

Description

Title of Invention: FLUID DEVICE, PRODUCTION METHOD FOR SAME,
AND ELECTROPHORESIS DEVICE USING SAME

Technical Field

[0001]

The present invention relates to a fluid device, a production method for the same, and an electrophoresis device using the same.

Background Art

[0002]

Conventionally, a known fluid device installed in an analyzer is one in which a mold imitating the shape of a fine flow path is pressed onto a heat-softened resin substrate to transfer the shape, and then a plate-like lid is attached to the resin substrate (see, for example, Patent Literature 1). In this fluid device, it is difficult to form a flow path with a substantially circular cross section and low flow path resistance, and a bonding strength greater than the internal pressure applied to the flow path is required. Also conceivable are fluid devices in which a substantially circular flow path is formed by machining a resin substrate, and fluid devices in which a substantially circular flow path is formed by a three-dimensional printer. However, in these fluid devices, fine irregularities are formed on the inner wall surface of the flow path due to cutting marks or scanning marks. If such irregularities are

formed in the flow path, problems arise to impede the flow of fluid and cause air bubbles to adhere to the inner wall surface.

Meanwhile, technologies have been conventionally disclosed for smoothing out irregularities on the surface of a resin substrate by applying an organic solvent or resin varnish to the surface of the resin substrate (see, for example, Patent Literatures 2 and 3).

Consequently, it may be possible to apply a technology for substrate surface planarization (see, for example, Patent Literatures 2 and 3) to a fluid device fabricated by machining or by a three-dimensional printer.

Citation List

Patent Literature

[0003]

Patent Literature 1: Japanese Unexamined Patent Application Publication (Translation of PCT Application) No. 2017-538416

Patent Literature 2: Japanese Unexamined Patent Application Publication No. Hei6(1994)-128398

Patent Literature 3: Japanese Unexamined Patent Application Publication No. Hei5(1993)-198952

Summary of Invention

Technical Problem

[0004]

However, even if the smoothing technologies disclosed in Patent Literatures 2 and 3 are applied to fluid devices fabricated by machining or by a three-dimensional printer, there is a problem that, for example, it is difficult for

the organic solvent to penetrate into a fine flow path. Meanwhile, it is also conceivable that the vapor of the organic solvent may be pressurized and forcibly introduced into the flow path. However, the organic solvent pressurized and introduced into the flow path is partially liquefied within the flow path. The liquefied organic solvent adheres to a plurality of longitudinal locations on the inner wall surface of the flow path. An uneven rough surface is formed in the longitudinal direction of the flow path of the fluid device. This makes it even easier for bubbles to adhere to the inner wall surface of the flow path of the fluid device.

[0005]

In order to solve the above-mentioned program, the present invention provides a fluid device that has a lower flow path resistance than conventional fluid devices and more reliably prevents bubbles from adhering to the inner wall surface of the flow path, a method of producing the same, and an electrophoresis device using the same.

Solution to Problem

[0006]

According to an aspect of the present invention, there is provided a fluid device that is composed of resin and is to be mounted on an analyzer. The fluid device has an internally positioned flow path having an aspect ratio, which is the ratio of length to diameter, of 10 or more and a cross-section shaped like a circular tube. The arithmetic mean roughness of an inner wall surface of the flow path is

0.5 μm or less, and the standard deviation thereof is 0.1 μm or less.

[0007]

According to another aspect of the present invention, there is provided a method of producing the above-described fluid device. This method is for producing a fluid device having a flow path that is internally positioned and has an aspect ratio, which is the ratio of length to diameter, of 10 or more, a cross-section shaped like a circular tube, and an arithmetic mean roughness of the inner wall surface of the flow path of 0.5 μm or less with a standard deviation of 0.1 μm or less. The method includes the steps of: forming a through-hole having a cross-section shaped like a circle in a resin block; and aspirating from one end of the through-hole while introducing the vapor of an organic solvent from the other end.

[0008]

According to yet another aspect of the present invention, there is provided an electrophoresis device that includes the fluid device described above, and the flow path in the fluid device forms a part of the flow path for electrophoresis.

Advantageous Effects of Invention

[0009]

According to the above-described aspects of the present invention, there are provided a fluid device that has a lower flow path resistance than conventional fluid devices and prevents bubbles from adhering to the inner wall

surface of the flow path, a method of producing the same, and an electrophoresis device using the same.

Brief Description of Drawings

[0010]

FIG. 1 is a diagram illustrating a configuration of a fluid device according to a first embodiment of the present invention.

FIG. 2 includes reference signs 201 to 204 that designate diagrams illustrating the steps included in a method of producing the fluid device depicted in FIG. 1.

FIG. 3 includes reference signs 301 and 302. Reference sign 301 designates a cross-sectional view taken along line IIIa-IIIa of the diagram designated by reference sign 204 in FIG. 2. Reference sign 302 designates a cross-sectional view illustrating a modified example of the flow path depicted in the diagram designated by reference sign 301.

FIG. 4 is a diagram illustrating a configuration of the fluid device according to a second embodiment of the present invention.

FIG. 5 includes reference signs 501 to 504 that designate diagrams illustrating the steps included in the method of producing the fluid device depicted in FIG. 4.

FIG. 6 is a diagram illustrating a configuration of the fluid device according to a third embodiment of the present invention.

FIG. 7 includes reference signs 701 to 704 that designate diagrams illustrating the steps included in the method of producing the fluid device depicted in FIG. 6.

FIG. 8 is a diagram illustrating a configuration of an electrophoresis device that uses the fluid device depicted in FIG. 6.

FIG. 9 is a graph illustrating the results of verifying the advantageous effects of the fluid device according to the embodiments of the present invention.

Description of Embodiments

[0011]

Modes (embodiments) for implementing the present invention will now be described in detail while referring to the accompanying drawings as appropriate. A fluid device according to the embodiments of the present invention is to be mounted on an analyzer for use. The fluid device can be utilized for any analyzer including an electrophoresis device that will be described in detail later. In such an analyzer, the fluid device according to the embodiments of the present invention is able to function as, for example, a reagent liquid delivery section, an optical cell, or a microreactor.

[0012]

First Embodiment

(Fluid Device)

FIG. 1 is a diagram illustrating a configuration of the fluid device 1A according to a first embodiment of the present invention.

As depicted in FIG. 1, the fluid device 1A is also called a polymer block and is a rectangular parallelepiped composed of resin. As will be described later, the fluid device 1A according to the present embodiment uses a resin substrate 11 (see FIG. 3) as a base, and has a flow path 23A formed therein. The resin substrate 11 corresponds to a "resin block."

