

Description

Title of Invention: PRETREATMENT-INTEGRATED ELECTROPHORESIS DEVICE

Technical Field

[0001]

The present disclosure relates to a pretreatment-integrated electrophoresis device.

Background Art

[0002]

Applications using nucleic acid analysis have been put into practical use in fields such as forensic science, immigration control, and counterterrorism. For example, in the field of forensic science, STR analysis has been put into practical use. In STR analysis, short tandem repeat (STR) sequences in specific regions of the genome are analyzed. The fact that the lengths of the STR sequences are unique to each individual enables DNA analysis for purposes such as personal identification and paternity testing.

[0003]

The procedure for STR analysis is, for example, as follows. First, nucleic acid (typically DNA) serving as a template is extracted from a test sample such as a biological sample or a sample of a biological-derived material. Further, the extracted template DNA is amplified by polymerase chain reaction (PCR), and then denatured from double-stranded DNA to single-stranded DNA by formamide treatment or heating and rapid cooling. For DNA amplification, multiplex PCR amplification is performed using 13 types of primer sets for each measurement DNA sample. During DNA amplification, the amplified DNA fragments are labeled. The solution resulting from this DNA amplification and labeling process serves as the analysis sample (see Patent Literature 1).

[0004]

When the steps for preparing the analysis sample from the aforementioned test sample are defined as the pretreatment process, the electrophoresis process involves separating

the labeled DNA fragments by electrophoresis and detecting and analyzing the electrophoretic patterns of the resulting separated DNA fragments.

[0005]

Until now, the separation and detection of DNA fragments have been actively automated using DNA sequencers and the like. Meanwhile, the pretreatment process has generally been performed manually by skilled personnel. In recent years, attempts have been made to automate this pretreatment process so that many genetic analyses, including STR analysis, is performed not only in limited facilities and by skilled personnel, but in more cases.

[0006]

Patent Literature 2 discloses a pretreatment-integrated electrophoresis device that performs a pretreatment process and an electrophoresis process consecutively. The pretreatment-integrated electrophoresis device according to Patent Literature 2 includes a sample cartridge for extracting and amplifying DNA from a sample, and a capillary cartridge for performing electrophoresis, which is equipped with capillaries. When the user places the sample cartridge containing a sample into the pretreatment-integrated electrophoresis device, the pretreatment-integrated electrophoresis device automatically performs processes from pretreatment to electrophoresis. Such a pretreatment-integrated electrophoresis device requires no specialized knowledge to use and can be easily operated, and can be easily used even by users who are not familiar with DNA analysis. Patent Literatures 3 to 5 will be described later.

Citation List

Patent Literature

[0007]

Patent Literature 1: U.S. Patent No. 6531282

Patent Literature 2: U.S. Unexamined Patent Application Publication No. 2016/0116439

Patent Literature 3: Japanese Unexamined Patent Application Publication No. 2016-0101166

Patent Literature 4: Japanese Unexamined Patent Application Publication No. Hei7(1995)-83900

Patent Literature 5: Japanese Unexamined Patent Application Publication No. Hei10(1998)-282055

Summary of Invention

Technical Problem

[0008]

Pretreatment-integrated electrophoresis devices, which perform all processes from pretreatment to electrophoresis, are primarily used in criminal investigations. In criminal investigations, the device is operated by a user who has no specialized knowledge of DNA analysis. The user also transports the device to the crime scene, collects samples there, and loads them into the device. For this reason, easy operability and portability are important functions of the device.

[0009]

In the pretreatment-integrated electrophoresis device according to Patent Literature 2, the only consumables are a capillary cartridge, in which reagents and capillaries are integrated, and a sample cartridge into which the samples are loaded. This eliminates the need for users to install multiple consumables in multiple locations, allowing very simple operation. Meanwhile, the cartridge itself is large, and the device has a configuration for mounting the cartridge inside the device. Therefore, a space for housing the cartridge must be provided within the device. This may hinder the miniaturization of the device, which is important for portability. In addition, when transporting the device in a transport vehicle that is not temperature-controlled, the cartridge containing the reagents must be removed. Even in this case, in the configuration of Patent Literature 2, the space for housing the cartridge within the device is not reduced, and therefore the volume of the device remains unchanged, and space in the transport vehicle is required. Furthermore, when the cartridge is removed, the interior of the device is exposed, which may allow dust or the like to enter the device.

