

Description

Title of Invention: CAPILLARY CARTRIDGE AND ASSEMBLING
METHOD THEREFOR

Technical Field

[0001]

This invention relates to a capillary cartridge and an assembling method therefor.

Background Art

[0002]

In a capillary electrophoresis device, the electrophoresis of a sample is performed within a minute tube called a capillary. During electrophoresis, the sample is gradually separated as it moves through the capillary, and the sample contents are optically analyzed at a detection window provided partway along the capillary.

[0003]

Ferrules are often used to connect capillaries to devices (see, for example, Patent Literature 1). Fixation of the capillary via a ferrule to a block in which a flow passage is formed is generally performed as follows.

[0004]

An external thread is formed on the outer peripheral surface of the ferrule, and a tapered surface is formed coaxially therewith. The ferrule has a hole portion drilled therethrough that is slightly larger than the capillary. When the capillary is passed through the hole

portion in the ferrule, there is a minute gap between the inner peripheral surface of the hole portion of the ferrule and the outer peripheral surface of the capillary, thereby allowing the ferrule to move freely in the longitudinal direction of the capillary.

[0005]

The block has a hole portion drilled therethrough, coaxial with the flow passage, an internal thread formed on the inner peripheral surface of the hole portion, and a tapered surface formed coaxially with the hole portion. By screwing the external thread of the ferrule clockwise into the internal thread of the block, the external and internal threads engage with each other and the ferrule is gradually inserted into the block.

Citation List

Patent Literature

[0006]

Patent Literature 1: Japanese Unexamined Patent Application Publication No. 2012-98309

Summary of Invention

Technical Problem

[0007]

When connecting a capillary to a device, the capillary may be fixed in such a manner as to protrude 1 to 2 mm from the ferrule into the flow passage. This is only to protrude such that the capillary is securely held by the ferrule, and the position of the capillary tip is not controlled, meaning it is in an arbitrary position. In

contrast, there are cases where it is necessary to precisely position the tip of the capillary in the flow passage into which the capillary is inserted. In such cases, the following procedure is used to fix the capillary via the ferrule.

[0008]

When the ferrule is screwed clockwise into the block, the tapered surface of the ferrule comes into contact with the tapered surface of the block. At this stage, the capillary inserted into the hole portion in the ferrule can move freely in the axial direction of the hole portion in the ferrule. Therefore, the length of the capillary protruding from the ferrule can be checked using a microscope or the like, and the amount of protrusion of the capillary from the ferrule is adjusted by moving the capillary relative to the ferrule.

[0009]

When the ferrule is further screwed clockwise into the block, a component force is generated in a normal direction of the rotation axis direction of the ferrule in accordance with the taper angle of the tapered surface. The ferrule is subjected to stress and deformed by the component force in the normal direction from the tapered surface, the hole portion drilled in the ferrule becomes uniformly smaller, and the gap between the ferrule and the capillary disappears. Furthermore, by screwing the ferrule into the block, the ferrule deforms to fix the capillary.

[0010]

Since the ferrule is screwed in for fixation after adjusting the amount of protrusion of the capillary in this manner, variation in the tip position of the capillary is unavoidable, and controlling the magnitude of this variation is also difficult. Furthermore, the end of the capillary may rotate along with the rotation of the ferrule, causing part of the capillary to be fixed to the block in a twisted state. In particular, when fastening the ferrule to the block with a large torque, the capillary may twist, causing stress to be applied to the capillary, which may result in breakage of the capillary.

[0011]

The present invention provides a capillary cartridge capable of accurately positioning the tip of the capillary and a method for assembling the same.

Solution to Problem

[0012]

In order to address the above problem, for example, the configurations described in the claims are adopted. The present application includes a plurality of means for solving the above problems, and as one example, a capillary cartridge is provided that includes: a capillary; a first capillary retainer member fixed at a position a predetermined distance from one end of the capillary; and a first block unit including a first member in which a main flow passage is formed and a second member connected to the first member, the first block unit holding the first capillary retainer member by sandwiching the first

capillary retainer member between the first member and the second member. In the capillary cartridge, the first capillary retainer member includes a first hole portion through which the capillary passes, a first tapered portion formed coaxially with the first hole portion, and a first rotation restricting portion having a pressing surface with a predetermined projected shape, the first member includes a second tapered portion connected to the main flow passage and formed coaxially with the main flow passage, and a second rotation restricting portion connected to the second tapered portion. The capillary is connected to the first block unit when the pressing surface of the first rotation restricting portion is pressed by a pressing surface of the second member in a state in which the first rotation restricting portion of the first capillary retainer member is fitted into the second rotation restricting portion of the first member and the first tapered portion of the first capillary retainer member is in contact with the second tapered portion of the first member.

