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FLOW MEMBER AND REACTION VESSEL

Abstract

A flow member and a reaction vessel are provided. The reaction vessel is constituted by the flow member together with a first reaction unit and a second reaction unit. The first reaction unit is provided inside with a first catalyst layer and including a first supply port and a first outflow port. The second reaction unit is provided inside with a second catalyst layer, including a second supply port and a second outflow port. The second reaction unit is provided below the first reaction unit. The flow member includes: a flow path forming part forming a flow path that causes a reaction liquid to flow down from an inside of the first reaction unit toward an inside of the second reaction unit; and a liquid extractor, configured to extract the reaction liquid to an outside of the flow path.

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Background/Summary

TECHNICAL FIELD

[0001] The present invention relates to a flow member constituting a reaction vessel that causes a supplied raw material liquid to pass through a catalyst layer and flow out as a reaction liquid, and a reaction vessel.

BACKGROUND ART

[0002] In designing an apparatus for producing a pharmaceutical product, a test for acquiring a reaction rate in the presence of a catalyst is performed for a raw material liquid containing a pharmaceutical raw material. This test is performed using, for example, a testing apparatus including a column that is a reaction vessel filled with a catalyst layer and a mechanism for supplying the raw material liquid to the column. In the test, for example, the above column assumes an attitude with an internal flow path extending in the vertical direction. The supply mechanism supplies the raw material liquid from above the column. This raw material liquid undergoes a reaction in contact with the catalyst layer, and flows out from below the column as a reaction liquid. In parallel with the supply of the raw material liquid, temperature adjustment is performed in the column. The reaction liquid obtained when the inside of the column is in a steady state is sampled. The above temperature adjustment in the column is performed, for example, by disposing the column in a heating/cooling apparatus.

[0003] This test will be described in more detail. A large number of columns having different times of passage of the raw material liquid from each other are prepared as the above column. That is, the prepared columns have different residence times of the raw material liquid (also different reaction times of the raw material liquid in the presence of the catalyst) from each other. Specifically, for example, columns having the same flow path diameter and different lengths are prepared. An operator sequentially replaces the columns in the testing apparatus, and the sampling described above is performed every time the columns are replaced. The concentration of the pharmaceutical raw material remaining in each sampled reaction liquid is detected using an analyzer, and the reaction rate described above is calculated on the basis of the residence time of each reaction liquid in the column and the detected concentration of the pharmaceutical raw material.

[0004] It takes time and effort to acquire the reaction rate by the test described above because it is necessary to replace the columns by the operator and to wait until the inside of the column becomes a steady state every time the columns are replaced. Patent Literature 1 discloses a reaction analysis system including a mixer to which two fluids are supplied, a reaction tube through which a fluid passing through the mixer flows, and a plurality of temperature measurement units that measure the temperature of the fluid in flow paths before and after the mixer, the reaction analysis system estimating a reaction parameter indicating a reaction state of the fluid on the basis of the temperature measured by each temperature measurement unit. However, this system has a different configuration from that of the above testing apparatus that causes a reaction between the raw material liquid and the catalyst layer, and is not a technique capable of solving the above-described problem.

CITATION LIST

Patent Literature

[0005] Patent Literature 1: JP 2021-159910 A

SUMMARY OF INVENTION

Technical Problem

[0006] The present invention has been made in view of such circumstances, and an object of the present invention is to provide a technique that enables easy analysis of reaction liquids having different reaction times from each other when a raw material liquid is caused to pass through a catalyst layer in a reaction vessel to obtain a reaction liquid for analysis.

Solution to Problem

[0007] The present invention (first invention) is a flow member constituting a reaction vessel that causes a supplied raw material liquid to pass through a catalyst layer and flow out as a reaction liquid, together with a first reaction unit and a second reaction unit, [0008] the flow member being provided between the first reaction unit and the second reaction unit, the first reaction unit being provided inside with a first catalyst layer and including a first supply port for supplying the raw material liquid to the first catalyst layer from above and a first outflow port for allowing a reaction liquid generated from the raw material liquid flowing down the first catalyst layer to flow out downward, the second reaction unit being provided inside with a second catalyst layer, including a second supply port for supplying the reaction liquid to the second catalyst layer from above and a second outflow port for allowing the reaction liquid flowing down the second catalyst layer to flow out to outside, and being provided below the first reaction unit, [0009] the flow member including: [0010] a flow path forming part forming a flow path that causes the reaction liquid to flow down from inside of the first reaction unit toward inside of the second reaction unit; and [0011] one of a liquid extractor configured to extract the reaction liquid to outside of the flow path and an attachment part provided in the flow path forming part to attach an analyzer configured to analyze the reaction liquid in the flow path from the outside of the flow path.

[0012] The second invention is the flow member according to the first invention, wherein [0013] the liquid extractor is provided, and [0014] the liquid extractor includes [0015] a liquid receiver configured to receive a part of the reaction liquid flowing down the flow path, and [0016] an extraction port provided in the flow path forming part to extract the reaction liquid from the liquid receiver to the outside of the flow path.

[0017] The third invention is the flow member according to the second invention, further including an opening/closing part configured to open and close the extraction port.

[0018] The fourth invention is the flow member according to the second or third invention, wherein [0019] the flow path forming part is provided with a side tube having one end side open at a position above the liquid receiver in the flow path and the other end side open at the outside of the flow path to form the extraction port, and [0020] the opening/closing part is a valve provided in the side tube.

[0021] The fifth invention is the flow member according to the fourth invention, wherein [0022] in a state where a formation direction of the flow path is a vertical direction, [0023] the side tube is inclined downward from the outside of the flow path toward the flow path.

[0024] The sixth invention is the flow member according to any one of the second to fifth inventions, wherein the liquid receiver forms a recess that stores the raw material liquid.

[0025] The seventh invention is the flow member according to the sixth invention, wherein [0026] a blocking part that blocks a part of the flow path is provided above the recess, and [0027] the blocking part is provided at a position displaced from the recess as viewed in a formation direction of the flow path.

[0028] The eighth invention is the flow member according to any one of the second to seventh inventions, wherein the flow path forming part is provided with a mounting part for mounting a measuring instrument from the outside of the flow path.

[0029] The ninth invention is the flow member according to the eighth invention, wherein [0030] the measuring instrument is a thermometer, and [0031] the mounting part is a connection hole that connects the flow path and the outside of the flow path to dispose the thermometer in the flow path by inserting the thermometer from the outside of the flow path.