[0010]

Accordingly, the present disclosure provides a pretreatment-integrated electrophoresis device that can be miniaturized and can be further reduced in size during

transport.

Solution to Problem

[0011]

In order to address the above problems, a pretreatment-integrated electrophoresis device according to the present disclosure includes a pretreatment unit that performs pretreatment on a biological sample to prepare a sample for electrophoresis, and an optical system that irradiates the sample separated by electrophoresis in a capillary with light and detects the light from the sample. The pretreatment-integrated electrophoresis device further includes: a first main body and a second main body; and a coupling member that couples the first main body and the second main body. At least one of the first main body and the second main body has an installation surface on which a detachable unit is installed. The coupling member couples the first main body and the second main body in such a manner that one of the first main body and the second main body is movable relative to the other, thereby enabling the overall size of the pretreatment-integrated electrophoresis device to be variable.

[0012]

Further features concerning the disclosure will be clarified from the content of this description and the accompanying drawings. In addition, aspects of the present disclosure are achieved and realized by the elements and various combinations of elements, as set forth in the following detailed description and the appended claims. The description in the present specification is merely illustrative and is not intended to limit the scope of the claims or applications of the present disclosure in any way.

Advantageous Effects of Invention

[0013]

The pretreatment-integrated electrophoresis device according to the present disclosure can be miniaturized and can be further reduced in size during transport. Issues, configurations, and advantages other than those mentioned above will become clear from the description of the embodiments below.

Brief Description of Drawings

[0014]

Fig. 1 illustrates a front view (left) and a side view (right) of the overall configuration of a pretreatment-integrated electrophoretic device according to a first embodiment.

Fig. 2 illustrates the configuration of a capillary cartridge.

Fig. 3 is an enlarged view of the area enclosed by the dotted circle A in Fig. 2.

Fig. 4 illustrates a plan view (left) and a side view (right) of the pretreatment-integrated electrophoresis device.

Fig. 5A is side views for explaining the shape of the pretreatment-integrated electrophoresis device when closing an interface unit.

Fig. 5B is a cross-sectional view of the pretreatment-integrated electrophoresis device.

Fig. 5C is an enlarged view of the area enclosed by the dotted circle in Fig. 5B, illustrating the boundary between a main body and the interface unit.

Fig. 5D is an enlarged view for explaining another structure of the boundary between the main body and the interface unit.

Fig. 6 illustrates a top view (left) and a side view (right) of a pretreatment-integrated electrophoresis device according to a second embodiment.

Fig. 7 is side views of the interface unit with and without a capillary cartridge mounted thereon.

Fig. 8 is a side view of a pretreatment-integrated electrophoretic device according to a third embodiment.

Fig. 9 is a side view of a pretreatment-integrated electrophoresis device according to a fourth embodiment.]

Fig. 10 illustrates a front view (left) and a side view (right) of a pretreatment-integrated electrophoretic device according to a fifth embodiment.

Fig. 11 is a side view of a pretreatment-integrated electrophoresis device according

to a sixth embodiment.

Fig. 12 is a side view of a pretreatment-integrated electrophoresis device according to a seventh embodiment.

Description of Embodiments

[0015]

Below, embodiments according to the present disclosure will be described with reference to the drawings. Note that while the drawings illustrate specific embodiments based on the principles of the present disclosure, these are intended to aid in understanding the present disclosure and are in no way intended to limit the interpretation of the present disclosure.

[0016]

First Embodiment

<Configuration Example of Pretreatment-Integrated Electrophoresis Device>

Fig. 1 illustrates a front view (left) and a side view (right) of the overall configuration of a pretreatment-integrated electrophoresis device 1 according to a first embodiment. The side view of Fig. 1 illustrates the internal and external components of the pretreatment-integrated electrophoresis device 1. Hereinafter, in the present specification, the surface illustrated in the front view of Fig. 1 may be referred to as the front surface, and the direction in which this surface faces may be referred to as the forward direction. The pretreatment-integrated electrophoresis device 1 is configured to perform nucleic acid analysis, including STR analysis.