Advantageous Effects of Invention

[0013]

A capillary cartridge capable of accurately positioning the tip of the capillary and a method for assembling the same are provided. Other problems and novel features will be apparent from a description of the present specification and accompanying drawings .

Brief Description of Drawings

[0014]

Fig. 1 is a block diagram illustrating a schematic configuration of a capillary electrophoresis device.

Fig. 2 illustrates the main parts of a capillary cartridge.

Fig. 3A illustrates the configuration of an anode block unit.

Fig. 3B illustrates the configuration of the anode block unit.

Fig. 4 is a cross-sectional view of flow passages formed in an anode block.

Fig. 5 illustrates the configuration of a capillary shell.

Fig. 6A illustrates the configuration of a cathode block unit.

Fig. 6B illustrates the configuration of the cathode block unit.

Fig. 7 is a cross-sectional view of flow passages formed in the cathode block.

Fig. 8 illustrates a state in which the tapered portion of a capillary cathode head and the tapered portion of the cathode block are in contact with each other.

Description of Embodiments

[0015]

Fig. 1 is a block diagram illustrating a schematic configuration of a capillary electrophoresis device. A capillary cartridge (hereinafter referred to as the cartridge) 200 is attached to a capillary electrophoresis device (hereinafter referred to as the electrophoresis

device) 100. Capillaries used in electrophoresis devices may experience accumulation of sample residues inside the capillaries and deterioration of their inner coatings due to repeated electrophoresis, resulting in reduced separation performance. For this reason, the electrophoresis device 100 requires replacement of the cartridge 200 after a certain number of electrophoresis runs. Even if the cartridge 200 is replaced, individual differences in the cartridge 200 must be kept to a minimum so that analysis can be performed with the same accuracy. First, the cartridge 200 will be described.

[0016]

Fig. 2 illustrates the main parts of a capillary cartridge. The cartridge 200 mainly includes a gel unit 401, an anode block unit 410, a capillary shell unit 420, and a cathode block unit 440. Each of these will be explained below.

[0017]

The gel unit 401 is configured to store a polymer aqueous solution, which is a DNA separation medium, and deliver the solution to the anode block unit 410. The inner peripheral surface of a gel syringe 401a and the outer peripheral surface of a gel piston 401b can slide against each other while maintaining sealing. By filling the gel syringe 401a with the polymer aqueous solution and moving the gel piston 401b in the A direction, which is the longitudinal direction of the gel syringe 401a, the polymer aqueous solution stored in the gel syringe 401a is

delivered to a gel tube 402 through a gel coupler 401c.

[0018]

The structure of the anode block unit 410 will be described with reference to Figs. 3A, 3B and 4. The anode block unit 410 is configured to deliver the polymer aqueous solution received through the gel tube 402 to a capillary 421 and apply an anode-side voltage to the polymer aqueous solution in the capillary 421 for electrophoresis. The anode block unit 410 is mainly comprised of an anode block 411, inside which flow passages 418 and 419 are formed (see Fig. 4). In this example, four ports are provided for delivering and discharging the polymer aqueous solution to and from the flow passages in the anode block 411, and one port is provided for applying voltage. Note that the material of the anode block 411 is, for example, polymethyl methacrylate (PMMA).

[0019]

The ports for delivering and discharging liquid are a gel inflow port 412 (see Figs. 2, 3B, and 4), a capillary connection port 413 (see Figs. 3B and 4), a gel pump port 414 (see Figs. 3B and 4), and a gel waste liquid port 415 (see Figs. 3A and 4). The port for applying voltage is an anode electrode port 416 (see Figs. 3B and 4).

[0020]

The gel inflow port 412 receives the polymer aqueous solution through the gel tube 402 and delivers the polymer aqueous solution to the flow passage 418 formed inside the anode block 411. The gel inflow port 412 communicates with

the capillary connection port 413 and the gel pump port 414 via the flow passage 418. The gel pump port 414 communicates with the gel waste liquid port 415 via the flow passage 419. The gel pump port 414 holds a gel pump 417. The inner peripheral surface of the gel pump port 414 and the outer peripheral surface of the gel pump 417 can slide against each other while maintaining sealing. By moving the gel pump 417 in the B direction, which is the longitudinal direction of the gel pump port 414, pressure is applied to the polymer aqueous solution delivered to the interior of the gel pump port 414, and the polymer aqueous solution is delivered to the capillary connection port 413 through the flow passage 418. The capillary connection port 413 is connected to the capillary 421 to which a capillary anode head 422 is fixed.

