DESCRIPTION

TITLE

ACTIVATED CARBON

TECHNICAL FIELD

[0001]

The present invention relates to activated carbon.

BACKGROUND ART

[0002]

Activated carbon has excellent ability to adsorb various substances such as pollutants and malodorous harmful substances, and has been used as an adsorbent in various fields, both for domestic use and for industrial use. In response to the demand for tasty water free from chlorine odor and musty smell in the field of water purification, water purifiers using various types of activated carbon have been proposed. There is also a growing interest in substances that affect water quality and safety such as trihalomethanes, environmental hormones, and heavy metals. Activated carbon alone is insufficient to meet such demand, and it is necessary to use the activated carbon in combination with an adsorbent having a specific adsorption capacity.

[0003]

In the field of water purification, the heavy metals, especially lead ions, are suspected of having an endocrine disruption effect. The concentration of lead ions contained in potable water was limited to 10 ppb or less in 2003, and the development of an effective water purifying material is required.

[0004]

Under such circumstances, activated carbon having functional groups introduced therein has been generally known as activated carbon with improved metal removal performance. For example, Patent Document 1 describes activated carbon to which the metal removal performance is added by introducing a predetermined amount of acidic functional groups such as carboxylic acids. Patent Document 2 describes activated carbon having the metal removal performance improved by a synergistic effect of setting predetermined ranges of a specific surface area, a total amount of acidic functional groups, and a ratio of a total amount of hydroxy groups and carboxy groups to the total amount of acidic functional groups.

CITATION LIST

PATENT DOCUMENTS

[0005]

Patent Document 1: Japanese Unexamined Patent Publication No. 2004-315243

Patent Document 2: Japanese Unexamined Patent Publication No. 2023-146963

SUMMARY OF THE INVENTION

TECHNICAL PROBLEM

[0006]

In the conventional activated carbon into which the acidic functional groups are introduced as described in Patent Documents 1 and 2, the acidic functional groups are usually derived from carboxylic acids rather than salts. Thus, an ion exchange reaction between hydrogen ions present in carboxylic acid and metal ions to be removed is less likely to occur, and the metal removal performance has not been satisfactory so far.

[0007]

The present invention is intended to solve the problem described above, and an object

thereof is to provide activated carbon having excellent metal removal performance.

SOLUTION TO THE PROBLEM

[0008]

As a result of intensive studies to solve the problem, the present inventors have found that activated carbon having excellent metal removal performance can be obtained by setting specific ranges of the total amount of surface functional groups, the amount of metal carboxylate-derived functional groups, and the BET specific surface area from the viewpoint that replacement of hydrogen ions of carboxylic acid in the activated carbon with metal ions improves the metal removal performance of the activated carbon. The present inventors have further conducted studies based on the above findings, and completed the present invention. That is, the present invention includes the following clauses.

[0009]

Clause 1. Activated carbon, wherein a total amount of surface functional groups is 2.50 mmol/g or more, an amount of metal carboxylate-derived functional groups is 0.30 mmol/g or more, and a BET specific surface area is 300 m^2/g or more.

[0010]

Clause 2. The activated carbon of clause 1, wherein metal constituting the metal carboxylate-derived functional groups is at least one selected from the group consisting of alkali metals and alkaline earth metals.

[0011]

Clause 3. The activated carbon of clause 1 or 2, wherein metal constituting the metal carboxylate-derived functional groups is at least one selected from the group consisting of sodium, potassium, calcium, and magnesium.

[0012]

Clause 4. The activated carbon of any one of clauses 1 to 3, wherein the amount of the metal carboxylate-derived functional groups is 10 mol% or more, assuming a total amount of functional groups is 100 mol%.

[0013]

Clause 5. The activated carbon of any one of clauses 1 to 4, which is granular activated carbon.

[0014]

Clause 6. The activated carbon of any one of clauses 1 to 5, having a median diameter of 1 μm to 130 μm.

[0015]

Clause 7. The activated carbon of any one of clauses 1 to 6, wherein an amount of CO_2 generated by the activated carbon at temperatures between 100°C and 400°C is 200 μmol/g or more as measured by temperature programmed desorption analysis (TPD analysis).

[0016]

Clause 8. The activated carbon of any one of clauses 1 to 7, wherein an oxygen content is 10 mass% or more.

[0017]

Clause 9. The activated carbon of any one of clauses 1 to 8, wherein an adsorption amount of free chlorine measured by an analysis method conforming to JIS S 3201 is 10 L/g to 100 L/g.

[0018]

Clause 10. The activated carbon of any one of clauses 1 to 9, which is chemically activated carbon.

[0019]

Clause 11. The activated carbon of any one of clauses 1 to 10, wherein an average pore

size is 2.30 nm or less.

[0020]

Clause 12. The activated carbon of any one of clauses 1 to 11, wherein a decomposition onset temperature measured at a temperature rise rate of 10°C/min by thermogravimetric analysis in an air atmosphere is 850°C or lower.

[0021]

Clause 13. A metal adsorbent, containing the activated carbon of any one of clauses 1 to 12.

[0022]

Clause 14. The metal adsorbent of clause 13, which adsorbs metal ions belonging to Groups 1 to 16 of the periodic table.

[0023]

Clause 15. A water purifier filter medium, containing the metal adsorbent of clause 13 or 14.

[0024]

Clause 16. A water purifier filter, including the water purifier filter medium of clause 15.

[0025]

Clause 17. A water purifier cartridge, including the water purifier filter of clause 16.

[0026]

Clause 18. A water purifier, including the water purifier cartridge of clause 17.

[0027]

Clause 19. A system kitchen, including the water purifier cartridge of clause 18.

[0028]

Clause 20. A method for producing the activated carbon of any one of clauses 1 to 12,

the method including: (1) oxidizing raw activated carbon; (2) washing the activated carbon oxidized in the oxidizing (1) with a basic solution and adjusting pH of a filtrate after the washing to 4 or more; and (3) rinsing with water the activated carbon washed with the basic solution in the washing (2).

ADVANTAGES OF THE INVENTION

[0029]

The activated carbon of the present invention can have excellent metal removal performance.

DESCRIPTION OF EMBODIMENTS

[0030]

In the present specification, the term "containing" encompasses any of "comprising," "consisting essentially of," and "consisting of."

[0031]

In the present specification, a numerical range "A to B" means a range from A or more to B or less.

[0032]

1. Activated Carbon

In the activated carbon of the present invention, a total amount of surface functional groups is 2.50 mmol/g or more, an amount of metal carboxylate-derived functional groups is 0.30 mmol/g or more, and a BET specific surface area is 300 m^2/g or more.

[0033]

This configuration allows replacement of hydrogen ions of carboxylic acid in the activated carbon with metal ions, improving metal removal performance of the activated carbon.

[0034]

Unlike inorganic porous carriers such as zeolite and alumina, the activated carbon has a disordered pore structure, and has sites capable of adsorbing metal species that are difficult to adsorb onto the other inorganic porous carriers.

[0035]

There are no particular limitations on the shape of the activated carbon, and the shape may be appropriately selected from, for example, a powder shape, a granular shape, a pellet shape, and a honeycomb shape. That is, any of powdery activated carbon, granular activated carbon, pellet-shaped activated carbon, and honeycomb-shaped activated carbon can be used. Among them, the activated carbon of the present invention is preferably granular activated carbon because it easily improves the performance of removing metals (particularly lead) and is less likely to deteriorate the pore structure of the activated carbon.