[0032] The present invention (tenth invention) is a reaction vessel causing a supplied raw material

liquid to pass through a catalyst layer and flow out as a reaction liquid, the reaction vessel including: [0033] a first reaction unit provided inside with a first catalyst layer and including a first supply port for supplying the raw material liquid to the first catalyst layer from above and a first outflow port for allowing a reaction liquid generated from the raw material liquid flowing down the first catalyst layer to flow out downward; [0034] a second reaction unit provided inside with a second catalyst layer, including a second supply port for supplying the reaction liquid to the second catalyst layer from above and a second outflow port for allowing the reaction liquid flowing down the second catalyst layer to flow out to outside, and provided below the first reaction unit; and [0035] a flow member provided between the first reaction unit and the second reaction unit and including a flow path forming part forming a flow path that causes the reaction liquid to flow down from inside of the first reaction unit toward the second supply port, and one of a liquid extractor configured to extract the reaction liquid to outside of the flow path and an attachment part provided in the flow path forming part to attach an analyzer configured to analyze the reaction liquid in the flow path from the outside of the flow path.

[0036] The eleventh invention is the reaction vessel according to the tenth invention, wherein [0037] the liquid extractor is provided, and [0038] the liquid extractor includes [0039] a liquid receiver configured to receive a part of the reaction liquid flowing down the flow path, and [0040] an extraction port provided in the flow path forming part to extract the reaction liquid from the liquid receiver to the outside of the flow path.

[0041] The twelfth invention is the reaction vessel according to the eleventh invention, wherein [0042] a plurality of sets of the first reaction units and the flow path forming parts each connected to a lower side of the first reaction unit are provided, and the second reaction unit is connected to a lower side of a composite formed by connecting the sets to each other in a longitudinal direction, and [0043] the reaction liquid is supplied instead of the raw material liquid to the first reaction units of the second and subsequent sets from an upper side in the composite.

[0044] The thirteenth invention is the reaction vessel according to the eleventh or twelfth invention, wherein [0045] the first reaction unit, the second reaction unit, and the flow path forming part are each a cylindrical body, and are connected to each other, [0046] a first flange connected to a lower portion-side flange formed at a lower end portion of the first reaction unit is provided at an upper end portion of the flow path forming part, and [0047] a second flange connected to an upper portion-side flange formed at an upper end portion of the first reaction unit or an upper end portion of the second reaction unit is provided at a lower end portion of the flow path forming part.

[0048] The fourteenth invention is the reaction vessel according to the thirteenth invention, wherein [0049] a gasket is provided between the lower portion-side flange and the first flange and between the upper portion-side flange and the second flange, and [0050] the gasket is provided with a mesh to partition the flow path and the inside of the first reaction unit or the inside of the second reaction unit.

[0051] The fifteenth invention is the reaction vessel according to any one of claims eleventh to fourteenth, wherein [0052] in a flow direction of the reaction liquid, [0053] a length of a first flow path accommodating the first catalyst layer in the first reaction unit is smaller than [0054] a length of a second flow path accommodating the second catalyst layer in the second reaction unit.

Advantageous Effects of Invention

[0055] The present invention enables easy analysis of reaction liquids having different reaction times from each other when a raw material liquid is caused to pass through a catalyst layer in a reaction vessel to obtain a reaction liquid for analysis.

Description

BRIEF DESCRIPTION OF DRAWINGS

[0056] FIG. 1 is a configuration diagram of a catalytic reactor for production of a pharmaceutical product according to an embodiment of the present invention.

[0057] FIG. 2 is a longitudinal sectional side view of a reaction vessel constituting the testing apparatus.

[0058] FIG. 3 is a perspective view of a flow member constituting the reaction vessel.

[0059] FIG. 4 is a longitudinal sectional perspective view of the flow member.

[0060] FIG. 5 is a schematic view of another example of the reaction vessel.

[0061] FIG. 6 is a longitudinal sectional side view of another example of the reaction vessel.

[0062] FIG. 7 is a longitudinal sectional perspective view illustrating another example of the flow member.

[0063] FIG. 8 is a schematic view illustrating still another example of the flow member.

[0064] FIG. 9 is a longitudinal sectional side view illustrating a modification of the flow member.

DESCRIPTION OF EMBODIMENTS

[0065] A catalytic reactor 1 including a reaction vessel 2 according to an embodiment of the present invention will be described with reference to a configuration diagram of FIG. 1. The catalytic reactor 1 is a testing apparatus for producing a pharmaceutical product, described in the paragraph of the background art. The outline of a configuration of the catalytic reactor 1 will be described. The reaction vessel 2 constituting the catalytic reactor 1 is configured as a vertically-long cylindrical column. A flow path 21 in the reaction vessel 2 is filled with a catalyst to form a catalyst layer 30.

[0066] A raw material liquid containing a pharmaceutical raw material is supplied to the reaction vessel 2 from above the reaction vessel 2 to flow down the flow path 21 and pass through the catalyst layer 30. During the passage through the catalyst layer 30, the pharmaceutical raw material in the raw material liquid undergoes a chemical reaction by the action of the catalyst layer 30, and the raw material liquid flows out from a lower portion of the reaction vessel 2 as a reaction liquid containing a reaction product. In the present embodiment, a H.sub.2 (hydrogen) gas is supplied into the reaction vessel 2 in addition to the raw material liquid, and a hydrogenation reaction is performed as the above chemical reaction. A N.sub.2 (nitrogen) gas, which is a gas for adjusting the concentration of the H.sub.2 gas, is also supplied into the reaction vessel 2.

[0067] Four of the above catalyst layers 30 are provided at intervals in the flow path 21. From another viewpoint, it can be said that a catalyst layer in the reaction vessel 2 is divided into four layers in the formation direction of the flow path 21, and each of the divided layers forms the catalyst layer 30. A liquid receiver 53 that receives and holds a part of the reaction liquid flowing down to the outside of the reaction vessel 2 is provided between the catalyst layer 30 and the catalyst layer 30.

[0068] Since the catalyst layers 30 and the liquid receivers 53 are provided as described above, the reaction liquid flowing out from the lower portion of the reaction vessel 2 and the reaction liquid taken out from each of the liquid receivers 53 have different contact times with the catalyst layer 30 (that is, different reaction times in the presence of the catalyst constituting the catalyst layer 30) from each other. An operator can calculate the rate of the hydrogenation reaction of the pharmaceutical raw material by sampling these reaction liquids and detecting the concentration of the remaining pharmaceutical raw material. As described later, the reaction vessel 2 is configured such that the operator can sample the reaction liquid held in each liquid receiver 53 from the outside of the reaction vessel 2. In addition to the reaction liquid held in the liquid receiver 53, the reaction liquid flowing out from a lower end of the reaction vessel 2 is also a sampling target.