[0017]

A capillary cartridge 101 and a sample cartridge 102, which are consumables, are detachably attached to the pretreatment-integrated electrophoresis device 1. The capillary cartridge 101 has one or more capillaries, reagents used during pretreatment, reagents used during electrophoresis, and the like. The sample cartridge 102 is loaded with biological samples such as cells collected from a human, and the cells are pretreated. The capillary cartridge 101 and the sample cartridge 102 are consumables, and are housed in a case different

from the transport case of the pretreatment-integrated electrophoresis device 1 during transport.

[0018]

As illustrated in the right side view of Fig. 1, the pretreatment-integrated electrophoresis device 1 includes a high-voltage power supply 103, an optical system 104, a high-pressure pump 105, a pretreatment unit 106, a PC 107, a touch panel 108, an interface unit 109 (second main body), a hinge 110 (coupling member), and a main body 111 (first main body). The high-voltage power supply 103 applies a high voltage to the capillary during electrophoresis. The optical system 104 irradiates the sample in the capillary with excitation light and detects fluorescence emitted from the sample. The high-pressure pump 105 is driven when injecting a electrophoresis medium into the capillary. The pretreatment unit 106 delivers reagent to the sample cartridge 102 and adjusts the temperature. The PC 107 controls each component of the pretreatment-integrated electrophoresis device 1. The touch panel 108 is operated by the user during the use of the pretreatment-integrated electrophoresis device 1. Instructions entered by the user via the touch panel 108 are sent to the PC 107.

[0019]

The interface unit 109 is coupled to the main body 111 by the hinge 110, and can be opened and closed like a door. Fig. 1 illustrates the interface unit 109 in an open state, protruding forward from the front surface of the main body 111. The interface unit 109 is opened during the use of the pretreatment-integrated electrophoresis device 1, and the capillary cartridge 101 is placed on the top surface thereof. The interface unit 109 serves to electrically connect, fluidically connect, and optically connect to the capillary cartridge 101. The coupling between the interface unit 109 and the main body 111 will be described in detail later.

[0020]

When the interface unit 109 is in the open state, the bottom surface of the interface unit 109 and the bottom surface of the main body 111 may be provided with legs.

[0021]

Fig. 2 illustrates the configuration of the capillary cartridge 101. Fig. 2 illustrates

the arrangement of each component when the capillary cartridge 101 is viewed from above. The capillary cartridge 101 has one or more capillaries 201, a heater 202, an irradiation detection unit 203, an optical fiber connection portion 204, a cathode block 205, an anode block 206, an electrophoresis medium portion 207, a waste liquid portion 208, an electrophoresis reagent portion 209, a pretreatment reagent portion 210, a waste liquid portion 211, an electrical interface 212, a high-voltage interface 213, a sample connection portion 214, a coupling 215, a positioning hole 216, and a pump 217.

[0022]

The heater 202 adjusts the temperature of the capillary 201. The irradiation detection unit 203 is configured to irradiate the capillary 201 with excitation light and detect fluorescence emitted from the sample in the capillary 201. The optical fiber connection portion 204 optically connects the capillary 201, the irradiation detection unit 203, and the optical system 104. The optical fiber connection portion 204 bundles optical fiber cables for introducing excitation light from the optical system 104 to the irradiation detection unit 203 and guiding fluorescence from the capillary 201 to the optical system 104. The cathode block 205 injects the sample into the capillary 201. The anode block 206 fills the capillary 201 with the electrophoresis medium. The electrophoresis medium portion 207 contains the electrophoresis medium for electrophoresis. The waste liquid portion 208 collects waste liquid from the electrophoresis medium. The electrophoresis reagent portion 209 contains reagents and the like to be used for electrophoresis. The pretreatment reagent portion 210 contains reagents to be used for pretreatment. The waste liquid portion 211 contains waste liquid and the like. The electrical interface 212 supplies a voltage to the heater 202 and the like. The high-voltage interface 213 applies the voltage output by the high-voltage power supply 103 to the capillary 201. The sample connection portion 214 supplies the pretreated sample to the cathode block 205. The coupling 215 supplies the reagent from the pretreatment reagent portion 210 to the pretreatment unit 106. The positioning hole 216 is used to align the capillary cartridge 101 with the interface unit 109 when installing the capillary cartridge 101. The pump 217 is driven when introducing the reagent from the electrophoresis reagent portion 209 into the cathode block 205. Note that the optical fiber

connection portion 204, the electrical interface 212, the high-voltage interface 213, the sample connection portion 214, and the coupling 215 are exposed from a connection surface (the bottom surface of the capillary cartridge 101) on the capillary cartridge 101 that is connected to the interface unit 109.

