96,00

According to all these data the conclusion may be made: application of thermal-acid-activated bentonite (thermally activated at temperature 120 °C – 4 h with further treatment by 20 % sulfuric acid – 4 h) in purification supports practically complete extraction of copper ions. Copper ion content in sewage water contacting with TAAS does not exceed the norm of MPC after purification at GKP «Øskemen-Vodokanal».

1. It was ascertained that copper ions interact with bentonite by mechanism of ion interaction that is its extraction with bentonite is impossible. The degree of extraction increases depending on bentonite mass.
2. Bentonite colloidal particles play significant part in copper ion binding.

## REFERENCES

1. Klyayev V.I., Slisarenko F.A. Structure of adsorbents and methods of its studying / Physicochemical investigation of natural sorbents and a series of analytic systems. – Saratov: Saratov university Press, 1967. – P. 5–11.
2. Ovcharenko G.I. Natural mineral sorbents. – Moscow: Vysshaya Shkola, 1960. – 371 p.
3. Sudnikovich V.G., Lebedev V.T. Sewage water purification by natural zeolites // Tsvetnye Metaly. – 1984. – № 9. – P. 90–91.
4. Distanov U.G., Mikhailov A.S., Konyukhov P.P. USSR natural sorbents. – Moscow: Nauka, 1990. – 208 p.
5. Batalova Sh.B. Physicochemical bases of obtaining and applying catalysts and adsorbents from bentonites. – Alma-Ata: Nauka, 1986. – 168 p.

Received on 14.11.2006