[0069] In the present specification, the raw material liquid passing through the catalyst layer 30 is described as a reaction liquid. Supplementarily, for example, when the raw material liquid is supplied into the reaction vessel 2 under a condition of low reactivity, the raw material liquid in an

unreacted state may be held in the liquid receiver **53** or may flow out from the lower portion of the reaction vessel **2**. This raw material liquid is also referred to as a reaction liquid. That is, the reaction liquid in the present specification includes a liquid having the same composition as that of the raw material liquid before being supplied to the reaction vessel **2**.

[0070] Hereinafter, the configuration of the catalytic reactor **1** will be specifically described. The catalytic reactor **1** includes a treatment liquid supply mechanism **7** and a gas supply mechanism **8**. The treatment liquid supply mechanism **7** includes a raw material liquid supply tube **71**, a pump **72**, a valve **73**, and a tank **74**. A downstream end of the raw material liquid supply tube **71** is connected to the reaction vessel **2**, and the pump **72** and the valve **73** are provided in this order toward the upstream side in the raw material liquid supply tube **71**. The tank **74** is connected to an upstream end of the raw material liquid supply tube **71**, and the tank **74** stores the raw material liquid. The raw material liquid is supplied to the reaction vessel **2** at a predetermined speed by the pump **72** operating in a state where the valve **73** is opened.

[0071] The gas supply mechanism **8** includes a gas supply tube **81**, gas supply tubes **82** and **83**, valves **84** and **85**, a H.sub.2 gas storage part **86**, and a N.sub.2 gas storage part **87**. A downstream end of the gas supply tube **81** is connected to a portion between the downstream end of the raw material liquid supply tube **71** and the pump **72**. The gas supply tube **81** branches on the upstream side to form the gas supply tubes **82** and **83**. An upstream end of the gas supply tube **82** is connected to the H.sub.2 gas storage part **86** through the valve **84**, and an upstream end of the gas supply tube **83** is connected to the N.sub.2 gas storage part **87** through the valve **85**. The H.sub.2 gas storage part **86** and the N.sub.2 gas storage part **87** are formed of, for example, a gas cylinder. During the supply of the raw material liquid to the reaction vessel **2** by the pump **72**, the valves **84** and **85** are opened to supply the H.sub.2 gas and the N.sub.2 gas to the raw material liquid supply tube **71**. As a result, the raw material liquid is supplied to the reaction vessel **2** together with the H.sub.2 gas and the N.sub.2 gas.

[0072] The reaction vessel **2** will be described in detail also with reference to FIG. **2** that is a longitudinal sectional side view. When the reaction vessel **2** is used (that is, when the raw material liquid is supplied), the reaction vessel **2** is heated or cooled by being disposed in a heating/cooling apparatus, for example, similarly to the column described in the paragraph of the background art. In a case where heating is performed, for example, an oven can be used as the heating/cooling apparatus. Hereinafter, description will be given on the assumption that the reaction vessel **2** is in a state of being used in this manner. Therefore, the description of the attitude and orientation of the reaction vessel **2** and each member constituting the reaction vessel **2** is the description of the attitude and orientation assumed when the reaction vessel **2** is used.

[0073] The reaction vessel **2** includes four reaction units **3** each accommodating the catalyst layer **30**, and three flow members **5** each accommodating the liquid receiver **53**. A schematic configuration of the reaction units **3** and the flow members **5** will be described. Each reaction unit **3** includes a tube wall **31** forming a cylindrical body. The inside of the tube wall **31** is configured as a flow path **32** for the raw material liquid or the reaction liquid, and the catalyst layer **30** is provided in the flow path **32**. Each flow member **5** includes a tube wall **51** forming a cylindrical body. The tube wall **51** is a flow path forming part. The inside of the tube wall **51** is configured as a flow path **52** for the reaction liquid, and the liquid receiver **53** is provided in the flow path **52**. The flow paths **32** and **52** have the same diameter as each other, for example.

[0074] The tube walls **31** of the four reaction units **3** and the tube walls **51** of the three flow members **5** are connected to each other such that their central axes are aligned in plan view and extend in the vertical direction, thereby forming the cylindrical reaction vessel **2** as described above. By the connection of the tube walls **31** and **51**, the flow paths **32** of the reaction units **3** and the flow paths **52** of the flow members **5** are connected to each other to form the flow path **21** of the reaction vessel **2** described above, and the formation direction of the flow path **21** (which is also the formation direction of the flow paths **32** and **52**) is along the vertical axis. The reaction units **3**

and the flow members **5** are alternately arranged in the vertical direction, and an upper end portion and a lower end portion of the reaction vessel **2** are each constituted by the reaction unit **3**. Therefore, each of the three flow members **5** is provided so as to be sandwiched between the reaction units **3** from above and from below. Hereinafter, for convenience of description, the reaction units **3** will sometimes be referred to as **3A**, **3B**, **3C**, and **3D** from above, and the flow members **5** will sometimes be referred to as **5A**, **5B**, and **5C** from above to be distinguished from each other.

[0075] Subsequently, the reaction units **3** will be described in detail. The reaction unit **3A** is provided with an upper lid **33** that closes an upper opening of the flow path **32**. The downstream end of the raw material liquid supply tube **71** is connected to the upper lid **33**, and the raw material liquid is supplied into the reaction vessel **2** through a through hole **33A** provided in the upper lid **33**. In addition, the reaction unit **3D** is provided with a lower lid **34** so as to close a lower opening of the flow path **32**. An upstream end of an outflow tube **35** is connected to the lower lid **34**, and the reaction liquid flows out to the outflow tube **35** through a through hole **34A** provided in the lower lid **34**. The flowing-out reaction liquid is sampled by the operator and used for the calculation of the above reaction rate. In addition, the outflow tube **35** is provided with a thermometer **23** to detect a temperature in the outflow tube **35**. The thermometer **23** will be described together with thermometers **23** provided in the flow members **5**.

[0076] The reaction units **3A** to **3D** are configured similarly to each other except that the upper lid **33** and the lower lid **34** are provided in the reaction units **3A** and **3D**, respectively. As a result, the reaction liquid similarly flows in each of the reaction units **3A** to **3D**, and only the time (reaction time) during which the reaction liquid sampled from each place is in contact with the catalyst layer **30** is made different. The flow path **32** of each reaction unit **3** is filled with the catalyst from an upper end portion to a lower end portion to form the catalyst layer **30** described above, and the raw material liquid or the reaction liquid flows down through a space in the catalyst of the catalyst layer **30**. Since the reaction units **3A** to **3D** have the same configuration except for the difference in the presence or absence of the upper lid **33** and the lower lid **34** as described above, the reaction units **3A** to **3D** also have the same volume of the catalyst layer **30**.

