CLAIMS

{Claim 1}

A simulated moving-bed type chromatographic separation method comprising separating a weakly adsorptive component, a strongly adsorptive component, and an intermediately adsorptive component that has intermediate adsorptive property in relation to both components, with respect to an adsorbent, with two or more kinds of eluents by using a circulation system in which a plurality of unit packed columns packed with the adsorbent are connected in series and in an endless form via pipes, the weakly adsorptive component, the strongly adsorptive component, and the intermediately adsorptive component being contained in a feed solution,

wherein a feed solution supply port F, two or more eluent supply ports D corresponding to the two or more kinds of eluents, an extraction port A of a weakly adsorptive fraction containing the weakly adsorptive component, an extraction port B of an intermediately adsorptive fraction containing the intermediately adsorptive component, and an extraction port C of a strongly adsorptive fraction containing the strongly adsorptive component are provided in the pipes of the circulation system, and positions of the feed solution supply port F, the extraction port A, the extraction port B, and the extraction port C are set as described in the following (a) to (c):

(a) the extraction port B is provided on the downstream side of the feed solution supply port F with at least one unit packed column interposed therebetween;

(b) the extraction port C is provided in the pipe having the feed solution supply port F or the extraction port C is provided on the upstream side of the feed solution supply port F with at least one unit packed column interposed therebetween; and

(c) the extraction port A is provided in the pipe having the extraction port B or the extraction port A is provided on the downstream side of the extraction port B with at least one unit packed column interposed therebetween, and wherein the chromatographic separation method comprises sequentially repeating the following steps (A) and (B):

[step (A)]

a step of simultaneously or separately supplying the feed solution and the two or more kinds of eluents from the feed solution supply port F and the two or more eluent supply ports D respectively, and simultaneously or separately extracting the weakly adsorptive fraction, the intermediately adsorptive fraction, and the strongly adsorptive fraction from the extraction port A, the extraction port B, and the extraction port C respectively; and

[step (B)]

a step of shifting the feed solution supply port F, the eluent supply ports D, the extraction port A, the extraction port B, and the extraction port C to the downstream side, while maintaining a relative positional relationship therebetween, after finishing the step (A).

{Claim 2}

The simulated moving-bed type chromatographic separation method according to claim 1, wherein the step (A) is configured by a plurality of sub-steps, and the plurality of sub-steps include a sub-step of supplying the feed solution and a sub-step of not supplying the feed solution.

{Claim 3}

The simulated moving-bed type chromatographic separation method according to claim 1 or 2, wherein the extraction port C is provided on the downstream side of an eluent supply port D1 supplying an eluent d1 having the

strongest desorption strength of the two or more kinds of eluents, at least one unit packed column is arranged between the eluent supply port D1 and the extraction port C, and in the step (A), during the eluent d1 is supplied, the same amount of the strongly adsorptive fraction as the amount of the eluent d1 supplied is extracted from the extraction port C.

{Claim 4}

The simulated moving-bed type chromatographic separation method according to any one of claims 1 to 3, wherein the extraction port B is provided on the downstream side of an eluent supply port D2 supplying an eluent d2 having the second strongest desorption strength of the two or more kinds of eluents, at least one unit packed column is arranged between the eluent supply port D2 and the extraction port B, and in the step (A), during the eluent d2 is supplied, a time interval in which the same amount of the intermediately adsorptive fraction as the amount of the eluent d2 supplied is extracted from the extraction port B is provided.

{Claim 5}

The simulated moving-bed type chromatographic separation method according to any one of claims 1 to 4, wherein four to six kinds of eluents each having different desorption strength are used.

