

## Adsorption Capacity of Nanosized Fibrous Aluminum Oxide

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### Abstract

The ability of oxide-hydroxide samples made from water oxidizing nanosized electroexplosive aluminum to adsorb has been investigated. It is demonstrated that the samples contain non-fibrous phases of various hydroxides and oxides as well as  $\text{AlO}(\text{OH})$  nanofibers. Specific surface area ( $400 \text{ m}^2/\text{g}$ ), the percentage of micro- and mesopores on the surface (about 90%), the pH of the isoionic state (7.7), which corresponds to a positive potential on the surface, and the exchange capacity for  $\text{H}^+$  and  $\text{OH}^-$ , which is the same for both ions and  $3.18 \text{ mmol/g}$ , indicate that the sample's entire surface is involved in the exchange, were all measured. For a variety of compounds comprising  $\text{As}^{3+}$ ,  $\text{As}^{5+}$ ,  $\text{Cr}^{6+}$ , and  $\text{Ni}^{2+}$ , adsorption isotherms were developed, and the influence of adsorption on pH was identified. It is demonstrated that  $\text{As}^{3+}$  is adsorbed as nickel -  $\text{Ni}^{2+}$ , chromium-chromate, and dichromate ions as well as molecules of the corresponding acid,  $\text{As}^{5+}$  -  $\text{H}_2\text{AsO}_4$ . The maximal capacity for anions was found to be rather low, at around  $0.12 \text{ meq/g}$ , and for  $\text{Ni}^{2+}$ , at  $0.24 \text{ meq/g}$ , which is consistent with ion adsorption occurring solely on the sample's outer surface and in its macropores.

### Keywords:

adsorption capacity; nanoscale alumina; fibrous alumina; aluminium oxide; oxide-hydroxide samples; water oxidation; electroexplosive aluminum; nanofibers; non-fibrous phases; hydroxides; oxides; specific surface area; micropores; macropores; isoionic state; positive potentials; surfaces; exchange containers; ions; exchange; isotherms; adsorption; substances; molecules; acids; maximum capacities; anions; samples.

By combining electroexplosive aluminum nanopowder with water, nanosized aluminum oxide was produced [5].  $\text{Al}(\text{OH})_3$  makes for around 60% of the sample that was obtained in this way (wt.). The

sample was then calcined for two hours at 400 °C. The calcined sample possesses up to 60% (wt.)  $\text{AlOOH}$  and up to 20% (wt.)  $\text{-Al}_2\text{O}_3$ , with the remainder being bayerite and  $\text{-Al}_2\text{O}_3$ , according to X-ray phase analysis. A 400  $\text{m}^2/\text{g}$  specific surface area was present in the powder that was harvested for investigation right away [2]. The adsorption of  $\text{H}^+$  and  $\text{OH}^-$  was investigated in order to determine the acid-base characteristics of the active surface centers of nanosized alumina. To achieve this, several amounts of  $\text{HCl}$  and  $\text{NaOH}$  solutions were made, and the pH of each solution was determined using an I-160 ion meter, with a pH accuracy of 0.02. Then, sections of 100 mL solutions with various pH values were filled with 50 mg of  $\text{Al}_2\text{O}_3$ . It was decanted, filtered, and the pH was once again measured after one hour of stirring. Three measurements are averaged to get each point. The study's findings demonstrated that the interaction of  $\text{HCl}$  and  $\text{NaOH}$  with an  $\text{Al}_2\text{O}_3$  solution in water exhibits a distinctive S-shaped connection between equilibrium and starting pH. The exchange or adsorption of  $\text{H}^+$  and  $\text{OH}^-$  from the solution is what causes the line to veer off course. Three isoionic sites for alumina have been identified with pH values of 2.1, 7.8, and 12.2. The following approach was followed during static mode sorption to measure the sorption capacity of nanosized alumina with regard to  $\text{Cr(VI)}$  and  $\text{Ni(II)}$  ions. Model solutions with varying amounts of  $\text{Cr(VI)}$  and  $\text{Ni(II)}$  ions were put into beakers containing the same quantity of sorbent (50 mg). A magnetic stirrer was used to agitate the mixture for five minutes, after which it was left to sit for an hour. The solution was then filtered via a paper filter to assess its residual concentration of  $\text{Cr(VI)}$  and  $\text{Ni(II)}$  ions. Photocolorimetric analysis was used to evaluate the concentrations of  $\text{Cr(VI)}$  and  $\text{Ni(II)}$  ions using diphenylcarbazide and dimethylglyoxime, respectively [4]. The maximum sorption capacity of nanosized aluminum oxide with regard to  $\text{Cr(VI)}$  and  $\text{Ni(II)}$  ions was calculated based on the observed sorption isotherms and was found to be 6.3  $\text{mg/g}$  and 7.5  $\text{mg/g}$ , respectively.

Solutions were created with pH ranges from 2 to 11, but with the same concentration of  $\text{Cr(VI)}$  and  $\text{Ni(II)}$  ions, in order to explore how sorption of these ions is affected by pH. Dependences A (amount of adsorbed  $\text{Cr(VI)}$  and  $\text{Ni(II)}$  ions, in  $\text{mg/g}$  on pH) were displayed. The obtained results demonstrated that the sorption capacity for  $\text{Cr(VI)}$  ions increases with decreasing pH of the solution, and the maximum sorption of  $\text{Cr(VI)}$  ions is observed in the pH range 2-3. In contrast, the sorption capacity for  $\text{Ni(II)}$  ions increases with increasing pH, and the maximum value of the sorption capacity is reached in the pH range of 9–10.