[0077] An upper end portion and a lower end portion of the tube wall **31** that is a cylindrical body protrude toward the outside of the cylindrical body to form flanges **37**, respectively. The upper flange **37** of the reaction unit **3A** and the lower flange **37** of the reaction unit **3D** are connected to the upper lid **33** and the lower lid **34**, respectively. The other flanges **37** of the reaction units **3A** to **3D** are connected to flanges **63** or flanges **64** to be described later provided in the flow members **5**.

[0078] Subsequently, the flow members **5** will be described also with reference to a perspective view of FIG. **3** and a longitudinal sectional perspective view of FIG. **4**. Since no catalyst layer **30** is provided, each flow member **5** does not contribute to the hydrogenation reaction of the pharmaceutical raw material, and thus the flow member **5** only needs to hold the reaction liquid by the liquid receiver **53** and to enable the operator to perform sampling. Therefore, the flow member **5** is configured as a short tube so as to prevent an increase in size of the reaction vessel **2**, and has a shorter tube length than the tube length of the reaction unit **3**.

[0079] The liquid receiver **53** will be described. The liquid receiver **53** includes lateral walls **54A** and **55A** and longitudinal walls **54B** and **55B**, and is provided so as to form one recess **54** and two recesses **55**. The recesses **54** and **55** open upward and are provided at the same height in the flow path **52**. The recesses **54** and **55** have different shapes, and the recess **54** is sandwiched between the recesses **55** from the left and right. The depths of the recesses **54** and **55** are set to be relatively small so that the reaction liquid is replaced in the recesses **54** and **55** when the reaction liquid is continuously supplied, as described later in a test procedure.

[0080] The recesses **54** and **55** will be described in more detail. A horizontal plate-shaped partition is provided so as to vertically partition the flow path **52**, and two slit-shaped through holes extending in the front-back direction are formed at an interval in the left-right direction, so that the

partition is divided into three portions. The divided partitions form the lateral walls **54A** and **55A** of the recesses **54** and **55**, and the lateral walls are arranged in the order of **55A**, **54A**, **55A** in the left-right direction. A right end and a left end of the lateral wall **54A** are extended vertically upward to form the longitudinal walls **54B**, and the respective longitudinal walls **54B** and the tube wall **51** constitute a side wall of the recess **54**. In addition, each of a right end of the left lateral wall **54A** and a left end of the right lateral wall **54A** is extended vertically upward to form the longitudinal wall **54B**. The longitudinal wall **54B** and the tube wall **51** constitute a side wall of the recess **55**. [0081] The longitudinal wall **54B** and the longitudinal wall **55B** face each other with a gap **56** interposed therebetween. A part of the reaction liquid in the flow path **52** falls into the recesses **54** and **55** to be accumulated in the recesses **54** and **55**, and a part of the accumulated reaction liquid overflows from the recesses **54** and **55** to flow downward through the gap **56**. In the flow path **52**, another part of the reaction liquid directly falls into the gap **56** and flows downward through the gap **56**.

[0082] In addition, the flow member **5** is provided with a side tube **61** penetrating the tube wall **51**. Therefore, one end and the other end of the side tube **61** open at the flow path **52** and the outside of the flow path **52**, respectively. The side tube **61** and the liquid receiver **53** constitute a liquid extractor for performing sampling. The side tube **61** is a straight tube, and is inclined downward from the outside of the tube wall **51** toward the flow path **52**. The one end of the side tube **61** opens at a position above the liquid receiver **53** in the flow path **52**. A portion of the side tube **61** at the outside of the tube wall **51** forms an extraction port for extracting and sampling the reaction liquid from the recesses **54** and **55**, and a valve **62** is provided in the portion. When the operator opens and closes the valve **62**, the extraction port is opened and closed. The valve **62** is closed so that foreign substances are not mixed into the reaction vessel **2** during the supply of the raw material liquid to the reaction vessel **2**, and the valve **62** is opened at the time of sampling the reaction liquid from the liquid receiver **53**.

[0083] The sampling from the liquid receiver **53** will be described. The operator inserts a syringe **22** into the side tube **61** from the outside of the reaction vessel **2** in a state where the valve **62** is opened. A syringe needle is caused to enter the recess **54** or the recess **55** to suck and sample the reaction liquid. As the syringe needle, for example, a bent needle as illustrated in FIG. **2** is used so as to be able to enter the recesses **54** and **55**.

[0084] In order to facilitate entry of the syringe into the recesses **54** and **55** with the upper side open as described above, the side tube **61** is provided to be inclined such that the side tube **61** on the flow path **52** side is positioned below the side tube **61** on the outer side of the flow path **52** as described above. The inclination of the side tube **61** in this manner is also preferable from the viewpoint of preventing the reaction liquid from being stored in the side tube **61**. More specifically, in a case where the side tube **61** is horizontal or inclined such that the side tube **61** on the outer side of the flow path **52** is positioned below the side tube **61** on the flow path **52** side, the reaction liquid flowing through the flow path **52** flows into the side tube **61** to be accumulated.

[0085] When the reaction liquid is accumulated in this way, the accumulated reaction liquid flows out of the reaction vessel **2** from the side tube **61** at the time of opening the valve **62** for sampling. Thus, it is necessary to receive the reaction liquid using a tool and remove the reaction liquid before sampling. In addition, depending on the length and inclination angle of the side tube **61**, the reaction liquid supplied to the flow path **52** before the inside of the reaction vessel **2** becomes a steady state remains in the side tube **61** until the valve **62** is opened. That is, the reaction liquid continues to be supplied to the flow path **52**, and a new reaction liquid flows into the side tube **61** near the flow path **52** to replace the reaction liquid. However, such replacement does not occur at the outside of the flow path **52**, and the reaction liquid supplied before the steady state stagnates. In this case, there is a risk that the reaction liquid before the steady state adheres to and remains in the side tube **61** even after the valve **62** is opened for sampling, and when the syringe **22** is inserted into the side tube **61**, the reaction liquid adheres to the syringe needle to be brought into the

recesses **54** and **55**, and is sucked together with the reaction liquid in the recesses **54** and **55**. As described above, from the viewpoint of reducing the work and improving the detection accuracy of the concentration of the pharmaceutical raw material in the reaction liquid, it is preferable that the side tube **61** is inclined such that the side tube **61** on the flow path **52** side is positioned below the side tube **61** on the outer side of the flow path **52** to prevent the storage of the reaction liquid.