[0023]

Fig. 3 is an enlarged view of the area enclosed by the dotted circle A in Fig. 2, illustrating the details of the anode block 206. The anode block 206 has a capillary anode end 301, a valve 302, a pump 303, an electrophoresis medium connection portion 304, a waste liquid connection portion 305, and a hole 306. At the capillary anode end 301, the capillaries 201 are bundled together. The valve 302 seals the flow passage. The pump 303 is driven when filling the capillaries 201 with the electrophoresis medium. The electrophoresis medium connection portion 304 is connected to the electrophoresis medium portion 207. The waste liquid connection portion 305 is connected to the waste liquid portion 208. The hole 306 is provided in the connection surface of the capillary cartridge 101 to the interface unit 109. The hole 306 allows an anode actuator, which will be described later, to access the valve 302 and the piston of the pump 303.

[0024]

Fig. 4 illustrates a plan view (left) and a side view (right) of the pretreatment-integrated electrophoresis device 1. Fig. 4 illustrates the pretreatment-integrated electrophoresis device 1 described in Fig. 1 with the capillary cartridge 101 removed. The main body 111 of the pretreatment-integrated electrophoresis device 1 has a protrusion 410 that protrudes forward from the front surface. The hinges 110 are provided on both side surfaces of the protrusion 410. The interface unit 109 has a roughly U-shape in top view, and is provided so as to surround the front and side surfaces of the protrusion 410. The interface unit 109 and the protrusion 410 are coupled by the hinges 110.

[0025]

The protrusion 410 is provided with a positioning pin 401, a body-side optical fiber connection portion 402, a body-side sample connection portion 403, a body-side reagent connection portion 404, and an anode actuator 405. The positioning pin 401 fits into the

positioning hole 216 of the capillary cartridge 101. By fitting the positioning pin 401 into the positioning hole 216, the capillary cartridge 101 can be installed in the pretreatment-integrated electrophoresis device 1 with high reproducibility. The body-side optical fiber connection portion 402 is connected to the optical fiber connection portion 204 of the capillary cartridge 101. The body-side sample connection portion 403 is connected to the sample connection portion 214 of the capillary cartridge 101. The body-side sample connection portion 403 delivers the sample, which has been pretreated in the pretreatment unit 106, to the capillary cartridge 101. The body-side reagent connection portion 404 is connected to the coupling 215 of the capillary cartridge 101. The body-side reagent connection portion 404 delivers the reagent contained in the pretreatment reagent portion 210 of the capillary cartridge 101 to the pretreatment unit 106. The anode actuator 405 controls the opening and closing operations of the pump 303 and valve 302 of the capillary cartridge 101.

[0026]

The interface unit 109 has a latch 406, a power supply unit 407, a high-voltage application unit 408, and a magnet switch 409. When the capillary cartridge 101 is placed on the interface unit 109, the latch 406 engages with a step (not illustrated) or the like provided on the side of the capillary cartridge 101. This fixes the capillary cartridge 101 in place. The power supply unit 407 supplies power to the electrical interface 212 of the capillary cartridge 101. The high-voltage application unit 408 applies a high voltage to the cathode end of the capillary 201 via the high-voltage interface 213 of the capillary cartridge 101. The magnet switch 409 passes a weak current when the capillary cartridge 101 is installed. This allows the PC 107 to confirm whether the capillary cartridge 101 is installed or not.

[0027]

The interface unit 109 and the protrusion 410 form an installation surface for the capillary cartridge 101. Therefore, when the interface unit 109 is open, the installation surface for the capillary cartridge 101 (the top surface of the interface unit 109 and the top surface of the protrusion 410) is designed to be flush. However, the top surface of the interface unit 109 and the top surface of the protrusion 410 need not all be at the same height, and it is acceptable for only part of them to be aligned in height.

