

EXTRACTION OF ALUMINUM COMPOUNDS FROM ALUMINUM-RICH BENTONITE CLAYS.

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Abstract. This article presents information on bentonite clay, its types, and deposits. It examines the physicochemical properties of bentonite clay and the production of aluminum sulfate coagulant from local aluminosilicates, as well as its use in the national economy. A technology for producing aluminum sulfate coagulants from kaolin and bentonites from aluminum silicates is presented. Information on bentonites in Uzbekistan, Russia, and abroad is also provided.

Key words: bentonite clay, types, physical and chemical properties, deposits, coagulant, aluminum sulfate, national economy application, complex mineral, alkaline bentonites, montmorillonites, nanofiltration, aluminum silicate.

Currently, global production of aluminum sulfate, the most common coagulant, is growing annually. It is widely used in industrial applications such as treating industrial and wastewater, water treatment, the pulp and paper industry, and in leather tanning and fabric dyeing. Therefore, providing various industries with effective coagulants is a key task for the chemical industry. Coagulants not only improve wastewater treatment efficiency but are also widely used to purify drinking water intakes, thermal power plants, and industrial water supplies. Therefore, providing enterprises with high-quality coagulants is a priority for Uzbekistan's chemical industry.

Bentonite clays are named after the port of Benton, located in the state of Wyoming (USA), where the first industrial mining began in the late 19th century. Subsequently,

interest in bentonite clays increased significantly, and deposits have been discovered on almost every continent.

Bentonite clays (bentonites) are finely dispersed clays consisting of at least 60-70% montmorillonite group minerals, possessing high binding capacity, adsorption, and catalytic activity. Bentonites also contain mixed-layer minerals, hydromica, polygorskite, zeolites, kaolinite, and other impurities.

Bentonite is a complex mineral, the composition of which is determined by the content of montmorillonite in the clay, which has the formula $\text{Si}_8\text{Al}_4\text{O}_{20}(\text{OH})_4\text{xnH}_2\text{O}$, where silicon can be replaced by various cations (aluminum, iron, zinc, magnesium, calcium, sodium, potassium, etc.).

The world's largest reserves of bentonite are located in China, with about 15% in the United States and 7% in Turkey. Other countries with bentonite reserves include Greece, Russia, France, India, Turkey, Azerbaijan, Georgia, and Armenia. Most deposits in all countries contain alkaline earth bentonites, while high-quality alkaline bentonites are limited in distribution and are concentrated in volcanogenic-sedimentary and hydrothermal-metasomatic deposits.

A number of alkaline earth bentonite clay deposits have been discovered in the Russian Federation: Lyubinskoye in Western Siberia, Podsinskoye in Eastern Siberia, Zyryanskoye in the Kurgan region, and others. All of them formed in freshwater lakes, in a reducing, slightly alkaline or neutral environment with a pH of 7-8. Bentonites from these deposits are characterized by relatively low quality, a lower montmorillonite content (on average 60-70%), and a relatively higher admixture of sandy-silty material than in bentonites of the marine subtype. They are also sometimes distinguished by increased calcareous content.

Geologists have discovered over 200 occurrences of bentonite and bentonite-like clays in Uzbekistan, with preliminary exploration reserves estimated at over 2 billion tons. High-quality clay formations were extensively formed during the Jurassic, Cretaceous, and Paleogene periods. Currently, only the Navbahor, Azkamar, Kattakurgan, Lagon, and Shorsu deposits are being developed on an industrial scale.

The total amount of bentonite clays mined and processed from these deposits currently amounts to only 30,000–40,000 tons per year.[1]

Bentonites are finely dispersed clay formations composed of aluminosilicates consisting of 80–90% well-crystallized dioctahedral montmorillonite with admixtures of mixed-layer clay minerals and celadonite-glaucanite mica. Typical paragenetic minerals include agate, chalcedony, zeolites, cristobalite, rock crystal, amethyst, and sulfide minerals (galena, chalcopyrite, sphalerite, and pyrite).

Bentonites are formed by hydrothermal metasomatism of subintrusive, effusive, and volcanogenic-sedimentary rocks, particularly andesite-basalt porphyry, liparite- and trachyte-basalt tuffs, and ashes. The qualitative diversity of the resulting bentonites depends on both the composition of the parent rocks and the composition and temperature of the thermal waters. The most favorable conditions for the transformation of volcanic glasses into montmorillonite were created by low (50–220°C) and moderate (200–300°C) thermal fluid temperatures and their high alkalinity (pH = 9–10).