[0036]

As the activated carbon (raw carbon), various types of activated carbon can be used as long as they satisfy the above conditions. Examples of the activated carbon include activated carbons derived from raw materials including plant-based or fossil-based raw materials such as wood, wood flour (e.g., sawdust), bamboo, fruit shells (e.g., coconut shells), by-products of pulp production, bagasse, blackstrap molasses, graphite, coal (such as peat, lignite, brown coal, and bituminous coal), anthracite, coal pitch, petroleum (especially petroleum distillation residues), petroleum pitch, coke, and coal tar; various synthetic resins such as phenol resin, vinyl chloride resin, vinyl acetate resin, melamine resin, urea resin, resorcinol resin, celluloid, epoxy resin, polyurethane resin, polyester resin, acrylic resin (e.g., polyacrylonitrile (PAN)), and polyamide resin; synthetic rubbers such as polybutylene, polybutadiene, and polychloroprene; polysaccharide such as cellulose and regenerated cellulose; other synthetic wood; and synthetic pulp. Among them, from the viewpoint of easy improvement in

performance of removing metals (particularly lead) and less deterioration of the pore structure of the activated carbon, plant-based activated carbon, coal activated carbon, synthetic resin-derived activated carbon, and polysaccharide-derived activated carbon are preferable, coconut shell activated carbon, sawdust activated carbon, coal activated carbon, phenol-based activated carbon, polyacrylonitrile (PAN)-based activated carbon, and cellulose-based activated carbon are more preferable, and the coconut shell activated carbon is even more preferable. These activated carbons may be used alone or in combination of two or more.

[0037]

The activated carbon (raw carbon) can be obtained by carbonizing or infusibilizing these raw materials as necessary, and then activating the carbonized or infusibilized raw materials. The carbonization, the infusibilization, and the activation can be performed by any common method without particular limitations. For example, the activation may be performed by gas activation which is a heat treatment of a carbon raw material (or a carbide or an infusible product thereof) in an activation gas (water vapor or carbon dioxide) at about 500℃ to 1000℃ (gas-activated carbon), or by chemical activation which is a heat treatment of a mixture of the carbon raw material (or a carbide or an infusible product thereof) and an activator (phosphoric acid, zinc chloride, potassium hydroxide, or sodium hydroxide) at about 300℃ to 800℃ (chemically activated carbon). Various commercially available products can be used as the activated carbon.

[0038]

The activated carbon of the present invention can be obtained by treating the activated carbon (raw carbon) as shown in the production method described later.

[0039]

Activated carbon usually has acidic groups on its surface. The type of acidic groups on the surface of the activated carbon varies depending on the activated carbon. In the activated

carbon of the present invention, the total amount of surface functional groups (especially the total amount of surface acidic functional groups) is 2.50 mmol/g or more, preferably 2.70 mmol/g to 9.00 mmol/g, more preferably 2.80 mmol/g to 8.00 mmol/g. When the total amount of the surface functional groups (especially the total amount of the surface acidic functional groups) is less than 2.50 mmol/g, the activated carbon is less likely to adsorb metals (particularly lead), resulting in poor performance of removing metals (particularly lead). The total amount of the surface functional groups (especially the total amount of the surface acidic functional groups) of the activated carbon of the present invention is measured by acid-base neutralization titration (Boehm method).

[0040]

There are various types of acidic functional groups on the surface of the activated carbon as described above. The activated carbon of the present invention improves in the metal removal performance by the replacement of hydrogen ions of carboxylic acid in the activated carbon with metal ions. Thus, the amount of metal carboxylate-derived functional groups is 0.30 mmol/g or more, preferably 0.35 mmol/g to 5.00 mmol/g, more preferably 0.45 mmol/g to 4.00 mmol/g, particularly preferably 0.60 mmol/g to 3.50 mmol/g. When the amount of the metal carboxylate-derived functional groups is less than 0.30 mmol/g, the activated carbon is less likely to adsorb metals (particularly lead), resulting in poor performance of removing metals (particularly lead). From the viewpoint of less deterioration of the pore structure of the activated carbon, it is preferable that the amount of the metal carboxylate-derived functional groups is not excessively large. The amount of the metal carboxylate-derived functional groups of the activated carbon of the present invention is measured by acid-base neutralization titration (Boehm method).

[0041]

Regarding the metal carboxylate-derived functional groups in the activated carbon of

the present invention, there are no particular limitations on metal species constituting the metal salt. Examples of the metal species include alkali metals (such as sodium and potassium) and alkaline earth metals (such as calcium and magnesium). These metal species may be contained alone or in combination of two or more kinds thereof. That is, the activated carbon of the present invention may contain one or more of groups having -COONa, -COOK, $-(COO)_2Ca$, or $-(COO)_2Mg$.

[0042]

There are various types of acidic functional groups on the surface of the activated carbon as described above. The activated carbon of the present invention improves in the metal removal performance by the replacement of hydrogen ions of carboxylic acid in the activated carbon with metal ions. Thus, a smaller amount of carboxylic acid-derived functional groups is preferred. For this reason, in the activated carbon of the present invention, the amount of carboxylic acid-derived functional groups is preferably 1.00 mmol/g or less, more preferably 0 mmol/g to 0.95 mmol/g, and still more preferably 0 mmol/g to 0.90 mmol/g. The amount of the carboxylic acid-derived functional groups can be even smaller, and can be 0 mmol/g to 0.20 mmol/g, particularly 0 mmol/g to 0.10 mmol/g. The amount of the carboxylic acid-derived functional groups in the activated carbon of the present invention is measured by acid-base neutralization titration (Boehm method).

[0043]

There are various types of acidic functional groups on the surface of the activated carbon as described above. The activated carbon of the present invention improves in the metal removal performance by the replacement of hydrogen ions of carboxylic acid in the activated carbon with metal ions. Thus, a larger amount of metal carboxylate-derived functional groups is preferred. For this reason, the amount of metal carboxylate-derived functional groups is preferably 10 mol% or more, more preferably 14 mol% to 60 mol%, still more preferably 16

mol% to 50 mol%, assuming the total amount of functional groups is 100 mol%. Among the functional groups of the activated carbon of the present invention, the amount of the metal carboxylate-derived functional groups is calculated from the total amount of the surface functional groups and the amount of the metal carboxylate-derived functional groups.

[0044]

A method for analyzing the functional groups in the activated carbon of the present invention will be described below.

[0045]

Usually, the acid-base neutralization titration (Boehm method) is used to determine the amount of the acidic functional groups on the surface of the activated carbon, such as the amount of quinone groups, carboxyl groups, lactone groups, and phenolic hydroxyl groups on the surface. The acid-base neutralization titration is a method of quantifying the amount of the acidic functional groups on the surface of the activated carbon by adding various types of alkali to the activated carbon to cause a reaction and back-titrating the concentration of alkali after the reaction with acid. In this case, the amounts of the respective acidic functional groups can be separately quantified, or the total amount of the surface functional groups (especially the total amount of the surface acidic functional groups) can be quantified, based on a reaction between alkali metal ethoxide (such as sodium ethoxide) and the carboxyl group, the lactone group, the phenolic hydroxyl group, or the quinone group, a reaction between alkali metal hydroxide (such as sodium hydroxide) and the carboxyl group, the lactone group, or the phenolic hydroxyl group, a reaction between alkali metal carbonate (such as sodium carbonate) and the carboxyl group or the lactone group, and a reaction between alkali metal hydrogen carbonate (such as sodium hydrogen carbonate) and the carboxyl group, due to the difference in acidity.

[0046]

However, carboxylic acid-derived groups and metal carboxylate-derived groups cannot be quantified separately by the acid-base neutralization titration (Boehm method). Thus, in the present invention, the amount of the metal carboxylate-derived functional groups is calculated from the difference between the amount of carboxylic acid in the activated carbon after washing with an aqueous alkaline solution determined by titration and the amount of carboxylic acid in the activated carbon before washing with the aqueous alkaline solution determined by titration.