[0021]

The gel waste liquid port 415 discharges unnecessary polymer aqueous solution remaining inside the anode block 411 to an anode waste tank 501 (see Fig. 1) disposed outside the anode block 411. In addition, an anode electrode 416e connected to the anode electrode port 416 is provided in the flow passage between the flow passage 419 and the gel waste liquid port 415.

[0022]

The structure of the capillary shell unit 420 will be described with reference to Fig. 5. The capillary shell unit 420 has a multi-layer structure including the capillary 421, a heat dissipation sheet 425, a heater unit

426, a heat-insulating material 427, and housings 428 and 429. Each of these will be explained below.

[0023]

The capillary 421 is a glass tube with an inner diameter of several tens of μm and an outer diameter of several hundreds of μm , the outer surface of which is protected by a polyimide coating. The capillary anode head 422 is attached to the end of the capillary 421 on the anode block unit 410 side, and a capillary cathode head 423 is attached to the end of the capillary 421 on the cathode block unit 440 side. In addition, a carriage 424 is disposed closer to the anode block unit than the center of the capillary 421, and the capillary 421 is attached to end points 424a and 424b of the carriage 424. A detection window 421a is provided in the capillary 421 that is attached between the end points 424a and 424b of the carriage 424. The detection window 421a is formed by removing the polyimide on the surface of the capillary 421 by several mm in the longitudinal direction of the capillary 421 to expose the glass tube.

[0024]

The heat dissipation sheet 425 is made of a material with high thermal conductivity, and improves the heat exchange efficiency between the capillary 421 and the heater unit 426. The capillary electrophoresis device utilizes a high heat dissipation performance of the capillary to reduce the effect of Joule heating generated during electrophoresis and improve separation performance.

In general, methods for temperature adjustment of capillaries include methods such as using a temperature-adjusted surface heater on the capillary surface or circulating air adjusted to a constant temperature in a space where the capillary is installed. In the present embodiment, a surface heater is used as an example, but an air circulation type may also be used. The heater unit 426 has a multi-layer structure of a surface heater 426a, a metal plate 426b, and an insulating sheet 426c. The surface heater 426a is controlled by a temperature sensor (not illustrated) installed on the heat dissipation sheet 425, and adjusts the temperature of the heat dissipation sheet 425 to a predetermined temperature. The metal plate 426b diffuses heat from the surface heater 426a within the surface, thereby uniformizing the temperature on the surface. In addition, by using a metal with a high heat capacity as the material for the metal plate 426b, it can be made less susceptible to disturbances such as fluctuations in outside air temperature. The insulating sheet 426c is made of a material with high electrical resistance, and prevents discharge from the capillary 421, to which a high voltage is applied, to the metal plate 426b.

[0025]

The heat-insulating material 427 prevents the heat generated by the heater unit 426 from being dissipated outside the housings 428 and 429, thereby minimizing the influence of the outside air temperature on the temperature

inside the capillary shell unit 420. The housings 428 and 429 hold the capillary 421, the heat dissipation sheet 425, the heater unit 426, and the heat-insulating material 427 in a multi-layer structure.

[0026]

For example, a silicone sheet can be used as the heat dissipation sheet 425, a polyimide heater can be used as the surface heater 426a, an aluminum alloy can be used as the metal plate 426b, a polyimide sheet can be used as the insulating sheet 426c, a low-foam urethane sheet can be used as the heat insulator, and ABS resin can be used for the housings 428 and 429.

[0027]

The structure of the cathode block unit 440 will be described with reference to Figs. 6A, 6B and 7. The cathode block unit 440 is configured to receive the polymer aqueous solution from the capillary 421, receive the buffer solution for electrophoresis, inject the sample DNA into the capillary 421, and apply a cathode-side voltage to the polymer aqueous solution in the capillary 421 for electrophoresis. The cathode block unit 440 is mainly comprised of a cathode block 441, inside which flow passages 450 and 451 are formed (see Fig. 7). In this example, four ports are provided for delivering and discharging the polymer aqueous solution to and from the flow passages in the cathode block 441, two ports are provided for voltage application and electrical measurement, and one port is provided for heating. Note

that the material of the cathode block 441 is also, for example, PMMA.