Bentonites, confined to humid and arid metagenetic zones, are subdivided into marine and continental (freshwater-lacustrine). Structurally, they are confined to platform regions. They formed during periods of reduced tectonic activity.

In terms of quality, these bentonites are inferior to those of the hydrothermal-metasomatic and volcanogenic-sedimentary types. However, they are high-quality molding raw materials in foundries, used to produce drilling fluids and high-grade expanded clay, and, when activated and upgraded, can be successfully used as adsorbents and catalysts in the petrochemical and food industries, agriculture, and elsewhere.

Alkaline bentonites are characterized by high swelling capacity, colloidal, plasticity, and the highest possible binding capacity for clays. They are primarily classified as high-quality raw materials used in many industries.

Alkaline earth bentonites are characterized by lower hydrophilicity and binding capacity. They are generally inferior in quality to alkaline bentonites and, in their natural state, are of limited use in some industries.

Bentonites possess high binding capacity, adsorption, and catalytic activity. Clays with a smaller, but predominant, content of montmorillonite are called bentonite-like [2].

The problem of purifying natural and industrial wastewater from suspended and colloidal-dispersed substances, using coagulants and flocculants, has made it possible to rationally solve the issue of complex processing of mineral raw materials, significantly increase water resources, involving new sources of water supply in economic activity, thanks to the creation and implementation of technological schemes with closed water circulation.

When purifying water from suspended solids, significant difficulties arise due to the small particle size and the high aggregation and sedimentation stability of the system. Intensification of these processes can often be achieved by coarsening the particles in aggregates under the influence of coagulants and flocculants, and especially their mixtures.

The use of more effective new coagulants, the development of technologically rational schemes that facilitate maximum separation of phases of dispersed systems, and the reduction of the cost and consumption of reagents are current and important problems.

Iron and aluminum salts, used as coagulants in water purification, are capable of hydration, forming a flocculent sediment that entrains suspended solids and bacteria. Aluminum-containing coagulants are the most widely used in our country and abroad. Aluminum sulfate, used for this purpose, is obtained primarily from aluminum hydroxide, which is an expensive reagent. In physicochemical water purification, coagulants based on iron and aluminum salts are most widely used. A disadvantage of iron salts as coagulants is the need for careful dosing, as improper dosing leads to iron ions leaking into the purified water. These disadvantages can be largely eliminated by

adding aluminum salts. Using a mixed coagulant significantly reduces the risk of iron salt overdosage, which leads to a significant reduction in the residual iron content in the purified water. The iron oxide content in the solution increases the amount of free sulfuric acid, with a slight increase in aluminum recovery. Requirements for aluminum sulfate strictly regulate the content of iron compounds and sulfuric acid [3].

Iron-containing water (especially groundwater) is initially clear and clean in appearance. However, even with brief exposure to atmospheric oxygen, the iron oxidizes, giving the water a yellowish-brown color. At iron concentrations above 0.3 mg/dm³, such water can cause rusty streaks on plumbing fixtures and stains on laundry. At iron concentrations above 1 mg/dm³, the water becomes cloudy, takes on a yellowish-brown color, and has a characteristic metallic taste. All this makes such water practically unsuitable for both industrial and drinking use.

Excess iron in water contributes to the development of many diseases. This element can accumulate to toxic levels in organs and tissues, including the joints, liver, endocrine glands, and heart. Iron can create a breeding ground for harmful microorganisms and malignant tumor cells, and also further stimulate the carcinogenic effects of free radicals.

If the total iron content in the body exceeds 15 g, internal organs are damaged. This condition is called hemochromatosis. Iron stimulates the oxidation of "bad" cholesterol, which leads to the progression of atherosclerosis and, secondarily, coronary heart disease. Iron also contributes to the development of skin diseases, dermatitis, and allergic reactions. Excess iron in the body increases the risk of heart attacks, and prolonged consumption of iron-containing water has a negative impact on reproductive function.

Iron toxicity is caused by mechanical damage and asphyxiation of fish and eggs due to the precipitation of iron hydroxide flakes or a reduction in the oxygen in the water required for the oxidation of ferrous iron. In an acidic environment, iron ions penetrate tissue and act independently as toxins.