[0047]

The BET specific surface area of the activated carbon of the present invention is 300 m^2/g or more, preferably 400 m^2/g to 3,500 m^2/g, more preferably 500 m^2/g to 2,000 m^2/g, and even more preferably 700 m^2/g to 1,500 m^2/g. When the BET specific surface area is less than 300 m^2/g, the activated carbon is less likely to adsorb metals (particularly lead), resulting in poor performance of removing metals (particularly lead). The BET specific surface area of the activated carbon is measured by the BET method.

[0048]

The median diameter of the activated carbon of the present invention is not particularly limited, but is preferably 1 μm to 130 μm, more preferably 5 μm to 100 μm, even more preferably 10 μm to 75 μm, from the viewpoint of easy improvement in the removal performance of metals (particularly lead) and less deterioration of the pore structure of the activated carbon. The median diameter of the activated carbon is calculated from particle size distribution obtained by the laser diffraction/scattering method.

[0049]

The amount of CO_2 generated at temperatures between 100°C and 400°C depends on the metal carboxylate-derived functional groups added to the activated carbon. In the activated carbon of the present invention, from the viewpoint of easy improvement in the performance

of removing metals (particularly lead) and less deterioration of the pore structure of the activated carbon, the amount of CO_2 generated at temperatures between 100°C and 400°C is preferably 200 μmol/g or more, more preferably 300 μmol/g to 4,000 μmol/g, still more preferably 500 μmol/g to 3,000 μmol/g, particularly preferably 1,000 μmol/g to 3,000 μmol/g, as measured by temperature programmed desorption analysis (TPD analysis). The amount of CO_2 generated at temperatures between 100°C and 400°C is measured by the temperature programmed desorption analysis (TPD analysis) with a mass spectrometer.

[0050]

The oxygen content of the activated carbon of the present invention is not particularly limited, but is preferably 10 mass% or more, more preferably 11 mass% to 25 mass%, even more preferably 12 mass% to 20 mass%, assuming the total amount of the activated carbon is 100 mass%, from the viewpoint of easy improvement in the performance of removing metals (particularly lead) and less deterioration of the pore structure of the activated carbon. The oxygen content of the activated carbon is measured by energy dispersive X-ray spectroscopy.

[0051]

The amount of free chlorine adsorbed on the activated carbon of the present invention is not particularly limited, but is preferably 10 L/g to 100 L/g, more preferably 20 L/g to 80 L/g, even more preferably 40 L/g to 60 L/g, from the viewpoint of easy improvement in the performance of removing metals (particularly lead) and less deterioration of the pore structure of the activated carbon. The amount of free chlorine adsorbed on the activated carbon is measured by an analysis method conforming to JIS S 3201.

[0052]

The average pore size of the activated carbon of the present invention is not particularly limited, but is preferably 2.30 nm or less, more preferably 1.60 nm to 2.20 nm, even more preferably 1.70 nm to 2.10 nm, from the viewpoint of easy improvement in the performance of

removing metals (particularly lead) and less deterioration of the pore structure of the activated carbon. The average pore size of the activated carbon is measured by nitrogen adsorption.

[0053]

In general, the higher the activation temperature for producing the activated carbon, the more developed the hexagonal network structure of the activated carbon becomes, reducing the number of edge sites having higher reactivity. In the activated carbon of the present invention, the functional groups are introduced in the edge sites. Thus, it is preferable to select activated carbon with a large number of edge sites and a more developed pore structure. From this viewpoint, the decomposition onset temperature of the activated carbon measured at a temperature rise rate of 10°C/min by thermogravimetric analysis (TGA) in an air atmosphere is preferably 850°C or lower, more preferably from 300°C to 800°C, even more preferably from 400°C to 700°C.

[0054]

2. Method for Producing Activated Carbon

The activated carbon of the present invention is not particularly limited, but can be produced by any method, and may include, for example:

(1) oxidizing raw activated carbon;

(2) washing the activated carbon oxidized in the oxidizing (1) with a basic solution and adjusting pH of a filtrate after the washing to 4 or more; and

(3) rinsing with water the activated carbon washed with the basic solution in the washing (2).

[0055]

(2-1) Oxidizing (1)

The oxidation treatment which can be used in the oxidizing (1) is not particularly limited, but the oxidizing (1) can be performed, for example, by using an oxidizing agent such

as nitric acid, sulfuric acid, hydrogen peroxide, ammonium peroxodisulfate, sodium peroxodisulfate, or ozone, or by a heat treatment in the presence of dioxygen, such as in the air, or an oxidation treatment with oxygen plasma and ultraviolet rays. These oxidation treatments may be performed alone or in combination of two or more. In particular, when hydrogen peroxide is used as the oxidizing agent, it is preferably used in combination with nitric acid, sulfuric acid, ammonium peroxodisulfate, or sodium peroxodisulfate. Among them, the oxidizing agent is preferably used from the viewpoint of mass production.

[0056]

The amount of the oxidizing agent used is preferably 5 parts by mass to 50 parts by mass, more preferably 10 parts by mass to 30 parts by mass, relative to 100 parts by mass of the activated carbon, because the amount of the metal carboxylate-derived functional groups is easily increased, the specific surface area is less likely to decrease, and the deterioration of the pore structure is less likely to occur within these ranges.

[0057]

The reaction temperature in the oxidizing (1) is not particularly limited, and can be appropriately adjusted according to the oxidizing power of the oxidizing agent, but is preferably 50℃ to 100℃, more preferably 70℃ to 90℃, because the amount of the metal carboxylate-derived functional groups is easily increased, the specific surface area is less likely to decrease, and the deterioration of the pore structure is less likely to occur within these ranges.

[0058]

The reaction time in the oxidizing (1), which is not particularly limited, can be set long enough to oxidize the raw activated carbon and increase the total amount of surface functional groups (particularly the total amount of surface acidic functional groups), and can be, for example, 10 minutes to 6 hours, preferably 30 minutes to 3 hours.

[0059]

(2-2) Washing (2)

In the washing (2), the activated carbon is washed with a base containing alkali metal or alkaline earth metal (alkali metal hydroxide such as sodium hydroxide or potassium hydroxide, or alkaline earth metal hydroxide such as calcium hydroxide or magnesium hydroxide) as a base contained in a basic solution to change the carboxylic acid-derived groups introduced by the oxidizing (1) to the metal carboxylate-derived groups. This can easily increase the amount of the metal carboxylate-derived functional groups. When the oxidizing agent used in the oxidizing (1) contains the alkali metal or the alkaline earth metal, metal carboxylate-derived groups can be introduced in the oxidizing (1), and thus, a base free from the alkali metal or the alkaline earth metal (e.g., ammonia) can also be used.

[0060]

In this case, the washing with the basic solution is performed to the extent that the pH of the filtrate after the washing is 4 or more, preferably 5 to 10, and more preferably 6 to 9. When the pH of the filtrate after the washing is 3 or less, the amount of the metal carboxylate-derived functional groups is insufficient, resulting in poor performance of removing metal (particularly lead).

[0061]

(2-3) Rinsing (3)

The rinsing with water can be performed by a conventional method. This can remove not only the oxidizing agent and the basic solution remaining in the pores and products of the reaction between the oxidizing agent and the basic solution, but also metal contained in the activated carbon and foreign matters attached to the surface.

[0062]

Thereafter, the obtained activated carbon is dried by a conventional method as needed to obtain the activated carbon of the present invention.

[0063]

3. Use of Activated Carbon

The activated carbon of the present invention has excellent metal removal performance as described above, and is particularly useful as a metal adsorbent. The metal to be removed by the activated carbon of the present invention is not particularly limited, and examples thereof include metal ions belonging to Groups 1 to 16 of the periodic table, such as lead, mercury, cadmium, copper, arsenic, zinc, selenium, nickel, manganese, chromium, iron, barium, and aluminum, preferably metal ions belonging to Groups 6 to 16 of the periodic table, more preferably metal ions belonging to Groups 10 to 15 of the periodic table.