[0028]

When installing the capillary cartridge 101, the aforementioned positioning pin 401 is inserted into the positioning hole 216. Thus, the corresponding connection portions of the interface unit 109 and the capillary cartridge 101 are connected with high accuracy, and further, the capillary cartridge 101 is fixed by the latch 406. Note that instead of providing the latch 406, the capillary cartridge 101 may be fixed by providing a magnet or the like on the installation surface. The fixing components for the capillary cartridge 101 are not limited to latches and magnets.

[0029]

In the present embodiment, the positioning pin 401 is disposed on the main body 111 (protrusion 410), which is a non-movable portion, and further, flow passage components (body-side sample connection portion 403, body-side reagent connection portion 404, and anode actuator 405) are installed on the same surface as the surface on which the positioning pin 401 is installed. This allows for accurate connection between the flow passage components (sample connection portion 214, coupling 215, and anode block 206) on the capillary cartridge 101 side and the flow passage components (body-side sample connection portion 403, body-side reagent connection portion 404, and anode actuator 405) on the pretreatment-integrated electrophoresis device 1 side. Meanwhile, the electrical components on the pretreatment-integrated electrophoresis device 1 side (power supply unit 407, high-voltage application unit 408, magnet switch 409) connected to the capillary cartridge 101 are arranged on the interface unit 109, which is a movable portion. This is because, compared to the flow passage components described above, the connection of the electrical components does not require high positioning accuracy, and rattles that occur in the hinges 110 when the interface unit 109 is opened can be tolerated. Furthermore, even if liquid such as reagents leaks from the flow passage components, the risk of liquid reaching the electrical components is reduced because the installation surface for the flow passage components and the installation surface for the electrical components are surfaces of different members.

[0030]

<Operation of Pretreatment-Integrated Electrophoresis Device>

The mechanism from the pretreatment process to the electrophoresis process of the pretreatment-integrated electrophoresis device 1 will be described below. First, the user removes the pretreatment-integrated electrophoresis device 1 from the transport case. After that, the user opens the interface unit 109 and places the capillary cartridge 101 on the top surface of the interface unit 109. When the capillary cartridge 101 is placed, the PC 107 detects that the capillary cartridge 101 has been mounted based on the current flowing from the magnet switch 409. The PC 107 drives a pump (not illustrated) or the like to aspirate the reagent from the pretreatment reagent portion 210 in the capillary cartridge 101 and fill the flow passage in the device with the reagent. Furthermore, the PC 107 drives the anode actuator 405 to operate the valve 302 and the pump 303. Thus, the electrophoresis medium is delivered from the electrophoresis medium portion 207 in the capillary cartridge 101 to the anode block 206 via the electrophoresis medium connection portion 304. The electrophoresis medium is then introduced into the capillary 201 via the capillary anode end 301. In addition, the PC 107 operates the pump 217 to introduce the reagent from the electrophoresis reagent portion 209 into the cathode block 205. At this time, the temperature of the capillary 201 is adjusted by the heater 202. The above is the preparatory operation of the pretreatment-integrated electrophoresis device 1 before analysis.

[0031]

Next, the analysis flow will be described. The user collects biological samples such as oral cells, bloodstains, and fingerprints using a swab. After collection, the user seals the swab into the sample cartridge 102 and mounts the sample cartridge 102 on the pretreatment-integrated electrophoresis device 1. When the user selects a desired application using the touch panel 108 or the like, the pretreatment-integrated electrophoresis device 1 starts the analysis operation. All subsequent processes are automatically executed by the pretreatment-integrated electrophoresis device 1. The pretreatment unit 106 of the pretreatment-integrated electrophoresis device 1 uses the reagent sealed in the sample cartridge 102 and the reagent in the pretreatment reagent portion 210 of the capillary cartridge 101 to perform lysis of cells in the sample cartridge 102, and elution, purification, amplification, and the like of DNA. DNA bases are labeled with a fluorescent dye. By