{Claim 6}

The simulated moving-bed type chromatographic separation method according to any one of claims 1 to 5, wherein the circulation system has four or more unit packed columns, the circulation system is divided into four sections 1 to 4 that are annularly continuous from the upstream side to the downstream side such that each section has at least one unit packed column, and the following

sub-steps (A1-1), (A2-1), and (A3-1) are performed in the step (A) by using the two or more kinds of eluents:

<sub-step (A1-1)>

supplying an eluent d-I from an eluent supply port D-I while using an upstream end of the section 1 as the eluent supply port D-I, extracting the strongly adsorptive fraction from the extraction port C while using a downstream end of the section 1 as the extraction port C, supplying an eluent d-II from an eluent supply port D-II while using an upstream end of the section 2 as the eluent supply port D-II, supplying the feed solution from the feed solution supply port F while using an upstream end of the section 3 as the feed solution supply port F, and extracting the weakly adsorptive fraction from the extraction port A while using a downstream end of the section 4 as the extraction port A, thereby

most strengthening desorption strength of the eluent passing through the section 1,

weakening desorption strength of the eluent passing through the section 2 more than desorption strength of the eluent passing through the section 1, and

weakening desorption strength of the eluent passing through the sections 3 and 4 more than desorption strength of the eluent passing through the section 2;

<sub-step (A2-1)>

supplying the eluent d-I from the eluent supply port D-I, extracting the strongly adsorptive fraction from the extraction port C, supplying the eluent d-II from the eluent supply port D-II, supplying an eluent d-III from an eluent supply port D-III while using an upstream end of the section 3 as the eluent supply port D-III, and extracting the weakly adsorptive fraction from the extraction port A, thereby

most strengthening desorption strength of the eluent passing through the section 1,

weakening desorption strength of the eluent passing through the section 2 more than desorption strength of the eluent passing through the section 1, and

weakening desorption strength of the eluent passing through the sections 3 and 4 more than desorption strength of the eluent passing through the section 2; and

<sub-step (A3-1)>

supplying the eluent d-I from the eluent supply port D-I, extracting the strongly adsorptive fraction from the extraction port C, supplying the eluent d-II from the eluent supply port D-II, extracting the intermediately adsorptive fraction from the extraction port B while using a downstream end of the section 3 as the extraction port B, supplying an eluent d-IV from an eluent supply port D-IV while using an upstream end of the section 4 as the eluent supply port D-IV, and extracting the weakly adsorptive fraction from the extraction port A, thereby

most strengthening desorption strength of the eluent passing through the section 1,

weakening desorption strength of the eluent passing through the sections 2 and 3 more than desorption strength of the eluent passing through the section 1, and

weakening desorption strength of the eluent passing through the section 4 more than desorption strength of the eluent passing through the sections 2 and 3.

{Claim 7}

The simulated moving-bed type chromatographic separation method according to any one of claims 1 to 5, wherein the circulation system has four or more unit packed columns, the circulation system is divided into four sections 1 to 4 that are annularly continuous from the upstream side to the downstream side such that each section has at least one unit packed column, and the following

sub-steps (A1-2), (A2-2), and (A3-2) are performed in the step (A) by using the two or more kinds of eluents:

<sub-step (A1-2)>

supplying an eluent d-II from an eluent supply port D-II while using an upstream end of the section 1 as the eluent supply port D-II, supplying the feed solution from the feed solution supply port F while using an upstream end of the section 3 as the feed solution supply port F, and extracting the weakly adsorptive fraction from the extraction port A while using a downstream end of the section 4 as the extraction port A, thereby

most strengthening desorption strength of the eluent passing through the sections 1 and 2, and

weakening desorption strength of the eluent passing through the sections 3 and 4 more than desorption strength of the eluent passing through the sections 1 and 2;

<sub-step (A2-2)>

supplying an eluent d-I from an eluent supply port D-I while using an upstream end of the section 1 as the eluent supply port D-I, extracting the strongly adsorptive fraction from the extraction port C while using a downstream end of the section 1 as the extraction port C, supplying the eluent d-II from the eluent supply port D-II while using an upstream end of the section 2 as the eluent supply port D-II, supplying an eluent d-III from an eluent supply port D-III while using an upstream end of the section 3 as the eluent supply port D-III, and extracting the weakly adsorptive fraction from the extraction port A, thereby

most strengthening desorption strength of the eluent passing through the section 1,

weakening desorption strength of the eluent passing through the section 2 more than desorption strength of the eluent passing through the section 1, and

weakening desorption strength of the eluent passing through the sections

3 and 4 more than desorption strength of the eluent passing through the section 2; and

<sub-step (A3-2)>

supplying the eluent d-I from the eluent supply port D-I, extracting the strongly adsorptive fraction from the extraction port C, supplying the eluent d-II from the eluent supply port D-II in the sub-step (A2-2), extracting the intermediately adsorptive fraction from the extraction port B while using a downstream end of the section 3 as the extraction port B, supplying an eluent d-IV from an eluent supply port D-IV while using an upstream end of the section 4 as the eluent supply port D-IV, and extracting the weakly adsorptive fraction from the extraction port A, thereby

most strengthening desorption strength of the eluent passing through the section 1,

weakening desorption strength of the eluent passing through the sections 2 and 3 more than desorption strength of the eluent passing through the section 1, and

weakening desorption strength of the eluent passing through the section 4 more than desorption strength of the eluent passing through the sections 2 and 3.