[0013]

The flow path 23A has a circular cross-section and is tubular. Further, in the present embodiment, the inner diameter of the flow path 23A is assumed to be 0.5 mm or more and 5 mm or less. However, the inner diameter of flow path 23A is not limited to this, and can be changed as appropriate in accordance with the properties of a fluid flowing through the flow path 23A.

Furthermore, the aspect ratio of the inner diameter to the length of the flow path 23A (length/inner diameter) is 10 or greater.

[0014]

Moreover, the roughness of the inner wall surface of the flow path 23A over the entire longitudinal area is 0.5 μm or less in terms of arithmetic mean roughness (R_a) compliant with ISO 4287-1997. Additionally, the standard deviation of the roughness of the inner wall surface of the flow path 23A over the entire longitudinal area is 0.1 μm or less in terms of root mean square height (S_q) compliant with ISO 25178.

The technical significance of the inner wall surface of the flow path 23A of the fluid device 1A according to the present embodiment having such surface roughness will be explained in detail below along with operational advantages of the fluid device 1A.

[0015]

The resin composing the fluid device 1A according to the present embodiment is assumed to be acrylic resin. However, the resin composing the fluid device 1A is not limited to this, and hard transparent resin can also be used.

Examples of hard transparent resins include, but are not limited to, polycarbonate, polyarylate, polysulfone, polyimide, polyetherimide, and norbornene resin.

[0016]

(Production Method)

A method of producing the fluid device 1A (see FIG. 1) will now be described.

Reference signs 201 to 204 in FIG. 2 designate diagrams illustrating the steps included in the method of producing the fluid device 1A depicted in FIG. 1.

The production method according to the present embodiment includes the steps of: preparing the resin substrate 11 (resin block) depicted in the diagram designated by reference sign 201 in FIG. 2; forming a through-hole 20A having a circular cross-section in the resin substrate 11 (resin block) as depicted in the diagram designated by reference sign 202 in FIG. 2; and aspirating from one end 21a of the through-hole 20A while introducing

the vapor of an organic solvent from the other end 21b as depicted in the diagram designated by reference sign 203 in FIG. 2.

[0017]

As a result, as indicated by the arrow V_{IN} in the diagram designated by reference sign 203 in FIG. 2, the vapor of the organic solvent flows at a predetermined flow rate through the through-hole 20A, which is at a reduced pressure lower than atmospheric pressure, and is discharged from the resin substrate 11 as indicated by the arrow V_{OUT} . In this instance, the vapor of the organic solvent dissolves or softens a fine resin convex portion (not depicted) of a rough surface of the through-hole 20A without liquefying, and levels off the convex portion along the direction of vapor flow. This smooths the rough surface of the through-hole 20A, which is formed with fine irregularities, and thus completes the fluid device 1A having the flow path 23A depicted in the diagram designated by reference sign 204 in FIG 2.

[0018]

In the present embodiment, the resin substrate 11 (resin block) is assumed to have a rectangular parallelepiped shape in a plan view, but is not limited to this as long as the flow path 23A can be formed therein. Other three-dimensional shapes, such as a polygonal prism shape, a cylindrical shape, a disk shape, a spherical shape, can also be used.

[0019]

In the present embodiment, the method of forming the through-hole 20A in the resin substrate 11 (resin block) is assumed to be machining. Specifically, the assumed method is to form a hole (through-hole 20A) having a predetermined inner diameter by using a drill or other tool so as to linearly penetrate the resin substrate 11 (resin block).

The cross-sectional shape of this through-hole 20A is formed in a shape close to the cross-sectional shape of the flow path 23A depicted in FIG. 1, and the aspect ratio is 10 or more.

However, the method of forming the through-hole 20A in the resin substrate 11 (resin block) is not limited to machining, and as will be described later, the resin substrate 11 (resin block) having the through-hole 20A can also be formed by a three-dimensional printer.

[0020]

Methods of introducing the vapor of the organic solvent into the through-hole 20A (see the diagram designated by reference sign 203 in FIG. 2) include, for example, a method of retaining the vapor of the organic solvent in the gas phase section of a bathtub containing the organic solvent at the bottom and introducing the vapor of the organic solvent into the through-hole 20A.

When such a method is to be adopted, it is desirable that saturated vapor of the organic solvent be generated in the gas phase section of the bathtub at a temperature lower than the temperature inside the through-hole 20A, that is, the temperature of the resin substrate 11 (resin block).

[0021]

Subsequently, as depicted in the diagram designated by reference sign 203 in FIG. 2, for example, a vacuum pump is used to aspirate from the one end 21a of the through-hole 20A while introducing the saturated vapor of the organic solvent from the other end 21b. This lowers the internal pressure applied to the through-hole 20A to a level lower than atmospheric pressure, and thus makes it possible to more reliably prevent the vapor of the organic solvent from liquefying inside the through-hole 20A.

In the present embodiment, the temperature of the resin substrate 11 (resin block) in the step designated by the reference sign 203 in FIG. 2 is assumed to be room temperature (25°C), but it can alternatively be set to a temperature higher than room temperature (25°C). When such an alternative temperature setting is adopted, the temperature of the organic solvent in the gas phase section of the bathtub can be set to a temperature lower than the temperature of the resin substrate 11 (resin block) and higher than room temperature (25°C).

[0022]

In the present embodiment, the organic solvent is assumed to be dichloromethane, which is capable of dissolving or softening the acrylic resin composing the resin substrate 11 (resin block), but is not limited to this. Therefore, the organic solvent to be selected may be the one that generates vapor capable of dissolving or softening the resin depending on the type of resin composing the resin

block, preferably at room temperature (25°C) under atmospheric pressure.

Examples of such organic solvents include, but are not limited to, halogenated hydrocarbon of a low carbon number, ketone of a low carbon number (e.g., acetone), and cyclic ether (e.g., tetrahydrofuran).

[0023]

The diagram designated by reference sign 301 in FIG. 3 is a cross-sectional view taken along line IIIa-IIIa of the diagram designated by reference sign 204 in FIG. 2. The diagram designated by reference sign 302 in FIG. 3 is a cross-sectional view illustrating a modified example of the flow path depicted in the diagram designated by reference sign 301 in FIG. 3.

The production method described above smoothes the inner wall surface of the through hole 20A (see the diagram designated by the reference sign 203 in FIG. 2) along the entire longitudinal direction, and forms the flow path 23A having a circular cross-section and an aspect ratio of 10 or more inside the resin substrate 11 (resin block) depicted in the diagram designated by reference sign 204 in FIG. 2.