In this regard, it is necessary to improve the methods and means of purifying water from iron. Effective but expensive methods can be used: reverse osmosis, nanofiltration, electrocoagulation, and others. However, the economic situation of many economic entities in the Russian Federation limits the resource capacity for implementing environmental protection activities. In this regard, it is necessary to implement effective methods of wastewater (WW) treatment that do not require large financial investments and do not have a negative impact on the natural environment. Therefore, for the treatment of WW contaminated with iron ions, it is promising to use industrial and agricultural waste as reagents, in particular, WW from petrochemical enterprises [4].

The pulp and paper industry consumes large quantities of natural water. Delignification, pulp transport, bleaching, and web casting processes are all performed in water. Water is used in the production of electricity, steam, and for auxiliary purposes. The industry has strict water quality requirements, as the extensive surface area and porosity of pulp fibers create conditions for the sorption of water impurities. The presence of organic and iron compounds in the water causes the pulp to acquire a yellow tint. Mineral impurities affect the strength, electrical conductivity, and photosensitivity of the produced paper. [5]

The production and export of finished products through the rational use of local raw materials is of great economic importance. The Republic of Uzbekistan possesses large reserves of various minerals, such as the Angren kaolin deposit, where reserves exceed 0.45 billion tons, with an aluminum oxide (Al_2O_3) content of 19-25%. Currently, this kaolin is enriched and partially used in the production of ceramic products. To increase the whiteness (up to 80%) of ceramic products, bauxite with a high aluminum oxide (Al_2O_3) content imported from the Russian Federation is added to the pre-enriched Angren kaolin (in quantities of up to 20%). However, the quality of the manufactured products does not fully meet international standards. In addition to kaolin ores containing Al_2O_3 , our Republic also has clays with reserves amounting to several billion tons (for example, montmorillonites of the Fergana Valley). The raw material

contains low levels of aluminum compounds (13-18% Al_2O_3), while its iron content (2-6% Fe_2O_3), which is harmful in ceramic production, is elevated, limiting its potential for rational use. In our country, no work has yet been conducted on the targeted use of aluminosilicates for industries other than ceramics. The authors of this article are conducting research on developing a technology for producing aluminum sulfate salts using sulfuric acid treatment of Angren kaolin and montmorillonites, which are common in the Fergana Valley. Aluminum sulfate salts are widely used as a coagulant in water treatment plants, as a chemical binder in the pulp and paper industry, in the furniture industry, in leather finishing, and as a filler in the textile industry.

The technology for producing a coagulant - aluminum sulfate from bentonite is as follows: raw materials containing bentonite are burned in a furnace; during the combustion process, the volatile fraction is separated and the crystalline structure of bentonite changes; after combustion, the cake is fed to a reactor, where it is decomposed by a 60% solution of sulfuric acid at 80-90 ° C for 1 hour; the mixture is heated due to the heat of reaction; in order to maintain the temperature at a given level, the mixture is stirred and superheated steam with a temperature of 110 ° C is fed there; the resulting hot pulp is fed to the second stage of the process, the reactor-neutralizer; recycled water and steam with a temperature of 110 ° C are fed there to dilute the solution; excess sulfuric acid is neutralized by feeding chalk $CaCO_3$ and carbon dioxide; during the neutralization process, iron compounds precipitate, which leads to an improvement in the quality of the product; the pulp after neutralization is filtered, the precipitate is washed with water at a temperature of 60 ° C; The filtrate and solution after the first wash are fed into the evaporator; the filtrate after the second wash of the sediment acts as a recirculating solution to maintain the ratio between the liquid and solid phases at a given level; by cooling the solution in the crystallizer after evaporation, the finished product is obtained - aluminum sulfate salt; the sludge formed after washing is recommended for use in the production of building materials [6].

The process of producing coagulants from kaolin clays differs little from the process of producing products from bentonite clays. When processing bentonite clays, we

pre-fire the raw materials to increase the yield of useful components. Firing bentonite clays is a crucial step in producing aluminum sulfate coagulants. Calculations have shown that industrial enterprises and water treatment facilities in the Republic require 100,000 tons of aluminum sulfate coagulant annually. Meeting the Republic's demand for aluminum sulfate by establishing a production technology from local raw materials will reduce its cost by a factor of three compared to the price of coagulant currently imported from abroad. This will also help conserve the Republic's hard currency reserves.

Conclusion. Thus, the implementation of technology for the production of coagulant from local aluminosilicates and the integrated use of the resulting waste is cost-effective and environmentally beneficial.

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