[0028]

The ports for delivering and discharging liquid are a capillary connection port 442 (see Figs. 6B and 7), a buffer solution inflow port 443 (see Figs. 6A and 7), a sample inflow port 444 (see Figs. 6A, 6B and 7), and a waste liquid port 445 (see Figs. 6A and 7). The port for applying voltage is a cathode electrode port 446 (see Figs. 6B and 7), and the port for electrical measurement is a measurement electrode port 447 (see Figs. 6B and 7). The port for heating is a cathode heater port 448 (see Fig. 6A).

[0029]

Here, the flow passage 450 connecting the capillary connection port 442 and the waste liquid port 445 is referred to as the main flow passage, and the flow passage connecting the sample inflow port 444 and the main flow passage 450 is referred to as the sample flow passage. The flow passages are formed such that the junction point between the main flow passage 450 and the sample flow passage 451 is located closer to the sample inflow port 444. The flow resistance to the upstream side of the main flow passage 450, i.e., the flow resistance toward the sample inflow port 444, is higher than the flow resistance to the downstream side of the main flow passage 450, i.e., the flow resistance toward the waste liquid port 445, and the sample DNA introduced through the sample inflow port

444 mainly flows downstream of the main flow passage 450.

[0030]

The capillary 421 with the capillary cathode head 423 fixed thereto is connected to the capillary connection port 442. The method for connecting the capillary 421 to the capillary connection port 442 will be described later. The capillary connection port 442 receives the polymer aqueous solution delivered from the capillary 421 and delivers the polymer aqueous solution to the main flow passage 450 formed inside the cathode block 441. The buffer solution inflow port 443 receives the buffer solution delivered through a buffer solution tube and delivers the buffer solution to the main flow passage 450 formed inside the cathode block 441. The sample inflow port 444 receives a solution containing sample DNA and buffer solution, and delivers the solution containing sample DNA and buffer solution to the main flow passage 450 through the sample flow passage 451. The waste liquid port 445 delivers unnecessary buffer solution, polymer aqueous solution, and sample DNA remaining in the main flow passage 450 of the cathode block 441 to the outside of the cathode block 441. The waste liquid is discharged into a cathode waste liquid tank 503 (see Fig. 1) through a waste liquid tube 449 (see Fig. 6B) connected to the waste liquid port 445.

[0031]

Here, one of the causes of individual differences in the cartridge 200 is the tip position of the capillary 421 in the flow passage of the cathode block 441. For example,

in the cartridge 200, the measurement electrode port 447 determines the amount of sample DNA injected into the capillary 421. Specifically, the injection quantity is determined from the conductivity of the liquid between a cathode electrode 446e connected to the cathode electrode port 446 and a measurement electrode 447e connected to the measurement electrode port 447, utilizing the fact that the sample DNA is negatively charged. However, variation in the tip position of the capillary 421 affects the determination result. Alternatively, since the capillary 421 in the flow passage is cooled by the sample DNA and buffer solution, variations in the length of the capillary 421 within the flow passage cause variations in the temperature influence on the capillary 421. Furthermore, if the capillary 421 is inserted at an angle to the flow passage, injection failure, in which the sample DNA is not sufficiently injected into the capillary 421, is more likely to occur. To prevent such variations in the performance of the electrophoresis device, it is necessary to suppress the variation in the tip position of the capillary 421 in the flow passage within the block.

[0032]

For this reason, the cartridge according to the present embodiment is configured such that a head (capillary retainer member) is fixed to the capillary without using a ferrule to fix the capillary to the block unit, and the capillary is fixed to the block unit via the head. Hereinafter, the connection of the capillary 421 to

the cathode block 441 will be described as an example.

[0033]

The capillary cathode head 423 is fixed to the capillary 421, and the length (protruding length) from the capillary cathode head 423 to the tip of the capillary is specified as x [mm].

[0034]

As illustrated in Fig. 6A, the capillary cathode head 423 is formed with a head rotation restricting portion 423a and has a hole portion 423b drilled therethrough to allow the capillary 421 to pass through. A tapered portion 423c with a varying cross-sectional area is formed coaxially with the hole portion 423b. In this example, the head rotation restricting portion 423a is rectangular with a long side and a short side. The diameter of the hole portion 423b is slightly larger than the diameter of the capillary 421, and the capillary 421 is passed through the hole portion 423b so that the protruding length is x mm. The capillary cathode head 423 is fixed to the capillary 421 by, for example, injecting adhesive between the inner peripheral surface of the hole portion 423b and the outer peripheral surface of the capillary 421.

