adsorbed, which is contained in a sample solution, at an excellent purification rate.

[0011] (2) The column according to (1), wherein the first lid surface when the θ1 satisfies Formula (1) is an inclined surface that is inclined with respect to a transverse plane of the column main body.

The column of the present invention is suitably applied to a column having such a configuration.

[0012] (3) The column according to (2), wherein the first lid surface is a surface corresponding to a circumferential surface of a conical frustum having the first flow path as a center axis.

The column of the present invention is suitably applied to a column having such a configuration.

[0013] (4) The column according to any one of (1) to (3), wherein the second lid surface when the θ2 satisfies Formula (2) is an inclined surface that is inclined with respect to a transverse plane of the column main body.

The column of the present invention is suitably applied to a column having such a configuration.

[0014] (5) The column according to (4), wherein the second lid surface is a surface corresponding to a circumferential surface of a conical frustum having the second flow path as a center axis.

The column of the present invention is suitably applied to a column having such a configuration.

[0015] (6) The column according to any one of (1) to (5), wherein the first partition wall and the second partition wall have liquid permeability.

The column of the present invention is suitably applied to a column having such a configuration.

[0016] (7) The column according to (6), wherein the first partition wall and the second partition wall are filter members.

The column of the present invention is suitably applied to a column having such a configuration.

[0017] (8) A column including:

a column main body that is tubular;

a first partition wall and a second partition wall that are disposed within the column main body and separated from each other along an axial direction of the column main body, the first partition wall and the second partition wall defining an adsorbent filling space therebetween;

a first lid defining a first space between the first lid and the first partition wall and having a first flow path communicating with the first space; and

a second lid defining a second space between the second lid and the second partition wall and having a second flow path communicating with the second space,

wherein

the first lid has a first lid surface facing the first space,

the second lid has a second lid surface facing the second space, and

when the first lid is located vertically above the second lid,

the first lid surface is inclined to approach a center in a length direction of the column main body from a center of the first lid surface toward an outer side thereof, and has an area of 100.40% or greater and 130.00% or less relative to a unit cross-sectional area of the column main body in a horizontal direction perpendicular to the length direction of the column main body, which occupies a region vertically below the first lid surface, or

the second lid surface is inclined to approach the center in the length direction of the column main body from a center of the second lid surface toward an outer side thereof, and has an area of 100.40% or greater and 130.00% or less relative to the unit cross-sectional area of the column main body in the horizontal direction perpendicular to the length direction of the column main body, which occupies a region vertically above the second lid surface.

[0018] As a result, it is possible to reduce trailing skirt in a peak, which is found in a peak indicating a content of the eluted substance to be adsorbed (isolation material), in a fraction that flows out of the adsorption apparatus. Therefore, the column can be used in an adsorption apparatus capable of purifying and isolating a substance to be adsorbed, which is contained in a sample solution, at an excellent purification rate.

[0019] (9) An adsorption apparatus including:

the column described in any one of (1) to (8); and

a powder of hydroxyapatite charged in the adsorbent filling space of the column.

[0020] The adsorption apparatus of the present invention is suitably applied to an adsorption apparatus including a powder of hydroxyapatite as an adsorbent, and, thus, can purify and isolate the substance to be adsorbed, which is contained in the sample solution, at an excellent purification rate.

[0021] (10) The adsorption apparatus according to (9), wherein the powder adsorbs a substance to be adsorbed when a sample solution containing the substance is supplied to the adsorbent filling space via the first flow path of the first lid in a state in which the first lid is located vertically above the second lid.

[0022] The adsorption apparatus of the present invention is suitably applied to an adsorption apparatus in which adsorption of a substance to be adsorbed is performed in the state described above, and thus can purify and isolate the substance to be adsorbed, which is contained in the sample solution, at an excellent purification rate.

[0023] (11) The adsorption apparatus according to (10), wherein the substance is purified by supplying a buffer solution to the adsorbent filling space, and

adsorbed with excellent accuracy, it is necessary to adjust the substance to be adsorbed to elute it in the collected fractions in a Gaussian distribution that exhibits a sharp peak. In particular, however, trailing skirt occurs in this peak, and this large tailing leads to a problem that the purification rate for the substance to be adsorbed cannot be sufficiently improved.

[0079] With regard to the problem, as a result of diligent research, the present inventors have found that the occurrence of tailing in the peak is associated with non-uniformity in passage rate of the eluate and effluent passing through the filter members 4 and 5 in the thickness direction, i.e., a difference between the passage rate at a center portion side of the filter members 4 and 5 and the passage rate at an edge side thereof, when the eluate is supplied from the space 262 to the filter member 4, and, in addition, when the effluent is supplied from the filter member 5 to the space 272, in the step [S2B].