[0024]

Further, the flow path 23A depicted in the diagram designated by reference sign 301 in FIG. 3 has an inner wall surface 23A1 having an arithmetic mean roughness of 0.5 μm or less with a standard deviation is 0.1 μm or less.

Furthermore, as depicted in the diagram designated by reference sign 302 in FIG. 3, it is assumed that a coating

layer L composed of a SiO₂ film is to be formed on the inner wall surface 23A1 of the flow path 23A.

The SiO₂ film, which is used for coating the inner wall surface 23A1, is formed by applying a dispersion of SiO₂ particles or a silicon alkoxide solution to the smoothed inner wall surface 23A1.

[0025]

The SiO₂ film using the dispersion of SiO₂ particles is formed by evaporating a dispersion medium from the dispersion of SiO₂ particles, which is applied to the inner wall surface 23A1. The SiO₂ film using the silicon alkoxide solution is formed by a hydrolysis reaction of silicon alkoxide on the inner wall surface 23A1. Examples of silicon alkoxide include, but are not limited to, tetramethoxysilane, tetraethoxysilane, tetraisopropoxysilane, and tetrapropoxysilane.

[0026]

(Operational Advantages)

The following describes the operational advantages that are provided by the fluid device 1A according to the present embodiment and by the production method for the same.

The fluid device 1A according to the present embodiment has a flow path 23A that is internally positioned and has an aspect ratio, which is the ratio of length to diameter, of 10 or more, a cross-section shaped like a circular tube, and an arithmetic mean roughness of the inner wall surface 23A1 of the flow path 23A of 0.5 μm or less with a standard deviation of 0.1 μm or less.

Having an aspect ratio of 10 or more, the fluid device 1A allows a reagent and sample (specimen) to remain in the flow path 23A for a long time. As a result, the fluid device 1A is able to thoroughly mix the reagent and sample (specimen) in the flow path 23A and allow them to react. This effect is advantageous when the fluid device 1A functions as a liquid delivery section of an analyzer or as a microreactor.

[0027]

Further, since the cross-sectional shape of the flow path 23A is circular, the flow path 23A in the fluid device 1A has no corners unlike conventional fluid devices (see, for example, Patent Literature 1). This allows the fluid device 1A to reduce flow path resistance when the fluid flows through the flow path 23A. Furthermore, since the flow path 23A in the fluid device 1A has no corners, the fluid device 1A prevents bubbles from adhering to the inner wall surface without affecting the flow of fluid.

[0028]

Moreover, since the fluid device 1A has an arithmetic mean roughness of the inner wall surface of the flow path 23A of 0.5 μm or less with a standard deviation of 0.1 μm or less, the fluid device 1A is able to not only inhibit the bubbles from adhering to the inner wall surface of the flow path 23A, but also inhibit the adhesion of chemical compounds contained in the reagent and biological materials contained in the sample. Therefore, the fluid device 1A is able to prevent a decrease in the reliability of analysis

results due to gradual accumulation of chemical compounds and biological materials on the inner wall surface of the flow path 23A. Additionally, the fluid device 1A is also able to more reliably prevent the chemical compounds and biological materials from gradually accumulating and blocking the flow path 23A.

[0029]

Further, if the surface roughness of the inner wall surface of the flow path is large even locally unlike the fluid device 1A according to the present embodiment, the chemical compounds and biological materials may easily adhere to such portions. The chemical compounds and biological materials gradually accumulate, and thus decrease the reliability of analysis results and block the flow path.

These effects are advantageous when the fluid device 1A functions as the liquid delivery section of an analyzer or as a microreactor.

[0030]

Furthermore, light scattering on the surface of the flow path 23A in the fluid device 1A is reduced because the arithmetic mean roughness of the inner wall surface of the flow path 23A is 0.5 μm or less. This improves the reaction efficiency of photochemical reaction of the reagent and sample in the flow path 23A in the fluid device 1A. Moreover, since the arithmetic mean roughness of the inner wall surface of the flow path 23A is 0.5 μm or less, the fluid device 1A improves the light detection sensitivity of luminescent reactions within the flow path 23A.

These effects are advantageous when the fluid device 1A functions as an optical cell in an analyzer.

[0031]

Additionally, it is desirable that acrylic resin be used as the resin for the above-described fluid device 1A.

The fluid device 1A described above provides excellent moldability of the resin substrate 11 (resin block), which serves as the base, and makes it easy to perform machining for forming the through-hole 20A in the resin substrate 11. Further, the fluid device 1A widens the range of organic solvent selection for introduction into the through-hole 20A.

[0032]

Furthermore, in the above-described fluid device 1A, it is desirable that the inner wall surface 23A1 of the flow path 23A be coated with a SiO₂ film.

The fluid device 1A increases the surface energy of the flow path 23A, and is thus able to more reliably inhibit the adhesion of bubbles.

[0033]

Moreover, the production method for the above-described fluid device 1A is a method of producing the fluid device 1A having the flow path 23A that is internally positioned and has an aspect ratio, which is the ratio of length to diameter, of 10 or more, a cross-section shaped like a circular tube, and an arithmetic mean roughness of the inner wall surface of the flow path 23A of 0.5 μm or less with a standard deviation of 0.1 μm or less. This method includes the steps of: forming a through-hole 20A

with a circular cross-sectional shape in the base formed by the resin substrate 11 (resin block); and aspirating from the one end 21a of the through-hole 20A while introducing the vapor of the organic solvent from the other end 21b.

[0034]

The production method described above introduces the vapor of the organic solvent into the through hole 20A by aspirating from the one end 21a of the through-hole 20A. Therefore, the vapor of the organic solvent can be easily introduced even into through-hole 20A with a high aspect ratio of 10 or more.

[0035]

Further, the production method described above introduces the vapor of the organic solvent into the through-hole 20A by aspirating from the one end 21a of the through-hole 20A. Therefore, the vapor of the organic solvent is introduced into the through-hole 20A at a reduced pressure lower than atmospheric pressure. This inhibits the vapor of the organic solvent from liquefying inside the through-hole 20A. The flow path 23A is smoothed without deformation in the entire longitudinal area.

Furthermore, the production method described above is able to reliably and efficiently produce the fluid device 1A having the flow path 23A that is internally positioned and has an aspect ratio, which is the ratio of length to diameter, of 10 or more, a cross-section shaped like a circular tube, and an arithmetic mean roughness of the inner

wall surface of the flow path 23A of 0.5 μm or less with a standard deviation of 0.1 μm or less.

[0036]

Moreover, when the production method for the above-described fluid device 1A is adopted, it is desirable that the through-hole 20A be formed by machining the resin substrate 11 (resin block).