[0035]

To connect the capillary 421, to which the capillary cathode head 423 is fixed, to the cathode block 441, the capillary cathode head 423 is mounted while being pressed against the capillary connection port 442 by a cathode knob 431. Hereinafter, how the capillary 421 is fixed to the

cathode block 441 via the capillary cathode head 423 will be explained, roughly divided into the capillary cathode head 423, the cathode block 441, and the cathode knob 431.

[0036]

As illustrated in Fig. 6B, an external thread 442a is formed on the outer peripheral surface of the capillary connection port 442 of the cathode block 441. A rotation restricting portion 442b and a tapered portion 442c are formed inside the capillary connection port 442. The rotation restricting portion 442b is rectangular in shape, the same as the projected shape of the head rotation restricting portion 423a, and has long and short sides.

[0037]

In addition, as illustrated in Figs. 6A and 6B, an internal thread 431a is formed on the inner peripheral surface of the cathode knob 431, and a hole portion 431b is formed therein. The hole portion 431b of the cathode knob 431 is rectangular in shape, the same as the projected shape of the head rotation restricting portion 423a, and has long and short sides.

[0038]

The hole portion 431b of the cathode knob 431 and the rotation restricting portion 442b of the cathode block 441 are each slightly larger than the projected shape of the head rotation restricting portion 423a of the capillary cathode head 423. This allows the capillary cathode head 423 to pass through the hole portion 431b of the cathode knob 431, and allows the head rotation restricting portion

423a of the capillary cathode head 423 to fit into the rotation restricting portion 442b of the cathode block 441.
[0039]

The procedure for connecting the capillary 421 to the cathode block 441 is described below. First, the internal thread 431a of the cathode knob 431 is engaged with the external thread 442a of the cathode block 441, and then screwed in the D direction, which is clockwise, so that the engagement width is maximized (until the cathode knob 431 can no longer move). Next, the cathode knob 431 is rotated 180° in the E direction, which is counterclockwise. That is, the D direction is the direction in which the cathode knob 431 is tightened, and the E direction is the direction in which the cathode knob 431 is loosened. Furthermore, the cathode knob 431 is rotated in the E direction by an angle of less than 180° so that the long side of the hole portion 431b of the cathode knob 431 and the long side of the rotation restricting portion 442b of the cathode block 441 become the same phase.
[0040]

The capillary 421 is inserted into the capillary connection port 442 of the cathode block 441 in this state. That is, the long side of the head rotation restricting portion 423a of the capillary cathode head 423 and the long side of the rotation restricting portion 442b of the cathode block 441 (and therefore, the long side of the hole portion 431b of the cathode knob 431) are brought into the same phase, and the capillary cathode head 423 attached to

the capillary 421 is inserted into the capillary connection port 442 along the C direction, which is the longitudinal direction of the capillary 421. As the capillary cathode head 423 is gradually inserted into the capillary connection port 442, the tapered portion 423c of the capillary cathode head 423 comes into contact with the tapered portion 442c of the cathode block 441. The state at this time is illustrated in Fig. 8.

[0041]

A pressing surface 423d of the capillary cathode head 423 is located further toward the C direction than a pressing surface 431c of the cathode knob 431 engaged with the cathode block 441. Here, the pressing surface 423d of the capillary cathode head 423 is the surface of the head rotation restricting portion 423a facing the surface of the cathode knob 431 where the hole portion 431b is provided (see Figs. 6B and 8). The pressing surface 431c of the cathode knob 431 is the surface of the cathode knob 431 in which the hole portion 431b is provided, and which faces the pressing surface 423d of the capillary cathode head 423 (see Figs. 6A and 8). In addition, the capillary cathode head 423, the cathode block 441, and the cathode knob 431 are formed such that a distance ε between the pressing surface 423d of the capillary cathode head 423 and the pressing surface 431c of the cathode knob 431 engaged with the cathode block 441 at this time becomes smaller than a distance L traveled by the cathode knob 431 in the C direction when rotated 180° in the D direction.