pretreating the biological sample in this way, a sample for capillary electrophoresis is prepared. The PC 107 operates a pump (not illustrated) to deliver the sample containing the finally amplified DNA from the pretreatment unit 106 to the cathode block 205 in the sample cartridge 102. After that, the PC 107 operates the high-voltage power supply 103 to apply a negative high voltage to the cathode block 205 via the high-voltage interface 213. Then, a voltage is applied between a ground electrode (not illustrated) in the anode block 206 and the cathode block 205. Since the DNA carries a negative charge, it migrates through the capillary 201 toward the anode block 206 during electrophoresis. The irradiation detection unit 203 emits laser light (excitation light) from a laser (not illustrated) and irradiates the capillary 201 via an optical fiber cable. As a result, the DNA migrating through the capillary 201 during electrophoresis emits fluorescence. The fluorescence is introduced into the optical system 104 via the optical fiber cable and detected. The PC 107 analyzes the DNA base sequence by processing the detected fluorescence signal. The above is the analysis flow for the pretreatment-integrated electrophoresis device 1.

[0032]

<After Use of Pretreatment-Integrated Electrophoresis Device>

Fig. 5A is a side view for explaining the shape of the pretreatment-integrated electrophoresis device 1 when closing the interface unit 109. The left side of Fig. 5A illustrates the interface unit 109 in an open state. The right side of Fig. 5A illustrates the interface unit 109 in a closed state. When the pretreatment-integrated electrophoresis device 1 is not used for a while after analysis, or when transporting the pretreatment-integrated electrophoresis device 1, the user removes the capillary cartridge 101 as illustrated in Fig. 5A and rotates the interface unit 109 about the hinges 110. This allows the size of the pretreatment-integrated electrophoresis device 1 to be reduced. In other words, at least one of the maximum values of the length, width, and height of the pretreatment-integrated electrophoresis device 1 is reduced. In the example of Fig. 5A, when the interface unit 109 is closed, the maximum length in the front-rear direction (the sum of the length of the bottom side of the main body 111 and the length of the bottom side of the interface unit 109) is reduced. Therefore, the pretreatment-integrated electrophoresis device 1 can be stored in a

space-saving manner. If a transport case is used for transporting the pretreatment-integrated electrophoresis device 1, the size of the transport case itself can also be reduced.

[0033]

Fig. 5B is a cross-sectional view of the pretreatment-integrated electrophoresis device 1. As illustrated in Fig. 5B, the interface unit 109 is closed so as to surround the top surface and side surfaces of the protrusion 410. In this way, by closing the interface unit 109, the installation surface for the capillary cartridge 101 (the top surface of the interface unit 109 and the top surface of the protrusion 410) is sealed, so that it is possible to prevent the intrusion of dust, dirt, and the like into the flow passage components for fluid connection and the electrical components for electrical connection on the interface unit 109.

[0034]

In the present embodiment, in consideration of dripping during the opening and closing of the interface unit 109, the fluid connection portion is not provided on the interface unit 109, but is instead provided on the protrusion 410 of the main body 111. Furthermore, since the fluid connection portion is disposed below the electrical connection portion in the vertical direction, liquid from the fluid connection portion does not drip onto the electrical connection portion when the interface unit 109 is closed. This arrangement of the fluid component and electrical component can prevent failure of the pretreatment-integrated electrophoresis device 1. However, if adequate measures against liquid dripping are taken (for example, by using a coupling that is resistant to liquid dripping), components such as fluid connection portions may be provided on the interface unit 109. Even in this case, when the interface unit 109 is closed, the fluid connection portion is located below the electrical connection portion, so that it is possible to prevent liquid from adhering to the electrical connection portion. By devising the arrangement of the fluid components and electrical components as described above, the folding structure of the pretreatment-integrated electrophoresis device 1 can be achieved.

[0035]

Fig. 5C is an enlarged view of the area enclosed by the dotted line in Fig. 5B, illustrating the boundary between the main body 111 and the interface unit 109. The main

body 111 and the interface unit 109 each have a stepped spigot structure 501 around the entire circumference, forming a structure that can prevent the inflow of air, dirt, dust, and the like from the outside. This prevents dirt, dust, and the like from adhering to the flow passage components provided on the protrusion 410.

[0036]

Fig. 5D is an enlarged view for explaining another structure of the boundary between the main body 111 and the interface unit 109. In order to prevent the inflow of dust and dirt, a packing 502 (sealing member) may be provided on the main body 111, as illustrated in Fig. 5D. The packing 502 can be provided, for example, on the front surface of the main body 111, around the entire periphery of the interface unit 109. The packing 502 makes it possible to prevent the inflow of dust and dirt more effectively than with the spigot structure 501. The packing 502 can be made of a material such as rubber or resin.