The production method described above is able to easily and accurately form the through-hole 20A having a predetermined aspect ratio in the resin substrate 11 (resin block).

[0037]

Additionally, when the production method for the above-described fluid device 1A is adopted, it is desirable that acrylic resin be used as the resin composing the resin substrate 11 (resin block), and that dichloromethane be used as the organic solvent.

The production method described above is able to efficiently form the flow path 23A in the resin substrate 11 (resin block) having an arithmetic mean roughness of the inner wall surface of 0.5 μm or less with a standard deviation of 0.1 μm or less.

[0038]

Further, it is desirable that the production method for the above-described fluid device 1A additionally include a step of forming a SiO_2 film on the inner wall surface of the through-hole 20A subsequently to the step of introducing the vapor of the organic solvent into the through-hole 20A.

The production method described above is able to form the flow path 23A having a high surface energy by using the SiO₂ film. This more reliably prevents the bubbles from adhering to the flow path 23A of the fluid device 1A.

[0039]

Second Embodiment

(Fluid Device)

The fluid device according to a second embodiment will now be described.

Component elements identical with those of the fluid device 1A (see FIG. 1) according to the first embodiment are designated by the same reference signs as the corresponding component elements in the first embodiment and will not be redundantly described in detail.

[0040]

FIG. 4 is a diagram illustrating a configuration of the fluid device 1B according to the second embodiment of the present invention.

As depicted in FIG. 4, the fluid device 1B is formed in such a manner as to bend a flow path 23B that is formed inside the resin substrate 11 (resin block) composed of acrylic resin. However, the material of the resin substrate 11 is not limited to acrylic resin. The above-mentioned hard transparent resin can also be used for the resin substrate 11.

[0041]

The flow path 23B includes a first flow path section 23B1 and a second flow path section 23B2. These flow path

sections 23B1, 23B2 both extend linearly. The first flow path section 23B1 and the second flow path section 23B2 communicate with each other inside the resin substrate 11 (resin block) in such a manner as to form an included angle with each other. As a result, the flow path 23B forms a single hole for integrating the first flow path section 23B1 and the second flow path section 23B2 to form a single hole that penetrates the resin substrate 11 (resin block).

The angle formed between the first flow path section 23B1 and the second flow path section 23B2 can be set in the range of more than 0 degrees and less than 180 degrees. However, the angle formed between the first flow path section 23B1 and the second flow path section 23B2 in the present embodiment is set to 120 degrees.

[0042]

The cross-sectional shape of the above-described flow path 23B is circular. In the present embodiment, the inner diameter of the flow path 23B is assumed to be 0.5 mm or more and 5 mm or less. However, the inner diameter of the flow path 23B is not limited to this, and can be changed as appropriate in accordance with the properties of the fluid flowing through the flow path 23B.

Further, the aspect ratio of the inner diameter to the length of the flow path 23B (length/inner diameter) is 10 or more.

[0043]

Furthermore, the roughness of the inner wall surface of the flow path 23B over the entire longitudinal area is

0.5 μm or less in terms of arithmetic mean roughness (Ra) compliant with ISO 4287-1997. Moreover, the standard deviation of the roughness of the inner wall surface of the flow path 23B over the entire longitudinal area is 0.1 μm or less in terms of root mean square height (Sq) compliant with ISO 25178.

Additionally, it is assumed that the coating layer L (see the diagram designated by reference sign 302 in FIG. 3) composed of a SiO_2 film is provided on the inner wall surface of the flow path 23B for coating the inner wall surface.

[0044]

(Production Method)

A method of producing the fluid device 1B (see FIG. 4) will now be described.

Reference signs 501 to 504 in FIG. 5 designate diagrams illustrating the steps included in the method of producing the fluid device 1B depicted in FIG. 4.

The production method according to the present embodiment includes the steps of: preparing the resin substrate 11 (resin block) depicted in the diagram designated by reference sign 501 in FIG. 5; forming a through-hole 20B having a circular cross-section in the resin substrate 11 (resin block) as depicted in the diagram designated by reference sign 502 in FIG. 5; and aspirating from the one end 21c of the through-hole 20B while introducing the vapor of the organic solvent from the other

end 21d as depicted in the diagram designated by reference sign 503 in FIG. 5.

[0045]

In the step of forming the through hole 20B depicted in the diagram designated by the reference sign 502 in FIG 5, the through-hole 20B, which is bent, is bored and formed from both the one end 21c and the other end 21d by using a drill or other tool.

Further, in the step introducing the vapor of the organic solvent into the through-hole 20B, as indicated by the arrow V_{IN} in the diagram designated by reference sign 503 in FIG. 5, the vapor of the organic solvent flows at a predetermined flow rate through the through-hole 20B, which is at a reduced pressure lower than atmospheric pressure, and is discharged from the resin substrate 11 as indicated by the arrow V_{OUT} . In this instance, the vapor of the organic solvent dissolves or softens the fine resin convex portion (not depicted) of a rough surface of the through-hole 20B without liquefying, and levels off the convex portion along the direction of vapor flow. This smooths the rough surface of the through-hole 20B, which is formed with fine irregularities, and thus completes the fluid device 1B having the flow path 23B depicted in the diagram designated by reference sign 504 in FIG 5.

[0046]

(Operational Advantages)

The following describes the operational advantages that are provided by the fluid device 1B according to the present embodiment and by the production method for the same.

The fluid device 1B according to the present embodiment has a flow path 23B that is internally positioned and has an aspect ratio, which is the ratio of length to diameter, of 10 or more, a cross-section shaped like a circular tube, and an arithmetic mean roughness of the inner wall surface of the flow path 23B of 0.5 μm or less with a standard deviation of 0.1 μm or less. Therefore, the fluid device 1B is able to provide the operational advantages similar to those provided by the fluid device 1A according to the first embodiment described earlier.

[0047]

Further, the flow path 23B of the fluid device 1B according to the present embodiment is bent.

The fluid device 1B and its production method are capable of changing the locations of the fluid outlet and inlet of the flow path 23B of the fluid device 1B by changing the angle formed between the first flow path section 23B1 and the second flow path section 23B2. The fluid device 1B and its production method are capable of obtaining a fluid device that allows for greater freedom in placement within an analyzer.

[0048]

Third Embodiment
(Fluid Device)

The fluid device according to a third embodiment will now be described

Component elements identical with those of the fluid device 1A (see FIG. 1) according to the first embodiment are designated by the same reference signs as the corresponding component elements in the first embodiment and will not be redundantly described in detail.