[0064]

Thus, the activated carbon of the present invention is useful as an adsorbent for metals such as lead, and can be used as a water purifier filter medium. In this case, when the activated carbon of the present invention described above is loaded as it is or as a water purifier filter into a cartridge case, or molded with a desired binder, a water purifier cartridge of the present invention can be obtained. A molding method for producing the water purifier cartridge of the present invention may be either a dry molding method or a wet molding method.

[0065]

When the dry molding method is used, a composition containing the activated carbon of the present invention and a thermoplastic resin is preferably molded into a hollow cylindrical shape or a disk shape. More specifically, the composition containing the activated carbon of the present invention and the thermoplastic resin is preferably placed in a die made of aluminum or any other material as necessary, and heated to be molded into a hollow cylindrical shape or a disk shape.

[0066]

Examples of the thermoplastic resin that can be used include polyethylene,

polypropylene, polystyrene, ethylene-vinyl acetate copolymer, acrylonitrile-butadiene-styrene copolymer resin, polyethylene terephthalate, polybutylene terephthalate, ethylene acrylic resin, polymethyl methacrylate, nylon, mesophase pitch, and hydrophilic resin (e.g., polyvinyl alcohol resin and ethylene-vinyl alcohol resin). The content of the thermoplastic resin is not particularly limited. Specifically, from the viewpoint of strength and adsorption characteristics of the molded product, the amount of the thermoplastic resin is preferably 5 parts by mass to 20 parts by mass, more preferably 8 parts by mass to 18 parts by mass, relative to 100 parts by mass of the activated carbon of the present invention.

[0067]

When the wet molding method is used, a composition containing the activated carbon of the present invention and a fibrous binder is preferably molded into a hollow cylindrical shape or a disk shape. More specifically, the composition containing the activated carbon of the present invention and the fibrous binder is dispersed in water to prepare slurry, and the slurry is molded into a hollow cylindrical shape or a disk shape while sucking the slurry as necessary.

[0068]

The fibrous binder is not particularly limited as long as it can entangle fibrous activated carbon and powdery activated carbon by fibrillation to shape the carbon, and a wide variety of binders can be used regardless of whether they are synthetic or natural. Examples of such a fibrous binder include acrylic fibers, polyethylene fibers, polypropylene fibers, polyacrylonitrile fibers, cellulose fibers, nylon fibers, and aramid fibers.

[0069]

The shape of the fibrous binder is not particularly limited, and the mean fiber length is preferably 0.5 mm to 4 mm, more preferably 0.7 mm to 2 mm, from the viewpoint of strength and workability of the molded product.

[0070]

The content of the fibrous binder is not particularly limited. Specifically, from the viewpoint of the strength and adsorption characteristics of the molded product, the amount of the fibrous binder is preferably 2 parts by mass to 15 parts by mass, more preferably 5 parts by mass to 10 parts by mass, relative to 100 parts by mass of the activated carbon for the water purifier of the present invention.

[0071]

The activated carbon of the present invention can be loaded into the cartridge together with conventional activated carbon. Further, zeolite and titanosilicate capable of removing soluble lead by adsorption, or an adsorbent containing silver ions and/or a silver compound capable of adding antibacterial properties can also be loaded. In this case, the mass of the activated carbon of the present invention relative to the total amount of the activated carbon to be loaded is preferably 50 mass% or more (50 mass% to 100 mass%), more preferably 70 mass% or more (70 mass% to 100 mass%), and even more preferably 80 mass% or more (80 mass% to 100 mass%).

[0072]

The method for molding the composition into a hollow cylindrical shape or a disk shape is not particularly limited, and a conventional method can be used. The size of the obtained hollow cylindrical or disk-shaped molded product is not particularly limited, and may be a size according to the cartridge into which the product is loaded.

[0073]

Further, the water purifier cartridge of the present invention as described above can be adopted to form a water purifier by a conventional method, and can be incorporated into a system kitchen having a general configuration except for the water purifier.

[Examples]

[0074]

The present invention will be described in detail below with reference to Examples. However, the present invention is not limited to the following Examples.

[0075]

As phosphoric acid-activated carbon, phosphoric acid-activated carbon (manufactured by Jacobi Carbons, BET specific surface area: 2,445 m^2/g; pore size: 2.5 nm) was used. As coconut shell activated carbon, coconut shell activated carbon (manufactured by Jacobi Carbons, steam-activated, BET specific surface area: 1,093 m^2/g; pore size: 1.7 nm), classified coconut shell activated carbon, or coconut shell activated carbon pulverized with a roller mill was used. As zinc chloride-activated carbon, commercially available zinc chloride-activated carbon (Carboraffin manufactured by Osaka Gas Chemicals Co., Ltd., BET specific surface area: 1,497 m^2/g, pore size: 3.4 nm) was used.

[0076]

Example 1

To 5 g of the phosphoric acid-activated carbon (2,420 m^2/g, median diameter: 34 μm), 100 mL of water was added, and the temperature was raised to 80°C while stirring the mixture. A solution obtained by dissolving 20 g of sodium peroxodisulfate in 160 mL of water was slowly added to the obtained mixture, and the mixture was reacted for 90 minutes. The mixture was then filtered by suction, and the residue was washed with 35 mL of a 1 mass% aqueous sodium hydroxide solution to adjust the pH of the filtrate to 8. The residue was rinsed with water and dried at 100°C, to obtain activated carbon of Example 1 as a lead adsorbent.

[0077]

Example 2

To 5 g of the coconut shell activated carbon (1,093 m^2/g, median diameter: 66 μm), 100 mL of water was added, and the temperature was raised to 80°C while stirring the mixture. A solution obtained by dissolving 20 g of sodium peroxodisulfate in 160 mL of water was

slowly added to the obtained mixture, and the mixture was reacted for 90 minutes. The mixture was then filtered by suction, and the residue was washed with 35 mL of a 1 mass% aqueous sodium hydroxide solution to adjust the pH of the filtrate to 8. The residue was rinsed with water and dried at 100°C, to obtain activated carbon of Example 2 as a lead adsorbent.

[0078]

Example 3

To 60 g of the phosphoric acid-activated carbon (2,420 m^2/g, median diameter: 34 μm), 300 mL of water was added, and 46 mL of hydrogen peroxide (30 mass%) and 14 mL of nitric acid (60 mass%) were slowly added while stirring the mixture. Then, the temperature was raised to 80°C, and the mixture was reacted for 90 minutes. The mixture was then filtered by suction, and the residue was washed with 420 mL of a 1 mass% aqueous sodium hydroxide solution to adjust the pH of the filtrate to 8. The residue was rinsed with water and dried at 100°C, to obtain activated carbon of Example 3 as a lead adsorbent.

[0079]

Example 4

To 5 g of the coconut shell activated carbon (1,093 m^2/g, median diameter: 21 μm), 100 mL of water was added, and the temperature was raised to 80°C while stirring the mixture. A solution obtained by dissolving 20 g of sodium peroxodisulfate in 160 mL of water was slowly added to the obtained mixture, and the mixture was reacted for 90 minutes. The mixture was then filtered by suction, and the residue was washed with 530 mL of a 0.002 mass% aqueous calcium hydroxide solution to adjust the pH of the filtrate to 7. The residue was rinsed with water and dried at 100°C, to obtain activated carbon of Example 4 as a lead adsorbent.