[0042]

When the cathode knob 431 is rotated in the D direction from the state illustrated in Fig. 8, the pressing surface 423d of the capillary cathode head 423 comes into contact with the pressing surface 431c of the cathode knob 431. When the cathode knob 431 is further rotated in the D direction, the cathode knob 431 presses the capillary cathode head 423 against the cathode block 441 and fixes the capillary cathode head 423 in place. Since the relationship $\varepsilon < L$ is established, the cathode knob 431 can reliably fix the capillary cathode head 423. At this time, the tapered portion 423c of the capillary cathode head 423 and the tapered portion 442c of the cathode block 441 come into line contact with each other, thereby generating a sealing force. This enables liquid transfer between the capillary 421 and the cathode block 441 without leakage.

[0043]

In this example, the projected shape of the head rotation restricting portion 423a of the capillary cathode head 423 is a rectangle, which is two-fold symmetric about the central axis of the hole portion 423b, and the rotation restricting portion 442b of the cathode block 441 and the hole portion 431b of the cathode knob 431 have the same shape as the projected shape of the head rotation restricting portion 423a. However, the projection shape is not limited to a rectangle as long as a pressing force is generated between the capillary cathode head 423 and the

cathode knob 431 when the phase is shifted. Although the rectangle is two-fold symmetric, but for example, if the shape has no rotational symmetry, the method for mounting the capillary cathode head 423 to the cathode block 441 is uniquely determined, so that the capillary 421 does not twist between the cathode block unit 440 and the anode block unit 410. However, in this case, when initially engaging the internal thread 431a of the cathode knob 431 with the external thread 442a of the cathode block 441, it is necessary to loosen the cathode knob 431 by 360° and then align the phase between the hole portion 431b of the cathode knob 431 and the rotation restricting portion 442b of the cathode block 441, making the installation work more complicated. Meanwhile, in the case of a figure having three-fold or four-fold symmetry, the amount of rotation of the cathode knob 431 can be reduced, making the installation work easier. However, this increases the likelihood that the capillary cathode head 423 will be installed on the cathode block 441 in a rotated state with respect to the original installation direction. In this case, the capillary 421 is twisted between the cathode block unit 440 and the anode block unit 410. In the case of two-fold symmetry, incorrect mounting would require the capillary 421 to be twisted by 180° , and therefore mounting errors are unlikely to occur.

[0044]

The above describes the procedure for connecting the capillary 421 to the cathode block 441. Similarly, by

mounting the capillary anode head 422 to the anode block 411 while pressing the capillary anode head 422 with an anode knob 430, the capillary 421 is mounted to the anode block 411 via the capillary anode head 422. This mounting method is similar to the procedure for connecting the capillary 421 to the cathode block 441, and therefore will not be described here.

[0045]

The electrophoresis device 100 with the cartridge 200 installed will be described with reference to Fig. 1. A central processing unit (CPU) 310 is configured to control the entire electrophoresis device 100, and is connected to a heater power supply unit 320, a high-voltage power supply unit 330, a pump unit 340, a linear actuator 350, a linear actuator 360, and the like. The heater power supply unit 320 supplies power to the heater unit 426 of the capillary shell unit 420. The high-voltage power supply unit 330 applies a voltage to the polymer aqueous solution in the capillary 421 for electrophoresis, and applies a high potential (HV) to the anode electrode port 416 of the anode block unit 410 and a reference potential (GND) to the cathode electrode port 446 of the cathode block unit 440. The pump unit 340 delivers the buffer solution to the main flow passage 450 of the cathode block 441. Note that a buffer solution tank 502, which contains the buffer solution, is provided in the cartridge 200, and the pump unit 340 pumps the buffer solution in the buffer solution tank 502 toward the buffer solution inflow port 443 of the

cathode block 441. The linear actuator 350 drives the gel piston 401b of the gel unit 401. The linear actuator 360 drives the gel pump 417 of the anode block unit 410.

[0046]

The DNA to be tested is introduced into the electrophoresis device 100 from a DNA sample inlet 390. The introduced test object undergoes processing, such as DNA amplification, in a reaction chamber 380, and is sent as sample DNA to the sample inflow port 444 of the cathode block 441. Note that the water and reagents required in the reaction chamber 380 are supplied from a water tank 504 and a reagent bottle 505 of the cartridge 200, respectively. The injection of the sample DNA into the capillary 421 is determined based on the conductivity of the liquid between the cathode electrode 446e connected to the cathode electrode port 446 and the measurement electrode 447e connected to the measurement electrode port 447, as measured by an instrumentation amplifier 370 connected to the measurement electrode port 447.