[0080] As a result of further investigation by the present inventors, it have been found that angles θ1 and θ2 formed by the lid surfaces 261 and 271 of the lids 26 and 27 and the flat surfaces 45 and 55 (first partition wall surface and second partition wall surface) of the filter members 4 and 5 in the spaces 262 and 272, respectively, are closely related to the occurrence of the difference in passage rate described above. By setting the angles θ1 and θ2 such that at least one of Formula (1) and Formula (2) below is satisfied, it is possible to securely suppress the occurrence of the difference in passage rate, and to set the passage rate substantially uniformly from the center portion side of the filter members 4 and 5 to the edge side thereof. Therefore, the inventors have discovered that the size of tailing in the peak can be reliably reduced, that is, the substance to be adsorbed can be purified and isolated, at an excellent purification rate, using the adsorption apparatus 1, and thus have completed the present invention.

$7.5° \leq \theta 1 \leq 20°$ ... (1), $7.5° \leq \theta 2 \leq 20°$ ... (2)

[0081] Here, when the angle θ1 formed by the lid surface 261 of the lid 26 and the flat surface 45 of the filter member 4 satisfies $7.5° \leq \theta 1 \leq 20°$, the angle θ1 has only to satisfy $7.5° \leq \theta 1 \leq 20°$, but preferably satisfies $7.5° \leq \theta 1 \leq 13.5°$ and more preferably satisfies $8.0° \leq \theta 1 \leq 12.0°$.

[0082] Further, when the angle θ2 formed by the lid surface 271 of the lid 27 and the flat surface 55 of the filter member 5 satisfies $7.5° \leq \theta 2 \leq 20°$, the angle θ2 has only to satisfy $7.5° \leq \theta 2 \leq 20°$, but preferably satisfies $7.5° \leq \theta 2 \leq 13.5°$ and more preferably satisfies $8.0° \leq \theta 2 \leq 12.0°$.

[0083] The angle θ1 and the angle θ2 each satisfy the relationship described above, so that the substance to be adsorbed can be purified and isolated at a better purification rate. Further, when the angle θ1 and the angle θ2 are each the lower limit value or greater, the space in which the liquid moves can be sufficiently ensured by ensuring a

a flow rate of water to the adsorbent passage space 220 of the column passage section 221 using the pump 60 was set to 160 mL/min.

[0094] Next, the supply of water to the adsorbent passage space 220 of the column passage section 221 using the pump 60 was continued until the adsorbent 3 rose sequentially in the adsorbent passage space 220 included in the column passage section 221 and the adsorbent filling space 20 included in the column main body 21, so that the adsorbent 3 was substantially fully charged in the adsorbent filling space 20 included in the column main body 21. The column was then returned to its original state, and the adsorbent was fully charged therein.

[0095] The operation of the pump 60 was then stopped, thereby terminating the supply of water to the adsorbent passage space 220 of the column passage section 221. Then, the extension column 200 was disengaged from the column 2 due to disengagement, from the column main body 21, of the connection section 229, which was attached, by screwing, to the inflow side end of the column main body 21 of the column 2. Then, the cover portion 22 was attached to the inflow side end of the column main body 21 in a state in which the filter member 4 was interposed on the inflow side end of the column main body 21, so that an adsorption apparatus 1 of Example 1 was obtained.

[0096] (Examples 2 to 5 and Comparative Examples 1 and 2)

Adsorption apparatuses 1 of Examples 2 to 5 and Comparative Examples 1 and 2 were obtained in the same manner as in Example 1, except that there were prepared: cover portions 22 and 23 including lids 26 and 27 having lid surfaces 261 and 271, respectively, such that $\theta 1$, $\theta 2 = 7.5°$ (Example 2); $\theta 1$, $\theta 2 = 13.5°$ (Example 3); $\theta 1$, $\theta 2 = 20°$ (Example 4); $\theta 1$, $\theta 2 = 5°$, 10° (Example 5); $\theta 1$, $\theta 2 = 5°$ (Comparative Example 1); and $\theta 1$, $\theta 2 = 40°$ (Comparative Example 2).

[0097] 2. Purification and isolation of substance to be adsorbed by adsorption apparatus

First, a sample solution was prepared by dissolving sodium chloride in ion exchanged water to achieve a concentration of 1 M.