[0049]

FIG. 6 is a diagram illustrating a configuration of a fluid device 1C according to the third embodiment of the present invention.

As depicted in FIG. 6, the fluid device 1C has a flow path 23C that is formed inside the resin substrate 11 (resin block) composed of acrylic resin. However, the material of the resin substrate 11 is not limited to acrylic resin. The above-mentioned hard transparent resin can also be used for the resin substrate 11.

In the present embodiment, the resin substrate 11 (resin block) is shaped like a rectangular parallelepiped.

The flow path 23C includes a plurality of flow paths, namely, a flow path 23C1, a flow path 23C2, a flow path 23C3, and a flow path 23C4.

[0050]

Further, the fluid device 1C has concave portions 24, 25 that are open to the surface of the resin substrate 11 (resin block). These two concave portions 24, 25 are formed as cylindrical spaces with bottoms. The surface to which the concave portion 24 is open and the surface to which the

concave portion 25 is open are positioned perpendicular to each other.

[0051]

The flow path 23C1 extends linearly from one side surface of the resin substrate 11 toward the inside of the resin substrate 11.

The flow path 23C2 has its base end at an end of the flow path 23C1 formed inside the resin substrate 11, and extends to form an L shape with the flow path 23C1. The tip of the flow path 23C2 is connected to the bottom surface of the concave portion 25.

The flow path 23C3 extends linearly from one end connected to the bottom surface of the concave portion 24 toward the inside of the resin substrate 11. The other end of the flow path 23C3 is connected to the inner circumferential surface of the concave portion 24.

[0052]

The flow path 23C4 extends linearly from one side surface of the resin substrate 11 toward the inside of the resin substrate 11 so as to be parallel to the flow path 23C1, and is connected to the inner circumferential surface of the concave portion 24.

That is, the fluid device 1C is configured such that the flow path 23C is formed by the plurality of flow paths, namely, the flow path 23C1, the flow path 23C2, the flow path 23C3, and the flow path 23C4, and that the flow path 23C2 and the flow path 23C3 communicate with each other through the concave portion 25, and further that the flow

path 23C3 and the flow path 23C4 communicate with each other through the concave portion 24.

[0053]

The cross-sectional shape of the above-described flow path 23C is circular. In the present embodiment, the inner diameter of the flow path 23B is assumed to be 0.5 mm or more and 5 mm or less. However, the inner diameter of the flow path 23C is not limited to this, and can be changed as appropriate in accordance with the properties of the fluid flowing through the flow path 23C.

Further, the aspect ratio of the inner diameter to the length of the flow path 23C (length/inner diameter) is 10 or more.

[0054]

Furthermore, the roughness of the inner wall surface of the flow path 23C over the entire longitudinal area is 0.5 μm or less in terms of arithmetic mean roughness (Ra) compliant with ISO 4287-1997. Moreover, the standard deviation of the roughness of the inner wall surface of the flow path 23C over the entire longitudinal area is 0.1 μm or less in terms of root mean square height (Sq) compliant with ISO 25178.

Additionally, the arithmetic mean roughness (Ra) of the inner wall surfaces of the concave portions 24, 25 is also 0.5 μm or less, and the root mean square height (Sq) thereof is 0.1 μm or less.

Further, it is assumed that the coating layer L (see the diagram designated by reference sign 302 in FIG. 3)

composed of a SiO₂ film is provided on the inner wall surface of the flow path 23C and on the inner wall surfaces of the concave portions 24, 25 for the purpose of coating such inner wall surfaces.

[0055]

(Production Method)

A method of producing the fluid device 1C (see FIG. 6) will now be described.

Reference signs 701 to 704 in FIG. 7 designate diagrams illustrating the steps included in the method of producing the fluid device 1C depicted in FIG. 6.

The production method according to the present embodiment includes the steps of: preparing the resin substrate 11 (resin block) depicted in the diagram designated by reference sign 701 in FIG. 7; forming a through-hole 20C having a circular cross-section in the resin substrate 11 (resin block) as depicted in the diagram designated by reference sign 702 in FIG. 7; and aspirating from one ends 21e, 21f, 21g of the through-hole 20C while introducing the vapor of the organic solvent into the through-hole 20C as depicted in the diagram designated by reference sign 703 in FIG. 7.

[0056]

The production method described above forms the concave portions 24, 25 in the resin substrate 11 by using a drill or other tool. Subsequently, the through-hole 20C having a circular cross-section is formed by machining. In the step of forming the through-hole 20C depicted in the

diagram designated by the reference sign 702 in FIG 7, a through-hole 20C1 is bored and formed from one end 21h of the through-hole 20C1 by using a drill or other tool. A through-hole 20C2 is bored and formed from the one end 21e of the through-hole 20C2 by using a drill or other tool. A through-hole 20C3 is bored and formed from the one end 21f of the through-hole 20C3 by using a drill or other tool. A through-hole 20C4 is bored and formed from the one end 21g of the through-hole 20C4 by using a drill or other tool.

[0057]

Further, in the process of introducing the vapor of the organic solvent into the through-hole 20C, as depicted in the diagram designated by reference sign 703 in FIG. 7, the through-holes 20C1, 20C2 and the through-hole 20C3 are aspirated through the concave portion 25, which communicates between the one end 21e of the through-hole 20C1 and the one end 21f of the through-hole 20C3. The through-hole 20C4 is aspirated through the one end 21g. As a result, the vapor of the organic solvent is introduced from the concave portion 24 and the one end 21h of the through-hole 20C1 at a reduced pressure lower than atmospheric pressure as indicated by reference sign V_{IN} in the diagram designated by reference sign 703 in FIG. 7, and is discharged from the concave portion 25 and the one end 21g of the through-hole 20C4 as indicated by reference sign V_{OUT} .

[0058]

In the above instance, the vapor of the organic solvent dissolves or softens the fine resin convex portion

(not depicted) of a rough surface of the through-hole 20C (see the diagram designated by reference sign 702 in FIG. 7) without liquefying, and levels off the convex portion along the direction of vapor flow. This smooths the rough surface of the through-hole 20C (see the diagram designated by reference sign 702 in FIG. 7), which is formed with fine irregularities, and thus completes the fluid device 1C (see FIG 6) having the flow path 23C depicted in the diagram designated by reference sign 704 in FIG 7.

[0059]

(Electrophoresis Device)

An electrophoresis device that uses the fluid device 1C (see FIG. 6) according to the present embodiment will now be described.

FIG. 8 is a diagram illustrating a configuration of a capillary electrophoresis device Ap (hereinafter simply referred to as the "electrophoresis device Ap") that is an example of the analyzer. The electrophoresis device Ap is used, for example, as a DNA sequencer or a DNA fragment analyzer.