{Claim 8}

The simulated moving-bed type chromatographic separation method according to any one of claims 1 to 5, wherein the circulation system has five or more unit packed columns, the circulation system is divided into five sections 1 to 5 that are annularly continuous from the upstream side to the downstream side such that each section has at least one unit packed column, and the following sub-steps (A1-3), (A2-3), and (A3-3) are performed in the step (A) by using the two or more kinds of eluents:

<sub-step (A1-3)>

supplying an eluent d-II from an eluent supply port D-II while using an upstream end of the section 1 as the eluent supply port D-II, supplying the feed solution from the feed solution supply port F while using an upstream end of the section 3 as the feed solution supply port F, supplying an eluent d-III from an eluent supply port D-III while using an upstream end of the section 4 as the eluent supply port D-III, and extracting the weakly adsorptive fraction from the extraction port A while using a downstream end of the section 5 as the extraction port A, thereby

most strengthening desorption strength of the eluent passing through the sections 1 and 2,

setting desorption strength of the eluent passing through the section 3 to be equal to desorption strength of the eluent passing through the sections 1 and 2 or weakening desorption strength of the eluent passing through the section 3 more than desorption strength of the eluent passing through the sections 1 and 2, and

weakening desorption strength of the eluent passing through the sections 4 and 5 more than desorption strength of the eluent passing through the section 3; and

<sub-step (A2-3)>

supplying an eluent d-I from an eluent supply port D-I while using an upstream end of the section 1 as the eluent supply port D-I, extracting the strongly adsorptive fraction from the extraction port C while using a downstream end of the section 1 as the extraction port C, supplying the eluent d-II from the eluent supply port D-II while using an upstream end of the section 2 as the eluent supply port D-II, supplying the eluent d-III from the eluent supply port D-III, and extracting the weakly adsorptive fraction from the extraction port A, thereby

most strengthening desorption strength of the eluent passing through the

section 1,

weakening desorption strength of the eluent passing through the sections 2 and 3 more than desorption strength of the eluent passing through the section 1, and

weakening desorption strength of the eluent passing through the sections 4 and 5 more than desorption strength of the eluent passing through the sections 2 and 3; and

<sub-step (A3-3)>

supplying the eluent d-I from the eluent supply port D-I, extracting the strongly adsorptive fraction from the extraction port C, supplying the eluent d-II from the eluent supply port D-II in the sub-step (A2-3), extracting the intermediately adsorptive fraction from the extraction port B while using a downstream end of the section 4 as the extraction port B, supplying an eluent d-IV from an eluent supply port D-IV while using an upstream end of the section 5 as the eluent supply port D-IV, and extracting the weakly adsorptive fraction from the extraction port A, thereby

most strengthening desorption strength of the eluent passing through the section 1,

weakening desorption strength of the eluent passing through the sections 2, 3, and 4 more than desorption strength of the eluent passing through the section 1, and

weakening desorption strength of the eluent passing through the section 5 more than desorption strength of the eluent passing through the sections 2, 3, and 4.