[0047]

Note that the anode block unit 410 and the cathode block unit 440 are arranged so that both ends of the capillary are arranged on the same plane relative to the direction of gravity, preventing a difference in water head between the two ends of the capillary. For example, if the assembly of the anode block unit 410, capillary shell unit 420, and cathode block unit 440 is installed on the electrophoresis device 100 horizontally in the longitudinal

direction of the capillary 421, it is sufficient that the height from the bottom surface of the capillary connection port 413 of the anode block 411 and the height from the bottom surface of the capillary connection port 442 of the cathode block 441 are equal.

[0048]

Here, an example in which a single capillary is disposed in the electrophoresis device 100 has been described, but it is also possible to arrange multiple capillaries in the electrophoresis device 100 by arranging multiple capillaries in the cartridge 200, or by enabling the electrophoresis device 100 to accommodate multiple cartridges 200.

[0049]

It should be noted that the present invention is not limited to the embodiments described above, and includes various modification examples. For example, the above-described embodiments have been described in detail in order to facilitate the understanding of the present invention, and the present invention is not necessarily limited to those including all of the described configurations. In addition, part of the configuration of one embodiment can be replaced with the configurations of other embodiments, and in addition, the configuration of the one embodiment can also be added with the configurations of other embodiments. In addition, part of the configuration of each of the embodiments can be subjected to addition, deletion, and replacement with

respect to other configurations. For example, an example is illustrated here where the cathode block 441 and the cathode knob 431, or the anode block 411 and the anode knob 430, are connected by meshing a threaded portion provided on the outer peripheral surface with a threaded portion provided on the inner peripheral surface. However, they may also be connected by engaging a latch.

List of Reference Signs

[0050]

100: capillary electrophoresis device, 200: capillary cartridge, 310: CPU, 320: heater power supply unit, 330: high voltage power supply unit, 340: pump unit, 350, 360: linear actuator, 370: instrumentation amplifier, 380: reaction chamber, 390: DNA sample inlet, 401: gel unit, 401a: gel syringe, 401b: gel piston, 401c: gel coupler, 402: gel tube, 410: anode block unit, 411: anode block, 412: gel inflow port, 413: capillary connection port, 414: gel pump port, 415: gel waste liquid port, 416: anode electrode port, 416e: anode electrode, 417: gel pump, 418, 419: flow passage, 420: capillary shell unit, 421: capillary, 422: capillary anode head, 423: capillary cathode head, 423a: head rotation restricting portion, 423b: hole portion, 423c: tapered portion, 423d: pressing surface, 424: carriage, 424a, 424b: end point, 425: heat dissipation sheet, 426: heater unit, 426a: surface heater, 426b: metal plate, 426c: insulating sheet, 427: heat-insulating material, 428, 429: housing, 430: anode knob, 431: cathode knob, 431a: internal thread, 431b: hole

portion, 431c: pressing surface, 440: cathode block unit, 441: cathode block, 442: capillary connection port, 442a: external thread, 442b: rotation restricting portion, 442c: tapered portion, 443: buffer solution inflow port, 444: sample inflow port, 445: waste liquid port, 446: cathode electrode port, 446e: cathode electrode, 447: measurement electrode port, 447e: measurement electrode, 448: cathode heater port, 449: waste liquid tube, 450: main flow passage, 451: sample flow passage, 501: anode waste liquid tank, 502: buffer solution tank, 503: cathode waste liquid tank, 504: water tank, 505: reagent bottle

Claims

[Claim 1]

A capillary cartridge comprising:

a capillary;

a first capillary retainer member fixed at a position a predetermined distance from one end of the capillary; and

a first block unit including a first member in which a main flow passage is formed and a second member connected to the first member, the first block unit holding the first capillary retainer member by sandwiching the first capillary retainer member between the first member and the second member,

the first capillary retainer member including a first hole portion through which the capillary passes, a first tapered portion formed coaxially with the first hole portion, and a first rotation restricting portion having a pressing surface with a predetermined projected shape,

the first member including a second tapered portion connected to the main flow passage and formed coaxially with the main flow passage, and a second rotation restricting portion connected to the second tapered portion, wherein

the capillary is connected to the first block unit when the pressing surface of the first rotation restricting portion is pressed by a pressing surface of the second member in a state in which the first rotation restricting portion of the first capillary retainer member is fitted into the second rotation restricting portion of the first

member and the first tapered portion of the first capillary retainer member is in contact with the second tapered portion of the first member.