As depicted in FIG. 8, the electrophoresis device Ap mainly includes the fluid device 1C, a capillary 26, a reagent bottle 31, a container 32, a container 33, a high-voltage power supply 50, and a laser light source 60.

[0060]

The capillary 26 has a sample injection end 26a and a capillary main body 26b having the sample injection end 26a at one end. The other end of the capillary main body 26b is

to be immersed in a later-described reagent that is to be filled into the container 32. The sample injection end 26a is attached to the concave portion 25 of the fluid device 1C. A cathode 52 is disposed within the container 32.

The reagent bottle 31 is attached to the one end 21g of the flow path 23C4 of the fluid device 1C through a valve 41. The reagent bottle 31 in the present embodiment is assumed to store a buffer gel as the reagent.

[0061]

The container 33 is attached to the one end 21h of the flow path 23C1 through a valve 43.

The container 33 is to be filled with the reagent from the reagent bottle 31 as will be described later.

An anode 53 is disposed in the container 33. The high-voltage power supply 50 applies a voltage between the cathode 52 and the anode 53.

The laser light source 60 irradiates a predetermined position 62 of the capillary main body 26b with a laser beam 61.

[0062]

Operations performed by the electrophoresis device Ap will now be described mainly with reference to FIG. 8.

The fluid device 1C of the electrophoresis device Ap functions as a liquid delivery device for the reagent stored in the reagent bottle 31.

A motor-driven plunger pump (not depicted) is attached to the opening of the concave portion 24 of the fluid device 1C.

[0063]

In the electrophoresis device Ap, when the plunger pump is driven to aspirate with the sample injection end 26a closed, the valve 43 closed, and the valve 41 opened, the reagent in the reagent bottle 31 is filled into the concave portion 24.

Subsequently, when the plunger pump is driven to push the reagent out of the concave portion 24 with the valve 41 closed and the sample injection end 26a opened, the reagent in the concave portion 24 is transferred to the container 32 through the capillary 26. When the above operation is repeated as needed, the container 32 is filled with the reagent to the extent that the tip of the capillary 26 is immersed. The cathode 52 is immersed in the reagent. The hollow portion of the capillary 26 is then entirely filled with the reagent.

[0064]

Next, in the electrophoresis device Ap, when the plunger pump is driven to aspirate with the sample injection end 26a closed, the valve 43 closed, and the valve 41 opened, the reagent in the reagent bottle 31 is filled into the concave portion 24.

Subsequently, when the plunger pump is driven to push the reagent out of the concave portion 24 with the valve 41 closed and valve 43 opened, the reagent in the concave portion 24 is transferred to the container 33 through the flow path 23C3, the flow path 23C2, and the flow path 23C1, and then through the capillary 26. When the above operation

is repeated as needed, at least the container 33, the flow paths 23C1, 23C2, and the concave portion 25 are filled with the reagent.

Subsequently, when the valve 43 and the sample injection end 26a are opened, an electrophoresis path is formed between the cathode 52 and the anode 53 via the reagent.

[0065]

When an analysis method using the electrophoresis device Ap is adopted, a sample containing, for example, a plurality of types of ingredients (such as DNA fragments) labeled with a plurality of types of phosphors is injected into the sample injection end 26a.

Subsequently, when a voltage is applied between the cathode 52 and the anode 53, negatively charged ingredients (such as DNA fragments) contained in the sample are electrophoresed in the capillary main body 26b from the sample injection end 26a toward the container 32.

[0066]

Due to differences in mobility during electrophoresis, the plurality of types of ingredients contained in the specimen are gradually separated. The position 62 of the capillary main body 26b, which is reached upon electrophoresis over a predetermined distance, is irradiated with the laser beam 61 emitted from the laser light source 60. The laser beam 61 promotes fluorescent emission by the plurality of types of phosphors labeled by the ingredients that sequentially pass through the position 62.

Fluorescence that changes with time as a result of electrophoresis is measured by a multicolor detection device (not depicted) that detects light with a plurality of types of wavelength bands.

[0067]

(Operational Advantages)

The following describes the operational advantages that are provided by the fluid device 1C according to the present embodiment, by the production method for the same, and by the electrophoresis device using the same.

The fluid device 1C according to the present embodiment is a fluid device 1C composed of resin that is included in an analyzer, and has a plurality of flow paths 23C1, 23C2, 23C3, 23C4 that are internally positioned and have an aspect ratio, which is the ratio of length to diameter, of 10 or more and a circular tubular cross-sectional shape. The flow paths 23C1, 23C2, 23C3, 23C4 have an arithmetic mean roughness of the inner wall surfaces of 0.5 μm or less with a standard deviation of 0.1 μm or less.

[0068]

The fluid device 1C described above has a flow path 23C that is internally positioned and has an aspect ratio, which is the ratio of length to diameter, of 10 or more, a cross-section shaped like a circular tube, and an arithmetic mean roughness of the inner wall surface of the flow path 23C of 0.5 μm or less with a standard deviation of 0.1 μm or less. Therefore, the fluid device 1C is able to provide the operational advantages similar to those provided by the

fluid device 1A according to the first embodiment described earlier.

Further, the fluid device 1C has the plurality of flow paths 23C1, 23C2, 23C3, 23C4, and thus allows for diversification of fluid flow paths within the fluid device 1C.

[0069]

Furthermore, it is desirable that acrylic resin be used as the resin for the above-described fluid device 1C.

The fluid device 1C described above provides excellent moldability of the resin substrate 11 (resin block), which serves as the base, and makes it easy to perform machining for forming the through-hole 20C in the resin substrate 11. Moreover, the fluid device 1C widens the range of organic solvent selection for introduction into the through-hole 20C.

[0070]

Additionally, in the above-described fluid device 1C, the inner wall surface of the flow path 23C is assumed to be coated with a SiO₂ film.

The fluid device 1C increases the surface energy of the inner wall surface of the flow path 23C, and is thus able to more reliably inhibit the adhesion of bubbles.

[0071]

Further, in the above-described fluid device 1C, the inner wall surfaces of the concave portions 24, 25 are assumed to be coated with a SiO₂ film.

The fluid device 1C increases the surface energy of the inner wall surfaces of the concave portions 24, 25, and

is thus able to more reliably inhibit the adhesion of bubbles.

[0072]

Furthermore, in the above-described fluid device 1C, the flow path 23C is composed of holes penetrating the resin substrate 11 (resin block), and provided with concave portions 24, 25 that are open to the surface of the resin substrate 11 (resin block). At least two of the plurality of flow paths 23C, namely, the flow path 23C2 and the flow path 23C3, communicate with each other through the concave portion 25. Moreover, the flow path 23C3 and the flow path 23C4 communicate with each other through the concave portion 24.