{Claim 9}

The simulated moving-bed type chromatographic separation method according to any one of claims 1 to 5, wherein the circulation system has seven

or more unit packed columns, the circulation system is divided into five sections 1 to 5 that are annularly continuous from the upstream side to the downstream side such that each section has at least one unit packed column, and the following sub-steps (A1-4), (A2-4), and (A3-4) are performed in the step (A) by using the two or more kinds of eluents:

<sub-step (A1-4)>

supplying an eluent d-II from an eluent supply port D-II while using an upstream end of the section 1 as the eluent supply port D-II, supplying the feed solution from the feed solution supply port F while using an upstream end of the section 3 as the feed solution supply port F, supplying an eluent d-III from an eluent supply port D-III while using an upstream end of the section 4 as the eluent supply port D-III, and extracting the weakly adsorptive fraction from the extraction port A while using a downstream end of the section 5 as the extraction port A, thereby

most strengthening desorption strength of the eluent passing through the sections 1 and 2,

setting desorption strength of the eluent passing through the section 3 to be equal to desorption strength of the eluent passing through the sections 1 and 2 or weakening desorption strength of the eluent passing through the section 3 more than desorption strength of the eluent passing through the sections 1 and 2, and

weakening desorption strength of the eluent passing through the sections 4 and 5 more than desorption strength of the eluent passing through the section 3; and

<sub-step (A2-4)>

supplying an eluent d-I from an eluent supply port D-I while using an upstream end of the section 1 as the eluent supply port D-I, extracting the strongly adsorptive fraction from the extraction port C while using a downstream

end of the section 1 as the extraction port C, supplying the eluent d-II from the eluent supply port D-II while using an upstream end of the section 2 as the eluent supply port D-II, supplying an eluent d-IV from an eluent supply port D-IV while using an upstream end of the section 4 as the eluent supply port D-IV, and extracting the weakly adsorptive fraction from the extraction port A, thereby

most strengthening desorption strength of the eluent passing through the section 1,

weakening desorption strength of the eluent passing through the sections 2 and 3 more than desorption strength of the eluent passing through the section 1, and

weakening desorption strength of the eluent passing through the sections 4 and 5 more than desorption strength of the eluent passing through the sections 2 and 3; and

<sub-step (A3-4)>

supplying the eluent d-I from the eluent supply port D-I, extracting the strongly adsorptive fraction from the extraction port C, supplying the eluent d-II from the eluent supply port D-II in the sub-step (A2-4), extracting the intermediately adsorptive fraction from the extraction port B while using a downstream end of the section 4 as the extraction port B, supplying an eluent d-V from an eluent supply port D-V while using an upstream end of the section 5 as the eluent supply port D-V, and extracting the weakly adsorptive fraction from the extraction port A, thereby

most strengthening desorption strength of the eluent passing through the section 1,

weakening desorption strength of the eluent passing through the sections 2, 3, and 4 more than desorption strength of the eluent passing through the section 1, and

weakening desorption strength of the eluent passing through the section

5 more than desorption strength of the eluent passing through the sections 2, 3, and 4.

{Claim 10}

The simulated moving-bed type chromatographic separation method according to any one of claims 1 to 5, wherein the circulation system has five or more unit packed columns, the circulation system is divided into five sections 1 to 5 that are annularly continuous from the upstream side to the downstream side such that each section has at least one unit packed column, and the following sub-steps (A1-5), (A2-5), and (A3-5) are performed in the step (A) by using the two or more kinds of eluents:

<sub-step (A1-5)>

supplying the feed solution from the feed solution supply port F while using an upstream end of the section 3 as the feed solution supply port F, supplying an eluent d-III from an eluent supply port D-III while using an upstream end of the section 4 as the eluent supply port D-III, and extracting the weakly adsorptive fraction from the extraction port A while using a downstream end of the section 5 as the extraction port A, thereby

most strengthening desorption strength of the eluent passing through the section 3, and

weakening desorption strength of the eluent passing through the sections 4 and 5 more than desorption strength of the eluent passing through the section 3;

<sub-step (A2-5)>

supplying an eluent d-I from an eluent supply port D-I while using an upstream end of the section 1 as the eluent supply port D-I, extracting the strongly adsorptive fraction from the extraction port C while using a downstream end of the section 1 as the extraction port C, supplying an eluent d-II from an

eluent supply port D-II while using an upstream end of the section 2 as the eluent supply port D-II, supplying the eluent d-III from the eluent supply port D-III, and extracting the weakly adsorptive fraction from the extraction port A, thereby

most strengthening desorption strength of the eluent passing through the section 1,

weakening desorption strength of the eluent passing through the sections 2 and 3 more than desorption strength of the eluent passing through the section 1, and

weakening desorption strength of the eluent passing through the sections 4 and 5 more than desorption strength of the eluent passing through the sections 2 and 3; and