[0037]

Note that in the present embodiment, the capillary cartridge 101 is referred to as such because it is equipped with the capillary. However, it is not necessarily required to use a cartridge equipped with the capillary 201, and the capillary 201 may alternatively be provided on the pretreatment-integrated electrophoresis device 1 side. Furthermore, in the present embodiment, a detachable unit placed on the interface unit 109 is defined as the capillary cartridge 101. Instead of the capillary cartridge 101, another unit (such as a reagent cartridge) may be configured to be detachably attached to the interface unit 109.

[0038]

<Summary of First Embodiment>

As described above, the pretreatment-integrated electrophoresis device 1 according to the first embodiment includes the pretreatment unit 106 for performing pretreatment on a biological sample (cells) to prepare a sample for electrophoresis, and the optical system 104 that irradiates the sample separated by electrophoresis in the capillary 201 with light and detects the light from the sample. The pretreatment-integrated electrophoresis device 1 includes: the main body 111 (first main body) and the interface unit 109 (second main body); and the hinge 110 (coupling member) that couples the main body 111 and the interface unit

109. The main body 111 and the interface unit 109 have an installation surface on which the capillary cartridge 101 (detachable unit) is placed. The hinge 110 couples the main body 111 and the interface unit 109 in such a manner that the interface unit 109 is rotatable relative to the main body 111 (movable relative to the main body 111). By rotating the interface unit 109 to open and close, the overall size of the pretreatment-integrated electrophoresis device 1 is variable. In this way, since the size of the pretreatment-integrated electrophoresis device 1 can be changed, it is possible to improve portability and reduce the transportation space by reducing the size during transportation. In addition, since there is no need to provide a space for housing the capillary cartridge 101 inside the device, the pretreatment-integrated electrophoresis device 1 itself can be miniaturized, and the size of the pretreatment-integrated electrophoresis device 1 does not depend on the size of the capillary cartridge 101.

[0039]

When the interface unit 109 is closed to reduce the size of the pretreatment-integrated electrophoresis device 1, the installation surface for the capillary cartridge 101 is sealed between the interface unit 109 and the main body 111. This makes it possible to protect the installation surface for the capillary cartridge 101 from contamination from the outside. Therefore, there is no need to seal the installation surface with a dummy cartridge or the like. Furthermore, when the interface unit 109 is opened to increase the size of the pretreatment-integrated electrophoresis device 1, the installation surface for the capillary cartridge 101 becomes exposed, enabling the capillary cartridge 101 to be placed.

[0040]

Here, Patent Literatures 3 to 5 disclose technologies for analyzing samples using electrophoresis. Patent Literature 3 discloses an analysis system enclosed within a suitcase-shaped housing. However, the structure according to Patent Literature 3 is clearly different from the pretreatment-integrated electrophoresis device 1 according to the present embodiment, in which the system itself has a foldable structure. Furthermore, Patent Literature 3 does not describe that the system itself can be miniaturized to fit into a transport case, as is the case with the pretreatment-integrated electrophoresis device 1.

[0041]

Patent Literatures 4 and 5 disclose electrophoresis devices equipped with a detachable unit. However, the electrophoresis devices according to Patent Literatures 4 and 5 do not have a folding structure, and there is no description or suggestion of folding them or making them compact for transportation.

[0042]

Second Embodiment

In the first embodiment, it has been described that the pretreatment-integrated electrophoresis device can be miniaturized by rotating the interface unit 109 using the hinges 110. In a second embodiment, an example will be described in which the pretreatment-integrated electrophoresis device is miniaturized by linearly moving the interface unit 109.

[0043]

<Configuration Example of Pretreatment-Integrated Electrophoresis Device>

Fig. 6 illustrates a top view (left) and a side view (right) of a pretreatment-integrated electrophoresis device 2 according to the second embodiment. The configuration of the pretreatment-integrated electrophoresis device 2 according to the present embodiment is almost the same as that of the first embodiment. However, the main body 111 does not have the protrusion 410. Instead, at the locations corresponding to the protrusion 410 on the interface unit 109, the positioning pin 401, the body-side optical fiber connection portion 402, the body-side sample connection portion 403, the body-side reagent connection portion 404, and the anode actuator 405 are provided. The arrangement of the fluid components and the electrical components is the same as that of the first embodiment. Further the interface unit 109 is coupled to the main body 111 by a linear guide component such as a linear rail 601 (coupling member). This allows the interface unit 109 to move in the front-rear direction. As illustrated on the right side of Fig. 6, a space 602 for accommodating the interface unit 109 is provided inside the main body 111.