[0073]

The fluid device 1C allows the length of flow path to increase within the resin substrate 11 (resin block). This allows the fluid to remain in the resin substrate 11 (resin block) for a longer period of time.

[0074]

Further, in the fluid device 1C described above, a plurality of concave portions (concave portions 24, 25) are formed in the resin substrate 11 (resin block).

The fluid device 1C allows various parts and devices, such as pumps and capillaries, to be easily mounted through the concave portions 24, 25.

[0075]

The production method for the above-described fluid device 1C includes the steps of: preparing the resin

substrate 11 (resin block); forming the through-hole 20C having a circular cross-section in the resin substrate 11 (resin block); and aspirating from the one ends 21e, 21f, 21g of the through-hole 20C while introducing the vapor of an organic solvent into the through-hole 20C.

Further, when the above-described production method is adopted, the through-hole 20C is formed by machining the resin substrate 11 (resin block).

The production method described above forms the concave portions 24, 25 in the resin substrate 11 by using a drill or other tool. Subsequently, the through-hole 20C having a circular cross-section is formed by machining.

Then, drill marks are formed on the inner wall surfaces of the through-hole 20C and concave portions 24, 25. When the fluid flows through the through-hole 20C in the state described above, bubbles tend to adhere to the inner wall surfaces.

[0076]

Consequently, the production method according to the present embodiment aspirates from the one ends 21e, 21f, 21g of the through-hole 20C while introducing the vapor of the organic solvent into the through-hole 20C. Further, the aspiration from the one ends 21e, 21f is performed through the concave portion 25. The vapor of the organic solvent is introduced into the through-holes 20C3, 20C4 through the concave portion 24.

As a result, the inner wall surfaces of the flow path 23C and concave portions 24, 25 are dissolved to become

smooth. The production method described above is able to produce the fluid device 1C that has the flow path 23C with an inner wall surface having a low surface roughness.

[0077]

Further, when the above-described production method is to be adopted, it is desirable that acrylic resin be used as the resin composing the resin block, and that dichloromethane be used as the organic solvent.

The production method described above is able to efficiently form the flow path 23C in the resin substrate 11 (resin block) with an arithmetic mean roughness of the inner wall surface of 0.5 μm or less and a standard deviation of 0.1 μm or less.

[0078]

Furthermore, it is desirable that the above-described production method additionally include a step of forming a SiO_2 film on the inner wall surface of the through-hole 20C after forming the flow path 23C by performing the step of introducing the vapor of the organic solvent into the through-hole 20C.

The above-described production method is able to form the flow path 23C having a high surface energy by using the SiO_2 film. This more reliably prevents the bubbles from adhering to the flow path 23C of the fluid device 1C.

[0079]

Moreover, the electrophoresis device Ap according to the present embodiment includes the fluid device 1C, and the

flow paths 23C1, 23C2 in the fluid device 1C form part of the flow paths for electrophoresis.

In the electrophoresis device Ap using the machined resin substrate 11 (resin block) depicted in the diagram designated by reference sign 702 in FIG. 7, the bubbles mixed in at the time of reagent aspiration adhere to the inner wall surface of the through-hole 20C that serves as the flow path. As a result, the electrophoresis to be performed through the through-hole 20C is impeded. Additionally, if the attached bubbles are large enough to block the through-holes 20C, the cathode 52 and the anode 53 may become damaged.

[0080]

In contrast, the fluid device 1C used for the electrophoresis device Ap according to the present embodiment does not allow the bubbles to adhere to the inner wall surface of the flow path 23C. Even if large bubbles enter the flow path 23C, they will be pushed out into the containers 32, 33.

Further, the electrophoresis device Ap using the fluid device 1C having a SiO₂ film on the inner wall surfaces of the flow path 23C and concave portions 24, 25 is able to increase the surface energy of such inner wall surfaces, and thus more effectively inhibit the adhesion of bubbles. This allows the electrophoresis device Ap to perform even better electrophoresis.

Examples

[0081]

The following describes the results of verifying the advantageous effects of the fluid device according to the embodiments of the present invention.

(Example 1)

For Example 1, a fluid device 1B depicted in FIG. 4 was fabricated by using acrylic resin.

First, a bent through-hole 20B (see the diagram designated by reference sign 502 in FIG. 5) was formed in a prepared resin substrate 11 (see the diagram designated by reference sign 501 in FIG. 5) by machining using a drill. The through-hole 20B had a length of 50 mm and an inner diameter of 0.8 mm. The aspect ratio (length/inner diameter) of the through-hole 20B was 62.5.

[0082]

Next, as depicted in the diagram designated by reference sign 503 in FIG. 5, aspiration was performed from one end 21c of the through-hole 20B while the vapor of dichloromethane was introduced from the other end 21d. As a result, the fluid device 1B (see the diagram designated by reference sign 504 in FIG. 5) having a flow path 23B (see the diagram designated by reference sign 504 in FIG. 5) with a smoothed inner wall surface was obtained.

The length from one end of the flow path 23B, which served as the vapor inlet, and the roughness of the inner wall surface at a position corresponding to that length were measured in terms of arithmetic mean roughness (Ra) compliant with ISO 4287-1997. The results of measurement are indicated by the graph in FIG. 9.

[0083]

The horizontal axis in FIG. 9 represents the position on one end side of the flow path 23B, that is, the position of the introduction end of the vapor of dichloromethane is regarded as 0 mm, and the position on the other end side of flow path 23B is regarded as 50 mm. The vertical axis in FIG. 9 represents the measured surface roughness [μm] (arithmetic mean roughness (Ra)) of the inner wall surface.

In FIG. 9, the surface roughness [μm] of Example 1, which is indicated by circle marks is concentrated at approximately 0.1 μm or less over the entire longitudinal area of the flow path 23B. Although the maximum value of the surface roughness [μm] (0.4 [μm]) is indicated as a part of the range of 5 mm or less in terms of the length of the introduction end of the vapor of dichloromethane, the surface roughness [μm] is 0.5 [μm] or less. The standard deviation of the roughness of the inner wall surface over the entire longitudinal area of the flow path 23B was 0.1 μm or less in terms of root mean square height (Sq) compliant with ISO 25178.

[0084]

(Comparative Example 1)

For Comparative Example 1, a fluid device was obtained by exposing the resin substrate 11, in which the through-hole 20B depicted in the drawing designated by reference sign 502 in FIG. 5 was formed, to the vapor of dichloromethane in a bathtub without aspirating from one end 21 of the through-hole 20B.