The identical quantity of  $\text{Cr(VI)}$  and  $\text{Ni(II)}$  ions were added to solutions with pH ranges of 2 to 11, and dependencies A (the amount of adsorbed  $\text{Cr(VI)}$  and  $\text{Ni(II)}$  ions, in  $\text{mg/g}$  from pH) were built. The obtained results demonstrated that the sorption capacity for  $\text{Cr(VI)}$  ions increases with decreasing pH of the solution, and the maximum sorption of  $\text{Cr(VI)}$  ions is observed in the pH range 2-3. In contrast, the sorption capacity for  $\text{Ni(II)}$  ions increases with increasing pH, and the maximum value of the sorption capacity is reached in the pH range of 9–10. As a result,  $\text{Al}_2\text{O}_3$  nanopowder may be used to make filters for home water purifiers and as a possible sorbent for the removal of

Cr(VI) and Ni(II) ions from aqueous solutions of diverse compositions.

The characteristics of the finished product are described as a mix of bulk aluminum oxide's characteristics and the particular characteristics of the nanostructure.

Aluminum oxide nanoparticles have the following characteristics:

- Small particle/fiber diameter (2–10 nm)
- High specific surface (>100 m<sup>2</sup>/g)
- The material's surface contains significant flaws and the nanoparticles' structure is unique (volume and size of pores, degree of crystallinity, phase composition, structure and composition of the surface - the possibility of modification)

Nanoscale aluminum oxide fiber characteristics:

length-to-diameter ratio of roughly 20,000,000:1

significant fiber orientation

Ineffective fiber interaction

surface pores absent

High surface OH group concentration

Powdered Alumina at Nanoscale

reducing aluminum oxide powder to nanometer-sized particles (for example, 10-50 nm). For instance, utilizing grinding media smaller than 0.1 microns in a planetary mill

Under conditions of quickly achieving a decomposition temperature of 175 °C and applying a pressure of 5 bar for this for thirty minutes, chemically newly produced AlOOH or Al(OH)<sub>3</sub> decomposes to alumina. The size of the resultant nanooxide particles decreases with the speed at which the breakdown temperature of aluminum hydroxo compounds is attained.

The ability of oxide-hydroxide samples made from water oxidizing nanoscale electroexplosive aluminum to adsorb has been investigated. It is demonstrated that the samples contain non-fibrous phases of various hydroxides and oxides as well as AlO(OH) nanofibers. Specific surface area (400 m<sup>2</sup>/g), the percentage of micro- and mesopores on the surface (about 90%), the pH of the iso-ionic state (7.7), which corresponds to a positive potential on the surface, and the exchange capacity for H<sup>+</sup> and OH<sup>-</sup>, which is the same for both ions and 3.18 mmol/g, indicate that the entire surface of the sample was involved in the exchange. Adsorption isotherms have been established for a number of compounds comprising As<sup>3+</sup>, As<sup>5+</sup>, Cr<sup>5+</sup>, and Ni<sup>2+</sup>, and the dependency of adsorption on pH has been identified. It is demonstrated that As<sup>3+</sup> is adsorbed in the form of nickel Ni<sup>2+</sup>, chromium

chromate, and dichromate ions,  $\text{As}^{5+}$   $\text{H}_2\text{AsO}_4$  molecules of the corresponding acids. According to research, anions have a maximum capacity of approximately. The highest capacity for anions was found to be at 0.12 meq/g, while for  $\text{Ni}^{2+}$  it was around 0.24 meq/g, which is consistent with the adsorption of ions exclusively on the sample's outer surface and in its macropores. Aluminum electroblasting at nanoscales produced oxide-hydroxide samples, and their adsorption capacity has been studied. The presence of nanofibers  $\text{AlO}(\text{OH})$  and non-fibrous phases of hydroxides and oxides in the samples has been shown. Measurements were made of the specific surface area (400  $\text{M}^2/\text{gr}$ ), the surface portion of the micro- and mesopores (about 90%), the pH of the isotonic condition (7.7), which corresponds to the positive potential on the surface, and the volume capacity for  $\text{H}^+$  and  $\text{OH}^+$ , which is the same for both ions and is, in turn, compatible with the occurrence of the entire surface sample in the exchange process. For a variety of compounds including  $\text{As}^{3+}$ ,  $\text{As}^{5+}$ ,  $\text{Cr}^{6+}$ , and  $\text{Ni}^{2+}$ , isotherms of the adsorption have been established, and the dependency of the adsorption on pH has been identified. It has been demonstrated that  $\text{As}^{3+}$  adsorbs as molecules in the corresponding acid,  $\text{As}^{5+}$   $\text{H}_2\text{AsO}_4$  chrome-chromate, and as nickel  $\text{Ni}^{2+}$  ions in biochromate.  $\text{Ni}^{2+}$  had a maximum capacity of 0.24 milliequivalent/gr while anions had a maximum capacity of roughly 0.12 milliequivalent/gr.

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