

Investigation of the sorption properties of synthetic layered double hydroxides of variable composition for the protection of water bodies from organic and inorganic pollutants

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Abstract – The work was to investigate the adsorption of both anions and cations of inorganic as well as organic pollutants on anionic clays belonging to the class of layered double hydroxides. In addition, methods were developed for the safe disposal of spent sorbents. Were investigated the kinetics of ion exchange for the anionic and cationic forms of chromium, sulfide ions, phenols. The physical-chemical properties of layered double hydroxides – composition, structure, basic were investigated. The physical-chemical properties of layered double hydroxides – composition, structure, basic were investigated.

Keywords– layered double hydroxides, adsorption, pollutants, anionic and cationic forms of chromium, sulfide ions, phenols, sorbents.

Introduction

Water basins located near the steel mills, mines, chemical plants are contaminated with toxic substances. The content of heavy metals, sulfides, phenols, toluene, formaldehyde, naphthalene series compounds and other potent substances is much higher than the maximum permissible concentration.

Most of the existing water purification methods require the use of scarce reagents that alter its physical and chemical composition, and the increase in salinity is harmful to living organisms.

For wastewater treatment using various methods, one of which is the adsorption using various adsorbents, the most common of which are activated carbons. However, these sorbents are expensive and their use is limited. Besides, there are problems with the disposal of sorbents absorbed contaminants.

Sorbents which would be absorbed at once both organic and inorganic substances, of both cationic and anionic type have not found wide practical application.

The aim of work was to investigate the adsorption of both anions and cations of inorganic as well as organic pollutants on anionic clays belonging to the class of layered double hydroxides. In addition, methods were developed for the safe disposal of spent sorbents [1].

Layered double hydroxides (LDHs) are products of the isomorphous substitution of the metal cation hydroxide cations higher oxidation. Isomorphous substitution of Mg^{2+} ions by Al^{3+} in the rod leads to an excess of positive charge, and thus to the basic properties, so LDH are solid bases. Bronsted main sites in these compounds may be a hydroxyl, localized at the tetrahedral aluminum. Lewis basic centers are the lone pair of electrons of oxygen.

The presence of the main sites of the Bronsted and Lewis type of process allows anion exchange in the inner space of LDH. Anion exchange process is an equilibrium, equilibrium shift the concentrations of anions and selective sorbents to certain anions. The greatest selectivity LDH show respect to carbonate anions.

The specific surface area and porosity of LDHs allow us to estimate the study of matter in terms of their effectiveness and suitability as sorbents.

In the thermal effects at temperatures above 500 °C is an irreversible dehydration to form spinel structures. This is a feature of layered double hydroxides are extremely important for their use as adsorbents of toxic anions.

Heat treatment can link them into insoluble compounds and disposed of without fear of the return of the desorption process under the action of external conditions, it is possible for conventional adsorbents such as activated carbons, and more. During the heat treatment the formation of new oxide phases.

When heat treatment is not only weight loss but changes and distribution sites strength.

Sorption removal of chromate-ions. Hexavalent chromium ions CrO_4^{2-} and $\text{Cr}_2\text{O}_7^{2-}$ pollutants are encountered in industrial wastewater. They can be extracted from the waste water by ion exchange with using LDHs and, furthermore, may be safely disposed of.

The adsorption capacity of sorbents studied in the reaction of chromate ions with CrO_4^{2-} LDHs of different composition.

Kinetic parameters of the ion exchange, the concentration of absorbed chromate ions in the aqueous phase after adsorption spectrophotometry with using diphenylcarbazide. The experimental results showed that the sorption rate varies in direct proportion to the concentration of injected sorbent.

Since LDH are the products of isomorphic substitution , they have a number of acidic and basic sites. The main sites in the LDHs and the processes taking place on them , discussed above. However, due to the statistical distribution of the isomorphic substitution are present both basic and acidic sites. Acid sites are local domains in which the metal cation is surrounded by cations with a higher degree of oxidation.

The main factor determining the number of acid sites and their strength is the degree of isomorphic substitution of metal cations , in this case the substitution of Al^{3+} ions by Mg^{2+} in the $\text{Al}(\text{OH})_3$. Therefore , you can always calculate the degree of isomorphic substitution , resulting in a maximum number of acid sites on the surface of LDH.

Kinetic studies were carried out sorption processes chromium (Cr^{3+}) by weight of the sorbent.

The activation energy was determined by performing the reaction at different temperatures: $E = 11.5 \text{ kJ/mol}$. The resulting value of the activation energy indicates that the reaction occurs in the diffusion region.

To determine the kinetic parameters of the process were carried out kinetic studies of sorption. Sorption sulfide ions layered double hydroxides in the CSTR was performed with periodic sampling , the concentration of sulfide ions was determined spectrophotometrically .

Were determined by calculation of the rate constant of the first order sorption of sulfide ions with different masses of the sorbent [2].

The resulting dependence of the kinetic sorption says the first order in the mass of the sorbent. To change the weight of sorbent at the concentration of active centers in the volume of solution used for dynamic capacitance values of LDH that are defined in terms of dynamic equilibrium.

To determine the activation parameters of sorption of sulfide ions were investigated on LDHs leakage of ion exchange at different temperatures. Were determined rate constants sorption of sulfide ions at various temperatures.

The resulting value of the activation energy indicates that the reaction proceeds in the diffusion region, but considerably closer to the kinetic area than other sorbents investigated , suggesting high acidity sulfide ions.

We have thus shown that the LDHs sorbents for the effective removal of sulfide ions from the liquid phase.

Sorption removal of the phenols

Since phenol is an acid , the reaction is represented by anion exchange takes place almost completely and irreversibly. In addition, phenol is a strong organic acid and ion exchange process takes place very quickly [3].

We investigated the adsorption capacity of the sorbent with varying degrees of isomorphous substitution in the reaction with phenol. Using this data were calculated the rate constants for adsorption of phenol sorbents with different molar ratio of Mg/(Mg+Al).

To determine the activation parameters sorption phenols LDH leakage was studied ion exchange at different temperatures.

By calculation were determined rate constants of adsorption of phenol at different temperatures .

Conclusion

1. The physical-chemical properties of layered double hydroxides – composition, structure, basic were investigated.

2. In the resulting investigations have shown that the sorption capacity is determined by elemental composition, structure, internal space.

3. We were investigated the kinetics of ion exchange for the anionic and cationic forms of chromium, sulfide ions, phenols.

4. The work was shown a difference in the behavior of layered double hydroxides during the sorption of organic compounds by ion-exchange mechanism and physical sorption and shows patterns of confirming speculation about changes in the structure of layered double hydroxides during the sorption of the compounds of the naphthalene series.

References

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