[0080]

Example 5

To 5 g of the coconut shell activated carbon (1,093 m^2/g, median diameter: 19 μm),

100 mL of water was added, and the temperature was raised to 80°C while stirring the mixture. A solution obtained by dissolving 20 g of sodium peroxodisulfate in 160 mL of water was slowly added to the obtained mixture, and the mixture was reacted for 90 minutes. The mixture was then filtered by suction, and the residue was washed with 50 mL of a 1 mass% aqueous potassium hydroxide solution to adjust the pH of the filtrate to 8. The residue was rinsed with water and dried at 100°C, to obtain activated carbon of Example 5 as a lead adsorbent.

[0081]

Example 6

To 5 g of the coconut shell activated carbon (1,093 m^2/g, median diameter: 19 μm), 100 mL of water was added, and the temperature was raised to 80°C while stirring the mixture. A solution obtained by dissolving 20 g of sodium peroxodisulfate in 160 mL of water was slowly added to the obtained mixture, and the mixture was reacted for 90 minutes. The mixture was then filtered by suction, and the residue was washed with 35 g of a 1 mass% aqueous sodium hydroxide aqueous solution to adjust the pH of the filtrate to 8. The residue was rinsed with water and dried at 100°C, to obtain activated carbon of Example 6 as a lead adsorbent.

[0082]

Example 7

To 5 g of the coconut shell activated carbon (1,093 m^2/g, median diameter: 21 μm), 100 mL of water was added, and the temperature was raised to 80°C while stirring the mixture. A solution obtained by dissolving 20 g of sodium peroxodisulfate in 160 mL of water was slowly added to the obtained mixture, and the mixture was reacted for 90 minutes. The mixture was then filtered by suction, and the residue was washed with 49,000 mL of a 0.0001 mass% aqueous magnesium hydroxide solution to adjust the pH of the filtrate to 7. The residue was rinsed with water and dried at 100°C, to obtain activated carbon of Example 7 as a lead adsorbent.

[0083]

Example 8

To 5 g of the coconut shell activated carbon (1,093 m^2/g, median diameter: 4 μm), 100 mL of water was added, and the temperature was raised to 80°C while stirring the mixture. A solution obtained by dissolving 20 g of sodium peroxodisulfate in 160 mL of water was slowly added to the obtained mixture, and the mixture was reacted for 90 minutes. The mixture was then filtered by suction, and the residue was washed with 35 mL of a 1 mass% aqueous sodium hydroxide solution to adjust the pH of the filtrate to 8. The residue was rinsed with water and dried at 100°C, to obtain activated carbon of Example 8 as a lead adsorbent.

[0084]

Example 9

To 5 g of the coconut shell activated carbon (1,093 m^2/g, median diameter: 111 μm), 100 mL of water was added, and the temperature was raised to 80°C while stirring the mixture. A solution obtained by dissolving 20 g of sodium peroxodisulfate in 160 mL of water was slowly added to the obtained mixture, and the mixture was reacted for 90 minutes. The mixture was then filtered by suction, and the residue was washed with 530 mL of a 0.002 mass% aqueous calcium hydroxide solution to adjust the pH of the filtrate to 7. The residue was rinsed with water and dried at 100°C, to obtain activated carbon of Example 9 as a lead adsorbent.

[0085]

Example 10

To 5 g of the coconut shell activated carbon (1,093 m^2/g, median diameter: 4 μm), 100 mL of water was added, and the temperature was raised to 80°C while stirring the mixture. A solution obtained by dissolving 20 g of sodium peroxodisulfate in 160 mL of water was slowly added to the obtained mixture, and the mixture was reacted for 90 minutes. The mixture was then filtered by suction, and the residue was washed with 32 mL of a 1 mass% aqueous sodium hydroxide

solution to adjust the pH of the filtrate to 5. The residue was rinsed with water and dried at 100°C, to obtain activated carbon of Example 10 as a lead adsorbent.

[0086]

Example 11

To 5 g of the coconut shell activated carbon (1,093 m^2/g, median diameter: 66 μm), 100 mL of water was added, and the temperature was raised to 80°C while stirring the mixture. A solution obtained by dissolving 20 g of sodium peroxodisulfate in 160 mL of water was slowly added to the obtained mixture, and the mixture was reacted for 90 minutes. The mixture was then filtered by suction, and the residue was washed with 35 mL of a 1 mass% aqueous sodium hydroxide solution to adjust the pH of the filtrate to 8. The residue was rinsed with water and dried at 100°C, to obtain activated carbon of Example 11 as a lead adsorbent.

[0087]

Example 12

To 5 g of the coconut shell activated carbon (1,093 m^2/g, median diameter: 66 μm), 100 mL of water was added, and the temperature was raised to 80°C while stirring the mixture. A solution obtained by dissolving 20 g of sodium peroxodisulfate in 160 mL of water was slowly added to the obtained mixture, and the mixture was reacted for 90 minutes. The mixture was then filtered by suction, and the residue was washed with 35 mL of a 1 mass% aqueous sodium hydroxide solution to adjust the pH of the filtrate to 8. The residue was rinsed with water and dried at 100°C, to obtain activated carbon of Example 12 as a copper adsorbent.

[0088]

Example 13

To 5 g of the coconut shell activated carbon (1,093 m^2/g, median diameter: 66 μm), 100 mL of water was added, and the temperature was raised to 80°C while stirring the mixture. A solution obtained by dissolving 20 g of sodium peroxodisulfate in 160 mL of water was

slowly added to the obtained mixture, and the mixture was reacted for 90 minutes. The mixture was then filtered by suction, and the residue was washed with 35 mL of a 1 mass% aqueous sodium hydroxide solution to adjust the pH of the filtrate to 8. The residue was rinsed with water and dried at 100°C, to obtain activated carbon of Example 13 as a cadmium adsorbent.

[0089]

Example 14

To 5 g of the coconut shell activated carbon (1,093 m^2/g, median diameter: 66 μm), 100 mL of water was added, and the temperature was raised to 80°C while stirring the mixture. A solution obtained by dissolving 20 g of sodium peroxodisulfate in 160 mL of water was slowly added to the obtained mixture, and the mixture was reacted for 90 minutes. The mixture was then filtered by suction, and the residue was washed with 35 mL of a 1 mass% aqueous sodium hydroxide solution to adjust the pH of the filtrate to 8. The residue was rinsed with water and dried at 100°C, to obtain activated carbon of Example 14 as a barium adsorbent.

[0090]

Example 15

To 5 g of the coconut shell activated carbon (1,093 m^2/g, median diameter: 66 μm), 100 mL of water was added, and the temperature was raised to 80°C while stirring the mixture. A solution obtained by dissolving 20 g of sodium peroxodisulfate in 160 mL of water was slowly added to the obtained mixture, and the mixture was reacted for 90 minutes. The mixture was then filtered by suction, and the residue was washed with 35 mL of a 1 mass% aqueous sodium hydroxide solution to adjust the pH of the filtrate to 8. The residue was rinsed with water and dried at 100°C, to obtain activated carbon of Example 15 as a mercury adsorbent.

[0091]

Example 16

To 5 g of the coconut shell activated carbon (1,093 m^2/g, median diameter: 66 μm),

100 mL of water was added, and the temperature was raised to 80°C while stirring the mixture. A solution obtained by dissolving 20 g of sodium peroxodisulfate in 160 mL of water was slowly added to the obtained mixture, and the mixture was reacted for 90 minutes. The mixture was then filtered by suction, and the residue was washed with 35 mL of a 1 mass% aqueous sodium hydroxide solution to adjust the pH of the filtrate to 8. The residue was rinsed with water and dried at 100°C, to obtain activated carbon of Example 16 as an aluminum adsorbent.