[0086] An upper end portion and a lower end portion of the tube wall **51** that is a cylindrical body protrude toward the outside of the cylindrical body to form the flanges **63** and **64**, respectively. In each of the flange **63** as a first flange and the flange **64** as a second flange, an annular groove **65** is formed along an opening of the flow path **52** so as to surround the opening, and an annular gasket **66** is provided in the groove **65**. The gasket **66** is provided with a mesh **67**, and the mesh **67** is stretched so as to vertically partition a circular region surrounded by the gasket **66**. The mesh **67** may be configured not to be connected to the gasket **66** but to be separated from the gasket **66**.

[0087] The flanges **63** and **64** of the flow members **5** and the flanges **37** of the reaction units **3A** to **3D** are connected each with the gasket **66** therebetween, so that leakage of the reaction liquid from between the reaction unit **3** and the flow member **5** is prevented. Since the gasket **66** and the respective flanges **63**, **64**, and **37** are disposed in this manner, the mesh **67** partitions the flow path **32** of the reaction unit **3** (that is, the inside of the reaction unit **3**) and the flow path **52** of the flow member **5**. The mesh **67** prevents the catalyst constituting the catalyst layer **30** from moving to the reaction unit **3** different from the reaction unit **3** in which the catalyst is provided or the flow member **5**.

[0088] In addition, a through hole **68** is provided in the tube wall **51** of the flow member **5**. The through hole **68** is a connection hole that connects the flow path **52** and the outside of the flow path **52**, and the thermometer **23** is inserted into the flow path **52** from the outside of the tube wall **51** through the through hole **68**. Therefore, the through hole **68** forms a mounting part for mounting the thermometer **23**, which is a measuring instrument, to the flow member **5**. The thermometer **23** detects the temperature of the flow path **52**. Therefore, a total of four thermometers including the thermometers **23** of the flow members **5A** to **5C** and the thermometer **23** of the outflow tube **35** are provided in the apparatus. The thermometers **23** are provided so as to correspond to the reaction units **3A** to **3D**, and the operator can monitor temperatures at outlets of the reaction units **3A** to **3D** by the temperatures detected by the corresponding thermometers **23** to determine whether the inside of the reaction vessel **2** is in a steady state. The thermometer **23** below and closest to the predetermined reaction unit **3** is the thermometer corresponding to the outlet of the reaction unit **3**. Therefore, the thermometers **23** of the flow members **5A**, **5B**, and **5C** and the outflow tube **35** correspond to the outlets of the reaction units **3A**, **3B**, **3C**, and **3D**, respectively.

[0089] Each thermometer **23** may be provided in the flow path **32** of the reaction unit **3**. In this case, however, the thermometer **23** enters the catalyst layer **30**. This makes the flow of the reaction liquid in a region around the thermometer **23** different from the flow of the reaction liquid in another region of the flow path **32**, thereby making the reaction time in the reaction unit **3** different from an intended time, and there arises a concern that the accuracy of the calculation result of the reaction rate is reduced. Therefore, a configuration in which the thermometer **23** is provided in the flow member **5** in which the catalyst layer **30** is not provided is preferable from the viewpoint of accurately calculating the reaction rate.

[0090] The reaction unit **3** and the flow member **5** provided adjacent to the lower side of the reaction unit **3** are combined as a set. That is, the reaction unit **3A** and the flow member **5A**, the reaction unit **3B** and the flow member **5B**, the reaction unit **3C** and the flow member **5C** are each combined as a set, and are adjacent to each other in the vertical direction as the longitudinal direction. When the three sets adjacent to each other are combined as a composite, the reaction vessel **2** has a configuration in which the reaction unit **3D** is provided adjacent to the lower side of the composite.

[0091] The reaction units **3A** to **3C** forming the sets correspond to first reaction units, and the upper

end portions and the lower end portions of the flow paths 32 of the reaction units 3A to 3C are configured as first supply ports and first outflow ports, respectively. The reaction unit 3D forming no set corresponds to a second reaction unit, and the upper end portion and the lower end portion of the flow path 32 of the reaction unit 3D are configured as a second supply port and a second outflow port, respectively. Since the raw material liquid in contact with the catalyst layer 30 is referred to as the reaction liquid as described above, the raw material liquid is supplied to the first supply port of the reaction unit 3A forming the first set from the top, and the reaction liquid is supplied to the reaction units 3B and 3C as the first reaction units forming the second and subsequent sets from the top and the reaction unit 3D as the second reaction unit. The second outflow port of the reaction unit 3D allows the reaction liquid to flow out of the reaction vessel 2 (to the outflow tube 35). The catalyst layers 30 provided in the reaction units 3A to 3C are first catalyst layers, the catalyst layer provided in the reaction unit 3D is a second catalyst layer, the flow paths 32 of the reaction units 3A to 3C correspond to first flow paths, and the flow path 32 of the reaction unit 3D corresponds to a second flow path. The lower flanges 37 of the reaction units 3A to 3C correspond to lower portion-side flanges. The upper flanges 37 of the first reaction units (reaction units 3A to 3C) and the second reaction unit (reaction unit 3D) correspond to upper portion-side flanges.

[0092] A test procedure using the catalytic reactor 1 will be described. The reaction vessel 2 is stored in the heating/cooling apparatus, and the inside of the heating/cooling apparatus is adjusted to a predetermined temperature. The treatment liquid supply mechanism 7 and the gas supply mechanism 8 supply the raw material liquid, the H.sub.2 gas and the N.sub.2 gas into the reaction vessel 2. The raw material liquid passes through the catalyst layer 30 of the reaction unit 3 to become the reaction liquid, and the reaction liquid flows down the flow path 21 in the reaction vessel 2 and flows out from the reaction vessel 2 to the outflow tube 35.

[0093] As described above, while the reaction liquid is flowing in the reaction vessel 2, the reaction liquid is supplied to and stored in the recesses 54 and 55 of the liquid receiver 53 in the flow member 5. As the raw material liquid continues to be supplied to the reaction vessel 2, a part of the reaction liquid accumulated in the recesses 54 and 55 overflows from the recesses 54 and 55 and flows down to the lower reaction unit 3 through the gap 56 between the recesses 54 and 55. Since the depths of the recesses 54 and 55 are relatively small, the reaction liquid overflowing as described above includes the reaction liquid positioned on the bottom side of the recesses 54 and 55. That is, while the reaction liquid is kept stored in the recesses 54 and 55, the stored reaction liquid is continuously replaced with a new reaction liquid.

[0094] When a predetermined time elapses from the start of the supply of the raw material liquid and each gas to the reaction vessel 2, and the operator confirms that the temperature detected by each thermometer 23 is an appropriate temperature, the operator determines that the inside of the reaction vessel 2 becomes a steady state, and stops the supply of the raw material liquid and each gas to the reaction vessel 2. The operator samples the reaction liquid flowing out to the outflow tube 35 by any method, and samples the reaction liquids from the liquid receivers 53 of the flow members 5A to 5C by the above-described method. Since there is a possibility that the reaction liquid falls from above into the flow paths 52 of the flow members 5A to 5C even after the stop of the supply of the raw material liquid to the reaction vessel 2, the sampling from the liquid receivers 53 is performed quickly. The concentration of the pharmaceutical raw material in each sampled reaction liquid is detected by an analyzer.

