

Oxidation/absorption of arsenite in groundwater using ozono/activated carbon from coconut shell charcoal

Abstract

Oxidation of As(III) to As(V) with ozone was investigated in groundwater sample containing 0.5 mg L⁻¹ at pH 10.0 with ozone doses of 1.3g L⁻¹ during 30min for the ozone reaction with more than 90% efficiency. The pH of the solution was an important parameter in the rate of oxidation. The absorption process was carried with two commercial activated carbon sources, one from wood and the other from coconut shell at different pH's. Coconut shell charcoal showed greater efficiency for the adsorption of As (V) as compared to wood charcoal. This is because coconut shell charcoal has better adsorptive characteristics such as pore size, surface area and surface functional groups. Using 187.4mg of ozone for the oxidation of 0.1mg of As(III) the oxidation process reaches the 99% of efficacy. At pH 5.0 with initial concentration of 0.5mg L⁻¹ of As(V) and a contact time of 240 min reaches an efficiency of 90% of arsenic removal.

Keywords: Arsenic; Oxidation; Ozone; Absorption; Activated carbon; Coconut shell; Water treatment

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Laura María Acevedo Afanado, María Rita Valladares Rodríguez, Clementina Rita Ramírez Cortina, Erasmo Flores Valverde, Manuel Soriano-García

Departamento de Química de Biomacromoléculas, Instituto de Química, Universidad Nacional Autónoma de México, México

Correspondence: Soriano-García M, Departamento de Química de Biomacromoléculas, Instituto de Química, Universidad Nacional Autónoma de México, UNAM, Delegación Coyoacán, Ciudad de México 04510, Tel 5255-5622 4569, Fax 5255 5616 2217, Email Soriano@unam.mx

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Introduction

Arsenic (As) is a ubiquitous element present in various compounds throughout the earth's crust. Contamination of the environment with arsenic from both natural and anthropogenic sources is widespread, occurs in many parts of the world and may be regarded as a global issue. It is widely distributed and mainly transported in the environment by water. Arsenic can impact human health through the ingestion of surface and ground water used for water supply. Chronic arsenic poisoning occurs in many countries, in which the arsenic concentration is up to 2mg L⁻¹.^{1,2} There is several removal techniques of arsenic widely used such as ion exchange, adsorption in activated carbon from different natural sources, reverse osmosis, coagulation with conventional iron and aluminum salts such as ferric chloride and aluminum sulfate/filtration, lime precipitation, selective membrane methods, absorption onto metal oxides or hydroxides in fixed-bed filters, oxidation with ozone/filtration, and various biological approaches. Each method has its advantages and disadvantages, and individual water treatment plant may choose the method that best suits their financial and managerial situations. In all above techniques follows the preoxidation that converts As(III) to As(V), which has a higher adsorption towards many adsorbents.³ The most characteristic chemical properties of ozone are its strong oxidizing and high standard redox potential according to the reaction conditions. It is strong oxidizing nature and its tendency to transfer an O atom with coproduction of O₂.⁴ In some cases, free radicals are formed from the ozone oxidation. The free radicals propagate themselves through the mechanisms of elementary steps to yield hydroxyl radicals. These hydroxyl radicals are extremely reactive with any organic and inorganic compounds.^{5,6} This reports presents the rates of oxidation of naturally occurring As(III) in groundwater samples in the presence of ozone. Coupling of arsenic oxidation to an absorption reaction process using carbon activate from coconut shell. The results obtained from this study should serve as bases in developing an effective methods to remove toxic As(III) from groundwater supplies.

Materials and methods

To generate ozone a continuous oxygen flux enters the ozone generator and makes the ozone under an electric discharge. Ozone flux production by the generator follows the 2350E method describe in the Standard Methods for the Examination of Water and Wastewater 22nd edition. For an ozonation method to be effective, the gas must be dissolved in a 2% of potassium iodine solution during five minutes, then 10mL of 2N sulfuric acid is added and the solution is valorized with 0.1N of sodium thiosulfate. The ozone concentration can be estimated by the amount of sodium thiosulfate used. The reaction produced potassium iodide with an iodine release. As(III) and As(v) were separated by using Dowex resin (Chloride form) its activation was performed by using acetic acid. The resin allowed As(III) to pass through it, but completely retained the As(V). The effects of ozone application rate, pH of the reaction (5, 7 and 10), oxidation of As(III) to As(v) performance by using an atomic absorption spectrophotometer GBC 932 A.A instrument equipped with the generation of hydrides. Two types of granulated activated carbon were provided by the CLARIMEX Company. (1) Activated carbon Type VG 6x20 and (2) Activated carbon from coconut shell Type CG 1000 12x40. Their activation was carried with phosphoric acid and hot steam, respectively. Before using both activated carbon samples their moisture content, apparent density, pH, determination of total ash, determination of iodine, rating thiosulfate solution and assessment of the iodine solution were determined. The surface area and pore size were determined using the adsorption isothermal of S. Brunauer, P. Emmett y E. Teller (BET) with Micromeritics triStar III equipment. This analysis uses gaseous N₂ as an adsorbent at 77°K. N₂ covers the entire range of porosity and weakly interacts weakly with the solid. A stock solution of As(III) and As(V) were prepared from arsenic trioxide, As₂O₃ and sodium arseniate, Na₃AsO₄ at 10mg L⁻¹ concentration. All chemicals were available commercially and the solvents were purified as conventional methods before use.⁷ Aqueous solutions required for the analysis were prepared by using water that was purified by a Millipore water purification system.

Results

In this work it became clear that the use of ozone in the treatment of groundwater is very effective due to its high oxidizing capacity to convert As(III) to As(V). Arsenic is one of the most toxic elements found in water. Both of them are the major sources of arsenic poisoning. It is known that As(V) can be more easily removed from water by absorptive methods than As(III). The optimum pH for the oxidation of As(III) to As(V) in the presence of ozone was 10 because of the formation of free hydroxyl groups, which react quickly with the As(III) with efficiencies greater than 90%.

Discussion

The process of oxidation of As(III) using ozone showed high efficiency for the four concentrations studied. The reported values of oxidation percentages are greater than 90% for ozone concentrations of 0.5 and 1.0 mg L⁻¹. The results of the tests carried out show that coconut shell charcoal showed greater efficiency for the adsorption of As(V) as compared to wood charcoal. This is because coconut shell charcoal has better adsorptive characteristics such as pore size, surface area and surface functional groups. It was observed that the pH value of the solution is a significant variable for the adsorption of As(V), better yields over 90% are obtained at pH 5. The study of adsorption isotherms for As(V) shows a Langmuir, type I model with a filling of monolayer of As(V) on the coal surface, with a capacity of 9.75 and 6.08 µg As/g of carbon adsorption for a concentration of 0.5 mg L⁻¹ of As(V).

Conclusion

Oxidation of As(III) with ozone and absorption of As(V) using coconut shell activated carbon combined process allows to transform As(III) to As(V) and facilitates their elimination of this toxic element through the application of optimum conditions such as pH, ozone dose and time of reaction and contact efficiency with the absorbent producing an efficiency greater than 90%.

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Conflicts of Interest

Do not exists any financial or conflict of interest.

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