[0092]

Example 17

To 5 g of the coconut shell activated carbon (1,093 m^2/g, median diameter: 66 μm), 100 mL of water was added, and the temperature was raised to 80°C while stirring the mixture. A solution obtained by dissolving 20 g of sodium peroxodisulfate in 160 mL of water was slowly added to the obtained mixture, and the mixture was reacted for 90 minutes. The mixture was then filtered by suction, and the residue was washed with 35 mL of a 1 mass% aqueous sodium hydroxide solution to adjust the pH of the filtrate to 8. The residue was rinsed with water and dried at 100°C, to obtain activated carbon of Example 17 as a chromium adsorbent.

[0093]

Comparative Example 1

Zinc chloride-activated carbon (1,700 m^2/g, median diameter: 28 μm) was used as it was as activated carbon of Comparative Example 1.

[0094]

Comparative Example 2

Phosphoric acid-activated carbon (2,420 m^2/g, median diameter: 34 μm) was used as it was as activated carbon of Comparative Example 2.

[0095]

Comparative Example 3

To 12 g of the zinc chloride-activated carbon (1,700 m^2/g, median diameter: 28 μm), 20 g of iron (II) sulfate heptahydrate and 300 mL of water were added, and 60 g of hydrogen peroxide (30 mass%) was slowly added while stirring the mixture. Then, the temperature was raised to 60℃, and the mixture was reacted for 90 minutes. The mixture was then filtered by suction, and the residue was washed with 35 mL of a 1 mass% aqueous sodium hydroxide solution to adjust the pH of the filtrate to 8. The residue was rinsed with water and dried at 100°C, to obtain activated carbon of Comparative Example 3.

[0096]

Comparative Example 4

To 5 g of the coconut shell activated carbon (1,093 m^2/g, median diameter: 22 μm), 100 mL of water was added, and the temperature was raised to 80°C while stirring the mixture. A solution obtained by dissolving 20 g of sodium peroxodisulfate in 160 mL of water was slowly added to the obtained mixture, and the mixture was reacted for 90 minutes. Then the mixture was filtered by suction, and the residue was rinsed with water and dried at 100°C.

[0097]

Comparative Example 5

To 5 g of the coconut shell activated carbon (1,093 m^2/g, median diameter: 4 μm), 100 mL of water was added, and the temperature was raised to 80°C while stirring the mixture. A solution obtained by dissolving 20 g of sodium peroxodisulfate in 160 mL of water was slowly added to the obtained mixture, and the mixture was reacted for 90 minutes. The mixture was then filtered by suction, and the residue was washed with 30 mL of a 1 mass% aqueous sodium hydroxide solution to adjust the pH of the filtrate to 3. The residue was rinsed with water and dried at 100°C, to obtain activated carbon of Comparative Example 5.

[0098]

Comparative Example 6

Pulverized and carbonized coconut shells were activated at a steam-carbon ratio of 0.9 to 1.3 and a temperature of 650°C to 950°C for 18 hours to 20 hours, and then pulverized and classified, to obtain activated carbon (1,093 m^2/g, median diameter: 66 μm) as a lead adsorbent.

[0099]

Comparative Example 7

Pulverized and carbonized coconut shells were activated at a steam-carbon ratio of 0.9 to 1.3 and a temperature of 650°C to 950°C for 18 hours to 20 hours, and then pulverized and classified, to obtain activated carbon (1,093 m^2/g, median diameter: 66 μm) as a copper adsorbent.

[0100]

Comparative Example 8

Pulverized and carbonized coconut shells were activated at a steam-carbon ratio of 0.9 to 1.3 and a temperature of 650°C to 950°C for 18 hours to 20 hours, and then pulverized and classified, to obtain activated carbon (1,093 m^2/g, median diameter: 66 μm) as a cadmium adsorbent.

[0101]

Comparative Example 9

Pulverized and carbonized coconut shells were activated at a steam-carbon ratio of 0.9 to 1.3 and a temperature of 650°C to 950°C for 18 hours to 20 hours, and then pulverized and classified, to obtain activated carbon (1,093 m^2/g, median diameter: 66 μm) as a barium adsorbent.

[0102]

Comparative Example 10

Pulverized and carbonized coconut shells were activated at a steam-carbon ratio of 0.9 to 1.3 and a temperature of 650°C to 950°C for 18 hours to 20 hours, and then pulverized and

classified, to obtain activated carbon (1,093 m^2/g, median diameter: 66 μm) as a mercury adsorbent.

[0103]

Comparative Example 11

Pulverized and carbonized coconut shells were activated at a steam-carbon ratio of 0.9 to 1.3 and a temperature of 650°C to 950°C for 18 hours to 20 hours, and then pulverized and classified, to obtain activated carbon (1,093 m^2/g, median diameter: 66 μm) as an aluminum adsorbent.

[0104]

Comparative Example 12

Pulverized and carbonized coconut shells were activated at a steam-carbon ratio of 0.9 to 1.3 and a temperature of 650°C to 950°C for 18 hours to 20 hours, and then pulverized and classified, to obtain activated carbon (1,093 m^2/g, median diameter: 66 μm) as a chromium adsorbent.

[0105]

Test Example 1: Amount of Acidic Functional Groups

The acidic functional groups on the surface of the activated carbon were reacted with a 0.1 mol/L aqueous sodium ethoxide solution. Next, an aqueous alkaline solution obtained after the reaction was back-titrated with hydrochloric acid to quantify the total amount of functional groups (total amount of acidic functional groups) present on the surface of the activated carbon.

[0106]

The acidic functional groups on the surface of the activated carbon were reacted with an aqueous sodium bicarbonate solution. Then, the aqueous alkaline solution obtained after the reaction was back-titrated with hydrochloric acid to quantify carboxyl groups present on the

surface of the activated carbon.

[0107]

The activated carbon was reacted with 0.1 mol/L hydrochloric acid to convert metal salts of the carboxyl groups on the surface into carboxyl groups. The activated carbon was washed with distilled water in an amount 100 times the weight of the activated carbon, and dried at 115°C. The acidic functional groups on the surface of the dried activated carbon were reacted with an aqueous sodium bicarbonate solution. Then, the aqueous alkaline solution obtained after the reaction was back-titrated with 0.1 mol/L hydrochloric acid to quantify carboxyl groups present on the surface of the activated carbon.

[0108]

The amount of metal carboxylate-derived functional groups was quantified from the difference in the amount of the carboxyl groups before and after the reaction with hydrochloric acid.

[0109]

Test Example 2: BET Specific Surface Area

The activated carbon was heated in a reduced pressure atmosphere at 115℃ for 3 hours, and a nitrogen adsorption isotherm was obtained to calculate a BET specific surface area by the BET method.

[0110]

Test Example 3: Median Diameter

The particle size distribution was measured by the laser diffraction/scattering method using a laser particle size analyzer (MT3300EX II, manufactured by MicrotracBel), and the median diameter was calculated.

[0111]

Test Example 4: Average Pore Size

The average pore size was calculated from the nitrogen adsorption isotherm of the activated carbon.

[0112]

Test Example 5: Amount of Soluble Lead Adsorbed (Examples 1 to 10 and Comparative Examples 1 to 5)

Several Erlenmeyer flasks were provided, the activated carbons of Examples and Comparative Examples were individually added to all of the flasks except one, and 50 mL of raw water prepared by dissolving lead nitrate in ultrapure water to a concentration of 5 mg/L was added. Then, the Erlenmeyer flasks were shaken for 20 hours while maintaining the temperature at 20℃. Thereafter, the raw water in each Erlenmeyer flask was filtered, 1 mass% of 60 mass% nitric acid was added to the filtrate, and the concentration of soluble lead was analyzed by a method using an atomic absorption spectrophotometer to check the adsorption amount of soluble lead when the concentration reached 1 ppb on the adsorption isotherm.