[0095] The reaction units 3A to 3D have the same volume of the catalyst layer 30. Thus, when the reaction time of the reaction liquid sampled from the outflow tube 35 is X, the reaction times of the reaction liquids sampled from the flow members 5A, 5B, and 5C can be described as $\frac{1}{4}X$, $\frac{2}{4}X$, and $\frac{3}{4}X$, respectively, due to the difference in the number of catalyst layers 30 through which the reaction liquid passes. The rate of the hydrogenation reaction of the pharmaceutical raw material is determined from these four mutually different reaction times and the concentration of the

pharmaceutical raw material detected from each sampled reaction liquid.

[0096] As described above, in the catalytic reactor **1**, the samples of the four reaction liquids having different reaction times from each other can be easily acquired without replacing the reaction vessel **2** as described in the paragraph of the background art. Therefore, the time and effort required for determining the rate of the above hydrogenation reaction are reduced. Suppose that the liquid extractor (the liquid receiver **53** and the side tube **61**) for performing sampling is provided in the reaction unit **3** instead of being provided in the flow member **5**. In this case, as in the above-described case where the thermometer **23** is provided in the reaction unit **3**, the flow of the reaction liquid in the catalyst layer **30** varies, and as a result, the calculation accuracy of the reaction rate may decrease. Therefore, in the reaction vessel **2**, since the flow member **5** is provided with the liquid receiver **53** and the side tube **61**, there is an effect that the reaction rate can be accurately calculated from the acquired samples of the reaction liquids in addition to the effect that the samples of the four reaction liquids can be easily obtained.

[0097] Although the flow path **21** of the reaction vessel **2** is described as being along the vertical axis, the flow path **21** may be inclined with respect to the vertical axis as long as there is no problem in the flow of the reaction liquid and the storage in the liquid receiver **53**. The number of flow members **5** and the number of reaction units **3** constituting the reaction vessel of the present invention are not limited to the above-described example. Specifically, the number of sets of the flow members **5** and the reaction units **3** described above may be any number. For example, the number of sets is not limited to the plurality of sets, and may be one set. That is, the reaction vessel may be formed of only one flow member **5** and two reaction units **3** sandwiching the flow member **5**. In addition, the reaction vessel **2** is not limited to the cylindrical body, and may be a square cylindrical body.

[0098] Moreover, the lower end portion of the reaction vessel of the present invention is not limited to be constituted by the reaction unit **3**, and may be constituted by the flow member **5**. Specifically, for example, a flow member **5D** is provided so as to be adjacent to the reaction unit **3D** of the reaction vessel **2** described above from below. The lower lid **34** to which the outflow tube **35** is connected is provided at a lower portion of the flow member **5D** instead of being provided at the lower portion of the reaction unit **3D**. Instead of sampling the reaction liquid from the outflow tube **35**, sampling from the flow member **5D** is performed.

[0099] In addition, the volumes of the catalyst layers **30** in the respective reaction units **3** may be different from each other. As such a configuration, for example, the flow paths **32** of the respective reaction units **3** have the same diameter and different lengths from each other in the flow direction of the reaction liquid. Specifically, as an example of the configuration, the lengths of the flow paths **32** are $3A < 3B < 3C < 3D$ in a schematic view of FIG. 5. Therefore, in the example illustrated in FIG. 5, the first flow path of each of the first reaction units has a shorter length than the second flow path of the second reaction unit, and among the first flow paths of the plurality of first reaction units, the upper first flow path has a shorter length. By configuring the respective flow paths **32** in this manner, the lengths of the catalyst layers **30** in the formation direction of the flow paths **32** are also $3A < 3B < 3C < 3D$. In the early stage of the reaction, the progress rate of the reaction may be higher (that is, the concentration change of the pharmaceutical raw material is larger) than that in the late stage of the reaction. In this case, according to this configuration, the number of tests to be performed can be reduced by causing the respective acquired samples to contain raw materials of different concentrations.

[0100] In performing the test, the reaction vessel **2** is not limited to being disposed in the heating/cooling apparatus. In order to adjust the temperature of the reaction vessel **2** in the case of not disposing the reaction vessel **2** in the heating/cooling apparatus, for example, a jacket **38** can be provided on the reaction unit **3** as illustrated in FIG. 6. The jacket **38** is provided to surround the tube wall **31** between the upper flange **37** and the lower flange **37**, and a fluid flow path is formed in the jacket **38**. A fluid supply tube and a fluid discharge tube are respectively connected to an

upstream end and a downstream end of the flow path, and a fluid adjusted to a predetermined temperature from a fluid supply source is supplied to the flow path of the jacket **38** through the supply tube and discharged from the discharge tube. An arrow close to the jacket **38** in the drawing indicates the flow direction of the fluid. When such a fluid flows during the supply of the raw material liquid to the reaction vessel **2**, the temperature of the flow path **32** of the reaction unit **3** can be adjusted. Illustration of the flow path, the fluid supply source, the supply tube, and the discharge tube in the jacket **38** is omitted.

[0101] Hereinafter, a modification of the flow member **5** will be described. The liquid receiver **53** provided in the flow member **5** may have any shape, and is not limited to forming the recesses **54** and **55** described above. For example, a horizontal plate may be provided as the liquid receiver in the flow path **52**, and after completion of the supply of the raw material liquid, the operator may suck liquid droplets remaining on the horizontal plate to perform sampling. However, in order to enable sampling of a sufficient amount of reaction liquid, it is preferable to form a recess as the liquid receiver. Although the side tube **61** penetrates the tube wall **51** of the flow member **5**, the present invention is also not limited to such a configuration. For example, a through hole serving as an extraction port for the reaction liquid may be formed in the tube wall **51**, and the through hole may be closed by a detachable lid from the outside of the tube wall **51**.