[0098] The column was then equilibrated with a 0.1 M NaCl solution at a rate of 100 cm/h for the adsorption apparatuses 1 of Examples 2 to 5 and Comparative Example 1. Thereafter, 40 mL of the sample solution was supplied (applied) into the adsorption apparatus 1. Thereafter, the electrical conductivity of the effluent exiting the adsorption apparatus 1 was measured while 500 mL of the 0.1 M NaCl solution was flowed into the adsorption apparatus 1 at the same rate.

[0099] In addition, the electrical conductivity (mS/cm) of the effluent flowing out of the column 2 was measured, over time, using an electrical conductivity meter associated with a liquid chromatography instrument (“BioLogic DuoFlow 40”, available from Bio-Rad Laboratories).

[0100] Furthermore, for the adsorption apparatus 1 of Comparative Example 2, the

Claims

[Claim 1]

A column comprising:

a column main body that is tubular;

a first partition wall and a second partition wall that are disposed within the column main body and separated from each other along an axial direction of the column main body, the first partition wall and the second partition wall defining an adsorbent filling space therebetween;

a first lid defining a first space between the first lid and the first partition wall and having a first flow path communicating with the first space; and

a second lid defining a second space between the second lid and the second partition wall and having a second flow path communicating with the second space,

wherein

the first lid has a first lid surface facing the first space,

the second lid has a second lid surface facing the second space, and

when an angle formed by a first partition wall surface facing the first space of the first partition wall and the first lid surface is θ1 [°], and an angle formed by a second partition wall surface facing the second space of the second partition wall and the second lid surface is θ2 [°], at least one of Formula (1) and Formula (2) is satisfied:

$7.5° \leq \theta 1 \leq 20°$ ... (1)

$7.5° \leq \theta 2 \leq 20°$ ... (2).

[Claim 2]

The column according to claim 1, wherein the first lid surface when the θ1 satisfies Formula (1) is an inclined surface that is inclined with respect to a transverse plane of the column main body.

[Claim 3]

The column according to claim 2, wherein the first lid surface is a surface corresponding to a circumferential surface of a conical frustum having the first flow path as a center axis.

[Claim 4]

The column according to any one of claims 1 to 3, wherein the second lid surface when the θ2 satisfies Formula (2) is an inclined surface that is inclined with respect to a transverse plane of the column main body.

[Claim 5]

The column according to claim 4, wherein the second lid surface is a surface corresponding to a circumferential surface of a conical frustum having the second flow path as a center axis.

[Claim 6]

The column according to any one of claims 1 to 5, wherein the first partition wall and the second partition wall have liquid permeability.

[Claim 7]

The column according to claim 6, wherein the first partition wall and the second partition wall are filter members.

[Claim 8]

A column comprising:

a column main body that is tubular;

a first partition wall and a second partition wall that are disposed within the column main body and separated from each other along an axial direction of the column main body, the first partition wall and the second partition wall defining an adsorbent filling space therebetween;

a first lid defining a first space between the first lid and the first partition wall and having a first flow path communicating with the first space; and

a second lid defining a second space between the second lid and the second partition wall and having a second flow path communicating with the second space,

wherein

the first lid has a first lid surface facing the first space,

the second lid has a second lid surface facing the second space, and

when the first lid is located vertically above the second lid,

the first lid surface is inclined to approach a center in a length direction of the column main body from a center of the first lid surface toward an outer side thereof, and has an area of 100.40% or greater and 130.00% or less relative to a unit cross-sectional area of the column main body in a horizontal direction perpendicular to the length direction of the column main body, which occupies a region vertically below the first lid surface, or

the second lid surface is inclined to approach the center in the length direction of the column main body from a center of the second lid surface toward an outer side thereof, and has an area of 100.40% or greater and 130.00% or less relative to the unit cross-sectional area of the column main body in the horizontal direction perpendicular to the length direction of the column main body, which occupies a region vertically above the second lid surface.

[Claim 9]

An adsorption apparatus comprising:

the column described in any one of claims 1 to 8; and

a powder of hydroxyapatite charged in the adsorbent filling space of the column.

[Claim 10]

The adsorption apparatus according to claim 9,

wherein the powder adsorbs a substance to be adsorbed when a sample solution containing the substance is supplied to the adsorbent filling space via the first flow path of the first lid in a state in which the first lid is located vertically above the second lid.

[Claim 11]

The adsorption apparatus according to claim 10, wherein

the substance is purified by supplying a buffer solution to the adsorbent filling space, and

the buffer solution is supplied to the adsorbent filling space at a rate of 40 cm/h or greater and 200 cm/h or less.