[0113]

Test Example 6: Amount of Lead adsorbed (Example 11 and Comparative Example 6)

Several Erlenmeyer flasks were provided, the activated carbons of Example and Comparative Example were individually added to all of the flasks except one, and 1,000 mL of raw water prepared by diluting a lead standard solution (1,000 ppm) with ultrapure water to a concentration of 500 μg/L was added. Then, the Erlenmeyer flasks were shaken for 24 hours at room temperature. Thereafter, 10 mL of the raw water was taken from each Erlenmeyer flask, to which 10 mL of a diluent for ICP spectrometry (a solution containing 10 mL of 70% HNO_3, 10 mL of 37% HCl, and 980 mL of ultrapure water) was added, and the concentration of lead was analyzed by inductively coupled plasma optical emission spectroscopy (ICP-OES) to check the adsorption amount of lead when the concentration reached 100 ppb on the adsorption isotherm.

[0114]

Test Example 7: Amount of Copper Adsorbed (Example 12 and Comparative Example 7)

Several Erlenmeyer flasks were provided, the activated carbons of Example and Comparative Example were individually added to all of the flasks except one, and 1,000 mL of raw water prepared by diluting a copper standard solution (1,000 ppm) with ultrapure water to a concentration of 500 μg/L was added. Then, the Erlenmeyer flasks were shaken for 24 hours at room temperature. Thereafter, 10 mL of the raw water was taken from each Erlenmeyer flask, to which 10 mL of a diluent for ICP spectrometry (a solution containing 10 mL of 70% HNO_3, 10 mL of 37% HCl, and 980 mL of ultrapure water) was added, and the concentration of copper was analyzed by ICP-OES to check the adsorption amount of copper when the concentration reached 100 ppb on the adsorption isotherm.

[0115]

Test Example 8: Amount of Cadmium Adsorbed (Example 13 and Comparative Example 8)

Several Erlenmeyer flasks were provided, the activated carbons of Example and Comparative Example were individually added to all of the flasks except one, and 1,000 mL of raw water prepared by diluting a cadmium standard solution (1,000 ppm) with ultrapure water to a concentration of 500 μg/L was added. Then, the Erlenmeyer flasks were shaken for 24 hours at room temperature. Thereafter, 10 mL of the raw water was taken from each Erlenmeyer flask, to which 10 mL of a diluent for ICP spectrometry (a solution containing 10 mL of 70% HNO_3, 10 mL of 37% HCl, and 980 mL of ultrapure water) was added, and the concentration of cadmium was analyzed by ICP-OES to check the adsorption amount of cadmium when the concentration reached 100 ppb on the adsorption isotherm.

[0116]

Test Example 9: Amount of Barium Adsorbed (Example 14 and Comparative Example 9)

Several Erlenmeyer flasks were provided, the activated carbons of Example and Comparative Example were individually added to all of the flasks except one, and 1,000 mL of raw water prepared by diluting a barium standard solution (1,000 ppm) with ultrapure water to a concentration of 500 μg/L was added. Then, the Erlenmeyer flasks were shaken for 24 hours at room temperature. Thereafter, 10 mL of the raw water was taken from each Erlenmeyer flask, to which 10 mL of a diluent for ICP spectrometry (a solution containing 10 mL of 70% HNO_3, 10 mL of 37% HCl, and 980 mL of ultrapure water) was added, and the concentration of barium was analyzed by ICP-OES to check the adsorption amount of barium when the concentration reached 100 ppb on the adsorption isotherm.

[0117]

Test Example 10: Amount of Mercury Adsorbed (Example 15 and Comparative Example 10)

Several Erlenmeyer flasks were provided, the activated carbons of Example and Comparative Example were individually added to all of the flasks except one, and 1,000 mL of raw water prepared by diluting a mercury standard solution (1,000 ppm) with ultrapure water to a concentration of 500 μg/L was added. Then, the Erlenmeyer flasks were shaken for 24 hours at room temperature. Thereafter, 10 mL of the raw water was taken from each Erlenmeyer flask, to which 10 mL of a diluent for ICP spectrometry (a solution containing 10 mL of 70% HNO_3, 10 mL of 37% HCl, and 980 mL of ultrapure water) was added, and the concentration of mercury was analyzed by ICP-OES to check the adsorption amount of mercury when the concentration reached 100 ppb on the adsorption isotherm.

[0118]

Test Example 11: Amount of Aluminum Adsorbed (Example 16 and Comparative

Example 11)

Several Erlenmeyer flasks were provided, the activated carbons of Example and Comparative Example were individually added to all of the flasks except one, and 1,000 mL of raw water prepared by diluting an aluminum standard solution (1,000 ppm) with ultrapure water to a concentration of 500 μg/L was added. Then, the Erlenmeyer flasks were shaken for 24 hours at room temperature. Thereafter, 10 mL of the raw water was taken from each Erlenmeyer flask, to which 10 mL of a diluent for ICP spectrometry (a solution containing 10 mL of 70% HNO_3, 10 mL of 37% HCl, and 980 mL of ultrapure water) was added, and the concentration of aluminum was analyzed by ICP-OES to check the adsorption amount of aluminum when the concentration reached 100 ppb on the adsorption isotherm.

[0119]

Test Example 12: Amount of Chromium Adsorbed (Example 17 and Comparative Example 12)

Several Erlenmeyer flasks were provided, the activated carbons of Example and Comparative Example were individually added to all of the flasks except one, and 1,000 mL of raw water prepared by diluting a chromium standard solution (1,000 ppm) with ultrapure water to a concentration of 500 μg/L was added. Then, the Erlenmeyer flasks were shaken for 24 hours at room temperature. Thereafter, 10 mL of the raw water was taken from each Erlenmeyer flask, to which 10 mL of a diluent for ICP spectrometry (a solution containing 10 mL of 70% HNO_3, 10 mL of 37% HCl, and 980 mL of ultrapure water) was added, and the concentration of chromium was analyzed by ICP-OES to check the adsorption amount of chromium when the concentration reached 100 ppb on the adsorption isotherm.

[0120]

The results are shown in Tables 1 and 2.

[0121]

[Table 1]