[0102] The flow member **5** may be provided with a blocking part **57** illustrated in a longitudinal sectional side view of FIG. **7**. Two of the blocking parts **57** are provided at positions above the recesses **54** and **55** in the flow path **52** so as to extend in the front-back direction to block a part of the flow path **52**, and these blocking parts **57** are located at the same height apart from each other in the left-right direction. The two blocking parts **57** are each formed in a horizontal plate shape, and a front end and a rear end of each blocking part **57** are each supported in contact with the tube wall **51**. When viewed in the formation direction (vertical direction) of the flow path **52**, the blocking part **57** covers the entire gap **56** immediately below the blocking part **57**. Therefore, the blocking part **57** is provided at a position displaced from the recesses **54** and **55** as viewed in the formation direction of the flow path, and more specifically, is provided over the entire region where the liquid receiver **53** is not provided. One end and the other end of left and right ends of the blocking part **57** are positioned to overlap with the end of the recess **54** and the end of the recess **55**, respectively. In the flow path **52**, the reaction liquid flows down directly to the recesses **54** and **55**, or flows down onto the blocking parts **57** and then flows to the ends of the blocking parts **57** to flow down to the recesses **54** and **55**.

[0103] The reason why the blocking parts **57** are provided will be described. The reaction vessel **2** can be used for various reactions, and various kinds of raw material liquids can be used. Depending on the raw material liquid to be used and an environment in which the test is performed, the raw material liquid undergoes a reaction in contact with the catalyst layer **30** and a non-catalytic thermal decomposition reaction in a state of not being in contact with the catalyst layer **30**. If the blocking parts **57** are not provided in the case of the non-catalytic thermal decomposition reaction progressing as described above, the degree of progress of the non-catalytic thermal decomposition reaction is different between the reaction liquid flowing down to the liquid receiver **53**, stagnating in the recesses **54** and **55**, and then supplied to the gap **56** of the flow path **52** and the reaction liquid flowing directly to the gap **56**. That is, the reaction liquids in which the reactions do not uniformly progress are mixed in each flow member **5** and supplied to the lower unit. In this case, the accuracy of the calculated reaction rate may decrease. However, in a case where such a non-catalytic thermal decomposition reaction does not progress, it is not necessary to provide the blocking parts **57** as illustrated in FIG. **4** and the like. The blocking parts **57** are not limited to the horizontal plate, and may have any shape such as an inclined plate.

[0104] An in-line analyzer that analyzes the components of the reaction liquid may also be connected to the tube wall **51** of the flow member **5** from the outside. The analyzer will be described with reference to a schematic view of FIG. **8**. This analyzer optically acquires the

concentration of the pharmaceutical raw material in the reaction liquid by using, for example, transmitted light and scattered light, and includes a light source **91** and a detector **92** that receives the transmitted light and the scattered light. Branch tubes **93** and **94**, which are short tubes, are connected to a side wall of the tube wall **51**, and are open at the flow path **52** so as to face each other. Flanges **95** are formed at end portions of the branch tubes **93** and **94** on the opposite side from the flow path **52**. The light source **91** and the detector **92** are connected to one flange **95** and the other flange **95**, respectively, using a fixture such as a screw. Therefore, the flanges **95** form an attachment part for attaching the analyzer to the tube wall **51** from the outside to the flow path **52**. With the above configuration, the detector **92** is irradiated with light (indicated by a dotted arrow in the drawing) from the light source **91** through the flow path **52**, whereby the components of the reaction liquid flowing down the flow path **52** are analyzed.

[0105] Suppose that the analyzer is a probe type configured to measure absorbance and the like with the probe being inserted into the flow path **52** from the outside through the through hole **68** similarly to the thermometer **23**, and the concentration of the pharmaceutical product is detected from the measurement result. In a case where the analyzer is configured as described above, the through hole **68** into which the probe is inserted forms the attachment part.

[0106] As described above, a region where the catalyst layer **30** is not provided is formed as the flow member **5** in the reaction vessel **2**, and the region is used as a region where the liquid extractor including the liquid receiver **53** and the side tube **61**, or the analyzer is provided. In a case where the liquid extractor is provided, the liquid extractor is prevented from affecting the flow of the reaction liquid in the catalyst layer **30** as described above. On the other hand, in a case where the analyzer illustrated in FIG. **8** is provided, it is prevented that the analysis becomes impossible due to blocking of the optical path by the catalyst layer **30**. As described above, the flow member **5** is also used as the region where the thermometer **23**, which is a measuring instrument for monitoring the state in the reaction vessel **2**, is installed, so that the thermometer **23** is prevented from affecting the liquid flow in the catalyst layer **30**. The measuring instrument is not limited to the thermometer **23**, and may be, for example, a pressure gauge for monitoring the pressure of the flow path **52**. The pressure gauge may be provided by providing the through hole **68** in the tube wall **51** and inserting the pressure gauge into the through hole **68** from the outside of the tube wall **51** as in the case of mounting the thermometer **23**. The thermometer **23** or the pressure gauge can be provided in the flow member **5** in both the cases where the liquid extractor is provided in the flow member **5** and where the analyzer is provided in the flow member **5**.

[0107] FIG. **9** is a longitudinal sectional side view illustrating a flow member **50**, which is a further modification of the flow member **5**. The flow member **50** is provided instead of the flow member **5** in the reaction vessel **2**. The flow member **50** will be described focusing on a difference from the flow member **5**. The flow path **52** is not provided with the lateral walls **54A** and **55A** and the longitudinal walls **54B** and **55B**, and the recesses **54** and **55** are not formed. Instead, an outflow side tube **41** penetrating the tube wall **51** of the flow member **5** is provided. The outflow side tube **41** is a straight tube, is inclined upward from the outside of the tube wall **51** toward the flow path **52**, and is open in the flow path **52**. A part of the reaction liquid supplied to the flow path **52** passes through the lateral side of the outflow side tube **41** to flow to the lower reaction unit **3**, and another part of the reaction liquid flows into the outflow side tube **41** and flows out of the reaction vessel **2**. Therefore, when the raw material liquid is supplied to the reaction vessel **2**, the reaction liquid flows out from the outflow side tube **41** in addition to the outflow tube **35**. When the inside of the reaction vessel **2** becomes a steady state, the operator samples each of the reaction liquids flowing out from the outflow tube **35** and the outflow side tube **41**.

[0108] As described above, the outflow side tube **41** forms the liquid receiver and the reaction liquid extraction port in the flow member **50**, and is configured to cause the received reaction liquid to flow out to the outside of the reaction vessel **2** without storing the reaction liquid in the flow path **52**. Therefore, the liquid receiver in the present invention is not limited to the configuration in

which the reaction liquid is stored in the flow path 52. However, the amount of reaction liquid flowing through each reaction unit 3 becomes different, and there is a possibility that the reactivity of the pharmaceutical raw material in each reaction unit 3 varies. That is, since there is a possibility that a difference in the concentration of the remaining pharmaceutical raw material may occur among the sampled reaction liquids due to the reaction time and other factors, it is preferable that the liquid receiver is configured to store the reaction liquid in the flow path 52 as in the liquid receiver 53 described above in order to increase the accuracy of the test.