As regards the above-mentioned fluid device, the surface roughness [μm] of the inner wall surface of a flow path was measured in the same manner as for Example 1. The results of measurement are indicated by square marks in the graph of FIG. 9. As depicted in FIG. 9, the surface roughness [μm] of the flow path in the fluid device of Comparative Example 1 was 0.5 μm or more over the entire longitudinal area. That is to say, the inner wall surface of the flow path was not smoothed. Further, the root mean square height (Sq) in compliant with ISO 25178 exceeded 0.1 μm .

[0085]

(Comparative Example 2)

For Comparative Example 2, the resin substrate 11 having the through-hole 20B formed therein as depicted in the drawing designated by reference sign 502 in FIG. 5 was subjected to reaming of the inner wall surface of the through-hole 20B. For Comparative Example 2, the resin substrate 11 was not brought into contact with the vapor of dichloromethane, and the through-hole 20B was merely reamed to fabricate a fluid device.

As regards the above-mentioned fluid device, the surface roughness [μm] of the inner wall surface of a flow path was measured in the same manner as for Example 1. The results of measurement are indicated by triangle marks in the graph of FIG. 9. As depicted in FIG. 9, the surface roughness [μm] of the flow path in the fluid device of Comparative Example 2 was 0.5 μm or less in some places.

However, the surface roughness [μm] significantly varied, and the standard deviation was 0.2 μm or more. Particularly, the surface roughness and the standard deviation significantly varied from a length of 8 mm, which exceeded an aspect ratio of 10.

[0086]

(Evaluation Results)

The fluid device of Comparative Example 1 was fabricated merely by exposing the resin substrate 11 to the vapor of dichloromethane. Therefore, it was confirmed that the inner wall surface of the through-hole 20B could not be smoothed.

Further, the flow path of the fluid device of Comparative Example 1 was formed merely by mechanical polishing of the through-hole 20B. Therefore, it was confirmed that the surface roughness [μm] significantly varied.

In contrast, for the fluid device 1B of Example 1 of the present invention (see the diagram designated by reference sign 504 in FIG. 5), aspiration was performed from one end of the through-hole while the vapor of the organic solvent was introduced from the other end. Consequently, it was verified that the arithmetic mean roughness of the inner wall surface of the flow path 23B was 0.5 μm or less, and that the standard deviation thereof was 0.1 μm or less.

[0087]

Although the embodiments of the present invention have been described above, the present invention is not limited

to the above-described embodiments. Various modifications can be made without departing from the spirit and scope of the present invention.

For the fluid devices 1A, 1B, 1C described in conjunction with the foregoing embodiments, namely, the first to third embodiments, the through-holes 20A, 20B, 20C are formed by machining the resin substrate 11 (resin block). However, the fluid devices 1A, 1B, 1C having the through-holes 20A, 20B, 20C can be fabricated by a three-dimensional printer. Further, the foregoing description assumes that the electrophoresis device Ap according to the embodiments uses the flow path 23C of the fluid device 1C according to the third embodiment as a part of the flow path for electrophoresis. However, the flow paths 23A, 23B of the fluid devices 1A, 1B can also be used as a part of the flow path for electrophoresis.

List of Reference Signs

[0088]

1A, 1B, 1C: Fluid device

20A, 20B, 20C: Through-hole

23A, 23B, 23C: Flow path

11: Resin substrate (resin block)

24, 25: Concave portion

Ap: Electrophoresis device

Claims

[Claim 1]

A fluid device that is composed of resin and is to be mounted on an analyzer, the fluid device comprising:

a flow path that is internally positioned and has an aspect ratio, namely, the ratio of length to diameter, of 10 or more and a cross-section shaped like a circular tube;

wherein the arithmetic mean roughness of an inner wall surface of the flow path is 0.5 μm or less, and the standard deviation thereof is 0.1 μm or less.

[Claim 2]

The fluid device according to claim 1, wherein acrylic resin is used as the resin.

[Claim 3]

The fluidic device according to claim 1, wherein the inner wall surface of the flow path is coated with a SiO_2 film.

[Claim 4]

A fluid device that is composed of resin and is to be mounted on an analyzer, the fluid device comprising:

a flow path that is internally positioned and has an aspect ratio, namely, the ratio of length to diameter, of 10 or more and a cross-section shaped like a circular tube;

wherein the arithmetic mean roughness of an inner wall surface of the flow path is 0.5 μm or less, and the standard deviation thereof is 0.1 μm or less.

[Claim 5]

The fluid device according to claim 4, wherein acrylic resin is used as the resin.

[Claim 6]

The fluid device according to claim 4, wherein the inner wall surface of the flow path is coated with a SiO₂ film.

[Claim 7]

The fluid device according to claim 4,
wherein the flow path is composed of holes penetrating a resin block;

the resin block is provided with concave portions that are open to the surface of the resin block; and

at least two of a plurality of the flow paths communicate with each other through the concave portions.

[Claim 8]

The fluid device according to claim 7, wherein a plurality of the concave portions are formed in the resin block.

[Claim 9]

An electrophoresis device comprising:

the fluid device according to claim 1 or 4;

wherein the flow path in the fluid device forms a part of the flow path for electrophoresis.

[Claim 10]

The electrophoresis device according to claim 9, wherein acrylic resin is used as the resin.

[Claim 11]

The electrophoresis device according to claim 9, wherein the inner wall surface of the flow path is coated with a SiO₂ film.

[Claim 12]

The electrophoresis device according to claim 7, wherein the inner wall surfaces of the concave portions are coated with a SiO₂ film.

[Claim 13]

A production method for a fluid device having a flow path that is internally positioned and has an aspect ratio, which is the ratio of length to diameter, of 10 or more, a cross-section shaped like a circular tube, and an arithmetic mean roughness of an inner wall surface of the flow path of 0.5 μm or less with a standard deviation of 0.1 μm or less, the production method comprising the steps of:

forming a through-hole having a cross-section shaped like a circle in a resin block; and

aspirating from one end of the through-hole while introducing the vapor of an organic solvent from the other end.

[Claim 14]

The production method according to claim 13, wherein the through-hole is formed by machining the resin block.

[Claim 15]

The production method according to claim 13, wherein acrylic resin is used as the resin composing the resin block; and dichloromethane is used as the organic solvent.

[Claim 16]

The production method according to claim 13 additionally comprising:

a step of forming a SiO_2 film on the inner wall surface of the through-hole subsequently to the step of introducing the vapor of the organic solvent into the through-hole.