	Oxidizing Agent	Reaction Temperature	Time	Amount of Carboxylate	Amount of Carboxylic Acid	Total Amount of Functional Groups	Specific Surface Area	Metal that Replaces Hydrogen in Carboxylic Acid	Amount of Carboxylate/Total Amount of Functional Groups	Median Diameter	Average Pore Size	Activated Carbon	pH of Filtrate	Adsorption Amount of Metal
		°C	min	mmol/g	mmol/g	mmol/g	(m^2/g)	-	-	μm	nm			mg/g @ 1 ppb
Example 1	$Na_2S_2O_8$	80	90	3.21	0.05	7.61	813	Na	42	34	1.89	Phosphoric Acid Activated Carbon (Chemically Activated Carbon)	8	Pb: 281
Example 2	$Na_2S_2O_8$	80	90	1.24	0.00	3.57	999	Na	35	66	1.7	Coconut Shell Activated Carbon	8	Pb: 78.4
Example 3	H_2O_2 + HNO_3	80	90	1.33	0	3.58	1270	Na	37	34	1.89	Phosphoric Acid Activated Carbon (Chemically Activated Carbon)	8	Pb: 82
Example 4	$Na_2S_2O_8$	80	90	0.67	0.66	3.75	999	Ca	18	21	1.7	Coconut Shell Activated Carbon	7	Pb: 281
Example 5	$Na_2S_2O_8$	80	90	1.24	0	3.57	999	K	35	19	1.7	Coconut Shell Activated Carbon	8	Pb: 129
Example 6	$Na_2S_2O_8$	80	90	1.24	0	3.57	999	Na	35	19	1.7	Coconut Shell Activated Carbon	8	Pb: 129
Example 7	$Na_2S_2O_8$	80	90	1.28	0.85	3.65	999	Mg	35	21	1.7	Coconut Shell Activated Carbon	7	Pb: 72
Example 8	$Na_2S_2O_8$	80	90	1.04	0	3.16	904	Na	33	4	1.7	Coconut Shell Activated Carbon	8	Pb: 73.9
Example 9	$Na_2S_2O_8$	80	90	0.67	0.66	3.75	999	Ca	18	111	1.7	Coconut Shell Activated Carbon	7	Pb: 67
Example 10	$Na_2S_2O_8$	80	90	0.39	0.613	2.9	904	Na	13	4	1.7	Coconut Shell Activated Carbon	5	Pb: 67.4
Comparative Example 1		-	-	0	0.15	1.15	1497	No replacement	0	28	3.6	Zinc Chloride Activated Carbon (Chemically Activated Carbon)	-	Pb: 1 or less
Comparative Example 2		-	-	0	0.21	1.53	2445	No replacement	0	34	2.5	Phosphoric Acid Activated Carbon (Chemically Activated Carbon)	-	Pb: 1 or less
Comparative Example 3	H_2O_2 + $FeSO_4$	60	90	0.49	0	1.87	1600	Na	26	28	3.6	Zinc Chloride Activated Carbon (Chemically Activated Carbon)	> 8	Pb: 5
Comparative Example 4	$Na_2S_2O_8$	80	90	0	1.24	1.53	999	No Replacement	0	22	1.7	Coconut Shell Activated Carbon	-	Pb: 54
Comparative Example 5	$Na_2S_2O_8$	80	90	0.22	0.84	3.01	904	Na	7	4	1.8	Coconut Shell Activated Carbon	3	Pb: 55.7

[0122]

[Table 2]

	Oxidizing Agent	Reaction Temperature	Time	Amount of Carboxylate	Amount of Carboxylic Acid	Total Amount of Functional Groups	Specific Surface Area	Metal that Replaces Hydrogen in Carboxylic Acid	Amount of Carboxylate/Total Amount of Functional Groups	Median Diameter	Average Pore Size	Activated Carbon	pH of Filtrate	Adsorption Amount of Metal
		°C	min	mmol/g	mmol/g	mmol/g	m^2/g	-	-	μm	nm			mg/g @ 100 ppb
Example 11	$Na_2S_2O_8$	80	90	1.24	0	3.57	999	Na	35	66	1.7	Coconut Shell Activated Carbon	8	Pb: 200
Example 12	$Na_2S_2O_8$	80	90	1.24	0	3.57	999	Na	35	66	1.7	Coconut Shell Activated Carbon	8	Cu: 101
Example 13	$Na_2S_2O_8$	80	90	1.24	0	3.57	999	Na	35	66	1.7	Coconut Shell Activated Carbon	8	Cd: 64
Example 14	$Na_2S_2O_8$	80	90	1.24	0	3.57	999	Na	35	66	1.7	Coconut Shell Activated Carbon	8	Ba: 77
Example 15	$Na_2S_2O_8$	80	90	1.24	0	3.57	999	Na	35	66	1.7	Coconut Shell Activated Carbon	8	Hg: 96
Example 16	$Na_2S_2O_8$	80	90	1.24	0	3.57	999	Na	35	66	1.7	Coconut Shell Activated Carbon	8	Al: 89
Example 17	$Na_2S_2O_8$	80	90	1.24	0	3.57	999	Na	35	66	1.7	Coconut Shell Activated Carbon	8	Cr: 52
Comparative Example 6		-	-	0	0	0.29	1093	No Replacement	0	66	1.7	Coconut Shell Activated Carbon	-	Pb: 1 or less
Comparative Example 7		-	-	0	0	0.29	1093	No Replacement	0	66	1.7	Coconut Shell Activated Carbon	-	Cu: 1 or less
Comparative Example 8		-	-	0	0	0.29	1093	No Replacement	0	66	1.7	Coconut Shell Activated Carbon	-	Cd: 1 or less
Comparative Example 9		-	-	0	0	0.29	1093	No Replacement	0	66	1.7	Coconut Shell Activated Carbon	-	Ba: 1 or less
Comparative Example 10		-	-	0	0	0.29	1093	No Replacement	0	66	1.7	Coconut Shell Activated Carbon	-	Hg: 1 or less
Comparative Example 11		-	-	0	0	0.29	1093	No Replacement	0	66	1.7	Coconut Shell Activated Carbon	-	Al: 1 or less
Comparative Example 12		-	-	0	0	0.29	1093	No Replacement	0	66	1.7	Coconut Shell Activated Carbon	-	Cr: 1 or less

CLAIMS

[Claim 1] Activated carbon, wherein

a total amount of surface functional groups is 2.50 mmol/g or more,

an amount of metal carboxylate-derived functional groups is 0.30 mmol/g or more, and

a BET specific surface area is 300 m^2/g or more.

[Claim 2] The activated carbon of claim 1, wherein

metal constituting the metal carboxylate-derived functional groups is at least one selected from the group consisting of alkali metals and alkaline earth metals.

[Claim 3] The activated carbon of claim 1 or 2, wherein

metal constituting the metal carboxylate-derived functional groups is at least one selected from the group consisting of sodium, potassium, calcium, and magnesium.

[Claim 4] The activated carbon of any one of claims 1 to 3, wherein

the amount of the metal carboxylate-derived functional groups is 10 mol% or more, assuming a total amount of functional groups is 100 mol%.

[Claim 5] The activated carbon of any one of claims 1 to 4, which is granular activated carbon.

[Claim 6] The activated carbon of any one of claims 1 to 5, having a median diameter of 1 μm to 130 μm.

[Claim 7] The activated carbon of any one of claims 1 to 6, wherein an amount of CO_2 generated by the activated carbon at temperatures between 100°C and 400°C is 200 μmol/g or more as measured by temperature programmed desorption analysis (TPD analysis).

[Claim 8] The activated carbon of any one of claims 1 to 7, wherein an oxygen content is 10 mass% or more.

[Claim 9] The activated carbon of any one of claims 1 to 8, wherein an adsorption amount of free chlorine measured by an analysis method conforming to JIS S 3201 is 10 L/g to 100 L/g.

[Claim 10] The activated carbon of any one of claims 1 to 9, which is chemically activated carbon.

[Claim 11] The activated carbon of any one of claims 1 to 10, wherein an average pore size is 2.30 nm or less.

[Claim 12] The activated carbon of any one of claims 1 to 11, wherein a decomposition onset temperature measured at a temperature rise rate of 10°C/min by thermogravimetric analysis in an air atmosphere is 850°C or lower.

[Claim 13] A metal adsorbent, comprising the activated carbon of any one of claims 1 to 12.

[Claim 14] The metal adsorbent of claim 13, which adsorbs metal ions belonging to Groups 1 to 16 of the periodic table.

[Claim 15] A water purifier filter medium, comprising the metal adsorbent of claim 13 or 14.

[Claim 16] A water purifier filter, comprising the water purifier filter medium of claim 15.

[Claim 17] A water purifier cartridge, comprising the water purifier filter of claim 16.

[Claim 18] A water purifier, comprising the water purifier cartridge of claim 17.

[Claim 19] A system kitchen, comprising the water purifier of claim 18.

[Claim 20] A method for producing the activated carbon of any one of claims 1 to 12, the method comprising:

(1) oxidizing raw activated carbon;

(2) washing the activated carbon oxidized in the oxidizing (1) with a basic solution and adjusting pH of a filtrate after the washing to 4 or more; and

(3) rinsing with water the activated carbon washed with the basic solution in the washing (2).