<sub-step (A3-5)>

supplying the eluent d-I from the eluent supply port D-I, extracting the strongly adsorptive fraction from the extraction port C, supplying the eluent d-II from the eluent supply port D-II, extracting the intermediately adsorptive fraction from the extraction port B while using a downstream end of the section 4 as the extraction port B, supplying an eluent d-IV from an eluent supply port D-IV while using an upstream end of the section 5 as the eluent supply port D-IV, and extracting the weakly adsorptive fraction from the extraction port A, thereby

most strengthening desorption strength of the eluent passing through the section 1,

weakening desorption strength of the eluent passing through the sections 2, 3, and 4 more than desorption strength of the eluent passing through the section 1, and

weakening desorption strength of the eluent passing through the section 5 more than desorption strength of the eluent passing through the sections 2, 3, and 4.

{Claim 11}

The simulated moving-bed type chromatographic separation method according to any one of claims 1 to 5, wherein the circulation system has five or more unit packed columns, the circulation system is divided into five sections 1 to 5 that are annularly continuous from the upstream side to the downstream side such that each section has at least one unit packed column, and the following sub-steps (A1-6), (A2-6), and (A3-6) are performed in the step (A) by using the two or more kinds of eluents:

<sub-step (A1-6)>

supplying an eluent d-II from an eluent supply port D-II while using an upstream end of the section 1 as the eluent supply port D-II, extracting the intermediately adsorptive fraction from the extraction port B while using a downstream end of the section 3 as the extraction port B, supplying an eluent d-IV from an eluent supply port D-IV while using an upstream end of the section 4 as the eluent supply port D-IV, and extracting the weakly adsorptive fraction from the extraction port A while using a downstream end of the section 5 as the extraction port A, thereby

most strengthening desorption strength of the eluent passing through the sections 1, 2, and 3, and

weakening desorption strength of the eluent passing through the sections 3 and 5 more than desorption strength of the eluent passing through the sections 1, 2, and 3;

<sub-step (A2-6)>

supplying an eluent d-I from an eluent supply port D-I while using an upstream end of the section 1 as the eluent supply port D-I, extracting the strongly adsorptive fraction from the extraction port C while using a downstream end of the section 1 as the extraction port C, supplying the feed solution from the feed solution supply port F while using an upstream end of the section 3 as the

feed solution supply port F, supplying an eluent d-III from an eluent supply port D-III while using an upstream end of the section 4 as the eluent supply port D-III, and extracting the weakly adsorptive fraction from the extraction port A, thereby

most strengthening desorption strength of the eluent passing through the section 1,

weakening desorption strength of the eluent passing through the section 3 more than desorption strength of the eluent passing through the section 1, and

weakening desorption strength of the eluent passing through the sections 4 and 5 more than desorption strength of the eluent passing through the section 3; and

<sub-step (A3-6)>

supplying the eluent d-I from the eluent supply port D-I, extracting the strongly adsorptive fraction from the extraction port C, supplying the eluent d-II from the eluent supply port D-II while using an upstream end of the section 2 as the eluent supply port D-II, supplying the eluent d-III from the eluent supply port D-III, and extracting the weakly adsorptive fraction from the extraction port A, thereby

most strengthening desorption strength of the eluent passing through the section 1,

weakening desorption strength of the eluent passing through the sections 2 and 3 more than desorption strength of the eluent passing through the section 1, and

weakening desorption strength of the eluent passing through the sections 4 and 5 more than desorption strength of the eluent passing through the sections 2 and 3.

{Claim 12}

The simulated moving-bed type chromatographic separation method

according to any one of claims 1 to 5, wherein the circulation system has five or more unit packed columns, the circulation system is divided into five sections 1 to 5 that are annularly continuous from the upstream side to the downstream side such that each section has at least one unit packed column, and the following sub-steps (A1-7), (A2-7), and (A3-7) are performed in the step (A) by using the two or more kinds of eluents:

<sub-step (A1-7)>

supplying an eluent d-I from an eluent supply port D-I while using an upstream end of the section 1 as the eluent supply port D-I, extracting the strongly adsorptive fraction from the extraction port C while using a downstream end of the section 1 as the extraction port C, supplying the feed solution from the feed solution supply port F while using an upstream end of the section 3 as the feed solution supply port F, supplying an eluent d-III from an eluent supply port D-III while using an upstream end of the section 4 as the eluent supply port D-III, and extracting the weakly adsorptive fraction from the extraction port A while using a downstream end of the section 5 as the extraction port A, thereby

most strengthening desorption strength of the eluent passing through the section 1,

weakening desorption strength of the eluent passing through the section 3 more than desorption strength of the eluent passing through the section 1, and

weakening desorption strength of the eluent passing through the sections 4 and 5 more than desorption strength of the eluent passing through the section 3;

<sub-step (A2-7)>

supplying the eluent d-I from the eluent supply port D-I, extracting the strongly adsorptive fraction from the extraction port C, supplying an eluent d-II from an eluent supply port D-II while using an upstream end of the section 2 as the eluent supply port D-II, supplying the eluent d-III from the eluent supply port

D-III, and extracting the weakly adsorptive fraction from the extraction port A, thereby

most strengthening desorption strength of the eluent passing through the section 1,

weakening desorption strength of the eluent passing through the sections 2 and 3 more than desorption strength of the eluent passing through the section 1, and

weakening desorption strength of the eluent passing through the sections 4 and 5 more than desorption strength of the eluent passing through the sections 2 and 3; and

<sub-step (A3-7)>

supplying the eluent d-I from the eluent supply port D-I, extracting the strongly adsorptive fraction from the extraction port C, supplying the eluent d-II from the eluent supply port D-II, extracting the intermediately adsorptive fraction from the extraction port B while using a downstream end of the section 4 as the extraction port B, supplying an eluent d-IV from an eluent supply port D-IV while using an upstream end of the section 5 as the eluent supply port D-IV, and extracting the weakly adsorptive fraction from the extraction port A, thereby

most strengthening desorption strength of the eluent passing through the section 1,

weakening desorption strength of the eluent passing through the sections 2, 3, and 4 more than desorption strength of the eluent passing through the section 1, and

weakening desorption strength of the eluent passing through the section 5 more than desorption strength of the eluent passing through the sections 2, 3, and 4.

{Claim 13}

A simulated moving-bed type chromatographic separation system separating a weakly adsorptive component, a strongly adsorptive component, and an intermediately adsorptive component that has intermediate adsorptive property in relation to both components, with respect to an adsorbent, with two or more kinds of eluents by using a circulation system in which a plurality of unit packed columns packed with the adsorbent are connected in series and in an endless form via pipes, the weakly adsorptive component, the strongly adsorptive component, and the intermediately adsorptive component being contained in a feed solution,

wherein a feed solution supply port F, two or more eluent supply ports D corresponding to the two or more kinds of eluents, an extraction port A of a weakly adsorptive fraction containing the weakly adsorptive component, an extraction port B of an intermediately adsorptive fraction containing the intermediately adsorptive component, and an extraction port C of a strongly adsorptive fraction containing the strongly adsorptive component are provided in the pipes of the circulation system, and positions of the feed solution supply port F, the extraction port A, the extraction port B, and the extraction port C are set as described in the following (a) to (c):

(a) the extraction port B is provided on the downstream side of the feed solution supply port F with at least one unit packed column interposed therebetween;

(b) the extraction port C is provided in the pipe having the feed solution supply port F or the extraction port C is provided on the upstream side of the feed solution supply port F with at least one unit packed column interposed therebetween; and

(c) the extraction port A is provided in the pipe having the extraction port B or the extraction port A is provided on the downstream side of the extraction port B with at least one unit packed column interposed therebetween, and

wherein the chromatographic separation system has a means for sequentially repeating the following steps (A) and (B):

[step (A)]

a step of simultaneously or separately supplying the feed solution and the two or more kinds of eluents from the feed solution supply port F and the two or more eluent supply ports D respectively, and simultaneously or separately extracting the weakly adsorptive fraction, the intermediately adsorptive fraction, and the strongly adsorptive fraction from the extraction port A, the extraction port B, and the extraction port C respectively; and

[step (B)]

a step of shifting the feed solution supply port F, the eluent supply ports D, the extraction port A, the extraction port B, and the extraction port C to the downstream side, while maintaining a relative positional relationship therebetween, after finishing the step (A).