[0109] A valve may be provided in the outflow side tube 41 outside the flow path 52, the valve may be closed to store the reaction liquid while the raw material liquid is being supplied to the reaction vessel 2, and the valve may be opened at the time of sampling. However, as described in the description of the side tube 61, such a configuration may make it difficult for the reaction liquid accumulated inside to be replaced. Therefore, as the liquid receiver provided in the reaction vessel 2, it is preferable to form a recess such as the liquid receiver 53 that causes the stored reaction liquid to stay in the flow path 52. That is, it is preferable that the stored reaction liquid stays in the flow path 52 and does not move to the outside of the flow path 52.

[0110] Although the reaction vessel 2 that performs the hydrogenation reaction has been described as an example, the reaction vessel 2 is not limited to performing such a reaction, and may be one in which a plurality of kinds of liquids are mixed to undergo a chemical reaction in the presence of a catalyst, or may be one in which a thermal decomposition reaction is performed in the presence of a catalyst. Furthermore, although it has been described that the raw material liquid contains the pharmaceutical raw material, the raw material liquid may contain any compound. Therefore, the present technology is not limited to application to the field of production of pharmaceutical products.

[0111] It should be construed that embodiments disclosed herein are given by way of illustration in all respects, not by way of limitation. The above-described embodiments may be omitted, substituted, modified, or combined in various forms without departing from the scope and spirit of the appended claims.

REFERENCE SIGNS LIST

[0112] 2 Reaction vessel [0113] 21 Flow path [0114] 3 Reaction unit [0115] 30 Catalyst layer
[0116] 5 Flow member [0117] 51 Tube wall [0118] 52 Flow path [0119] 53 Liquid receiver [0120]
61 Side tube

Claims

1. A flow member constituting a reaction vessel that causes a supplied raw material liquid to pass through a catalyst layer and flow out as a reaction liquid, together with a first reaction unit and a second reaction unit, wherein the flow member being provided between the first reaction unit and the second reaction unit, the first reaction unit being provided inside with a first catalyst layer and including a first supply port for supplying the raw material liquid to the first catalyst layer from above and a first outflow port for allowing a reaction liquid generated from the raw material liquid flowing down the first catalyst layer to flow out downward, the second reaction unit being provided inside with a second catalyst layer, including a second supply port for supplying the reaction liquid to the second catalyst layer from above and a second outflow port for allowing the reaction liquid flowing down the second catalyst layer to flow out to outside, and the second reaction unit being provided below the first reaction unit, the flow member comprising: a flow path forming part, forming a flow path that causes the reaction liquid to flow down from an inside of the first reaction unit toward an inside of the second reaction unit; and a liquid extractor, wherein the liquid extractor is configured to extract the reaction liquid to an outside of the flow path, wherein the liquid extractor includes: a liquid receiver, configured to receive a part of the reaction liquid flowing down the flow path, and an extraction port, provided in the flow path forming part to extract the

reaction liquid from the liquid receiver to the outside of the flow path.

2. (canceled)

3. The flow member according to claim 1, further comprising: an opening/closing part, configured to open and close the extraction port.

4. The flow member according to claim 3, wherein the flow path forming part is provided with a side tube, having one end side open at a position above the liquid receiver in the flow path and an other end side open at the outside of the flow path to form the extraction port, and the opening/closing part is a valve provided in the side tube.

5. The flow member according to claim 4, wherein in a state where a formation direction of the flow path is a vertical direction, the side tube is inclined downward from the outside of the flow path toward the flow path.

6. The flow member according to claim 1, wherein the liquid receiver forms a recess that stores the raw material liquid.

7. The flow member according to claim 6, wherein a blocking part that blocks a part of the flow path is provided above the recess, and the blocking part is provided at a position displaced from the recess as viewed in a formation direction of the flow path.

8. The flow member according to claim 1, wherein the flow path forming part is provided with a mounting part for mounting a measuring instrument from the outside of the flow path.

9. The flow member according to claim 8, wherein the measuring instrument is a thermometer, and the mounting part is a connection hole that connects the flow path and the outside of the flow path to dispose the thermometer in the flow path by inserting the thermometer from the outside of the flow path.

10. A reaction vessel causing a supplied raw material liquid to pass through a catalyst layer and flow out as a reaction liquid, the reaction vessel comprising: a first reaction unit, provided inside with a first catalyst layer and including a first supply port for supplying the raw material liquid to the first catalyst layer from above and a first outflow port for allowing a reaction liquid generated from the raw material liquid flowing down the first catalyst layer to flow out downward; a second reaction unit, provided inside with a second catalyst layer, including a second supply port for supplying the reaction liquid to the second catalyst layer from above and a second outflow port for allowing the reaction liquid flowing down the second catalyst layer to flow out to outside, and provided below the first reaction unit; and a flow member, provided between the first reaction unit and the second reaction unit, and including: a flow path forming part, forming a flow path that causes the reaction liquid to flow down from an inside of the first reaction unit toward the second supply port, and a liquid extractor, wherein the liquid extractor is configured to extract the reaction liquid to an outside of the flow path, wherein the liquid extractor includes: a liquid receiver, configured to receive a part of the reaction liquid flowing down the flow path, and an extraction port, provided in the flow path forming part to extract the reaction liquid from the liquid receiver to the outside of the flow path.

11. (canceled)

12. The reaction vessel according to claim 10, wherein a plurality of sets of the first reaction units and the flow path forming parts each connected to a lower side of the first reaction unit are provided, and the second reaction unit is connected to a lower side of a composite formed by connecting the sets to each other in a longitudinal direction, and the reaction liquid is supplied instead of the raw material liquid to the first reaction units of the second and subsequent sets from an upper side in the composite.

13. The reaction vessel according to claim 12, wherein the first reaction unit, the second reaction unit, and the flow path forming part are each a cylindrical body, and are connected to each other, a first flange connected to a lower portion-side flange formed at a lower end portion of the first reaction unit is provided at an upper end portion of the flow path forming part, and a second flange connected to an upper portion-side flange formed at an upper end portion of the first reaction unit

or an upper end portion of the second reaction unit is provided at a lower end portion of the flow path forming part.

14. The reaction vessel according to claim 13, wherein a gasket is provided between the lower portion-side flange and the first flange and between the upper portion-side flange and the second flange, and the gasket is provided with a mesh to partition the flow path and the inside of the first reaction unit or the inside of the second reaction unit.

15. The reaction vessel according to claim 10, wherein in a flow direction of the reaction liquid, a length of a first flow path accommodating the first catalyst layer in the first reaction unit is smaller than a length of a second flow path accommodating the second catalyst layer in the second reaction unit.