[Claim 2]

The capillary cartridge according to claim 1, wherein the first member includes a sample flow passage for introducing a sample into the main flow passage, and a cathode electrode provided in the main flow passage and configured to apply a cathode-side voltage to a polymer aqueous solution introduced into the capillary, and

the one end of the capillary is located closer to the cathode electrode than a junction point between the main flow passage and the sample flow passage.

[Claim 3]

The capillary cartridge according to claim 2, wherein the first member includes a measurement electrode provided in the main flow passage between the cathode electrode and the junction point,

injection of the sample into the main path is determined based on a conductivity of liquid between the cathode electrode and the measurement electrode, and

the one end of the capillary is located between the cathode electrode and the measurement electrode.

[Claim 4]

The capillary cartridge according to claim 3, further comprising:

a second capillary retainer member fixed at a position a predetermined distance from the other end of the

capillary; and

a second block unit including a third member in which a flow passage is formed and a fourth member connected to the third member, the second block unit holding the second capillary retainer member by sandwiching the second capillary retainer member between the third member and the fourth member,

the second capillary retainer member including a second hole portion through which the capillary passes, a third tapered portion formed coaxially with the second hole portion, and a third rotation restricting portion having a pressing surface with a predetermined projected shape,

the second member including a fourth tapered portion connected to the flow passage and formed coaxially with the flow passage, and a fourth rotation restricting portion connected to the fourth tapered portion, wherein

the capillary is connected to the second block unit when the pressing surface of the third rotation restricting portion is pressed by a pressing surface of the second member in a state in which the third rotation restricting portion of the second capillary retainer member is fitted into the fourth rotation restricting portion of the second member and the third tapered portion of the second capillary retainer member is in contact with the fourth tapered portion of the second member,

the second member includes an anode electrode provided in the flow passage and configured to apply an anode-side voltage to the polymer aqueous solution

introduced into the capillary, and

there is no difference in water head between the one end and the other end of the capillary.

[Claim 5]

The capillary cartridge according to claim 4, wherein the one end and the other end of the capillary are arranged in the same plane with respect to a direction of gravity.

[Claim 6]

The capillary cartridge according to claim 1, wherein the projected shape of the pressing surface of the first rotation restricting portion of the first capillary retainer member is two-fold symmetric about a central axis of the first hole portion.

[Claim 7]

A method for assembling a capillary cartridge having a block unit and a capillary, the method comprising:

fixing a capillary retainer member at a position a predetermined distance from one end of the capillary,

the capillary retainer member including a first hole portion through which the capillary passes, a first tapered portion formed coaxially with the first hole portion, and a first rotation restricting portion having a pressing surface with a predetermined projected shape,

the block unit including a first member in which a main flow passage is formed and a second member connected to the first member,

the first member including a second tapered portion

connected to the main flow passage and formed coaxially with the main flow passage, and a second rotation restricting portion connected to the second tapered portion;

bringing the first member and the capillary retainer member into a state in which the first rotation restricting portion is fitted into the second rotation restricting portion and the first tapered portion is in contact with the second tapered portion; and

pressing the pressing surface of the first rotation restricting portion of the capillary retainer member with a pressing surface of the second member to connect the capillary to the block unit.

[Claim 8]

The method according to claim 7, wherein

the first member has an outer peripheral surface on which a first threaded portion is formed, and the second member has an inner peripheral surface on which a second threaded portion is formed, the first member and the second member being connected by meshing the first threaded portion with the second threaded portion,

the second member includes a second hole portion with the predetermined projected shape,

the second rotation restricting portion of the first member has the predetermined projected shape, and

with the second rotational restriction portion of the first member and the second hole portion of the second member aligned in phase, in a state where the first member

and the second member are connected, the capillary is inserted into the main flow passage of the first member.

[Claim 9]

The method according to claim 8, further comprising:
screwing the second member into the first member in such a manner that the second rotation restricting portion of the first member and the second hole portion of the second member are out of phase with each other; and
pressing the pressing surface of the first rotation restricting portion of the capillary retainer member with the pressing surface of the second member.

[Claim 10]

The method according to claim 8, wherein
the projected shape of the pressing surface of the first rotation restricting portion of the first capillary retainer member is two-fold symmetric about a central axis of the first hole portion.