[0044]

Fig. 7 is side views of the interface unit 109 with and without the capillary cartridge 101 mounted thereon. The connection portion between the interface unit 109 and the capillary cartridge 101 is similar to that in the first embodiment. When using the

pretreatment-integrated electrophoresis device 2, the user places the capillary cartridge 101 on the top surface of the interface unit 109. When the capillary cartridge 101 is not mounted, the interface unit 109 is housed in the space 602 of the pretreatment-integrated electrophoresis device 2, thereby enabling the miniaturization of the pretreatment-integrated electrophoresis device 2. In addition, the fluid connection portion and electrical connection portion between the capillary cartridge 101 and the interface unit 109 are housed inside the pretreatment-integrated electrophoresis device 2. This makes it possible to protect the fluid connection portion and electrical connection portion from the adhesion of dust and the like.

[0045]

<Summary of Second Embodiment>

As described above, in the pretreatment-integrated electrophoresis device 2 according to the second embodiment, the interface unit 109 (second main body) and the main body 111 (first main body) are coupled by a linear guide component, and the interface unit 109 is linearly movable. The main body 111 is provided with the space 602 for accommodating the interface unit 109. The size of the pretreatment-integrated electrophoresis device 2 is variable by pulling out the interface unit 109 from the space 602 in the main body 111 or housing the interface unit 109 in the space 602. This allows the pretreatment-integrated electrophoresis device 2 to be miniaturized regardless of the size of the capillary cartridge 101, as in the first embodiment. By transforming the pretreatment-integrated electrophoresis device 2 into a smaller size during transportation, portability is improved and the transportation space can also be reduced.

[0046]

In addition, in the second embodiment, the interface unit 109 (second main body) has an installation surface for the capillary cartridge 101 (detachable unit). Since both the flow passage components and the electrical components are arranged on the interface unit 109 and the orientation of the installation surface for the capillary cartridge 101 does not change, there is no risk of liquid from the flow passage components reaching the electrical components. In addition, the pretreatment-integrated electrophoresis device 2 according to the second embodiment is easy to design.

[0047]

Third Embodiment

In the second embodiment, the pull-out type interface unit 109 has been described. In a third embodiment, a configuration similar to that of the second embodiment will be described, in which the size of the pretreatment-integrated electrophoresis device is variable in accordance with the size of the capillary cartridge 101.

[0048]

Fig. 8 is a side view of a pretreatment-integrated electrophoresis device 3 according to the third embodiment. The configuration of the pretreatment-integrated electrophoresis device 3 is almost the same as that of the second embodiment. However, as illustrated in Fig. 8, a plurality of grooves 801 are provided in the interface unit 109, and a ball plunger 802 is provided on the main body 111. When the interface unit 109 is pulled out, the ball plunger 802 fits into the grooves 801, thereby allowing the pull-out amount of the interface unit 109 to be changed. Although not illustrated in the figure, the plurality of grooves 801 are provided at intervals along the linear motion direction of the interface unit 109. In the example of Fig. 8, the pull-out amount of the interface unit 109 can be changed in three stages, but this is not limited thereto.

[0049]

By forming the grooves 801 in the interface unit 109 to match the size of the capillary cartridge 101 to be used, the user can easily change the pull-out amount of the interface unit 109. This allows the size of the pretreatment-integrated electrophoresis device 2 to be matched to the size of the capillary cartridge 101. Note that in the present embodiment, other positioning components such as magnets or leaf springs can be used instead of the ball plunger 802 and grooves 801, and the configuration is not limited to these.

[0050]

Fourth Embodiment

In the first to third embodiments, the configuration in which the interface unit 109 is movable relative to the main body 111 has been described. However, the interface unit 109 does not necessarily need to be movable.

[0051]

Fig. 9 is a side view of a pretreatment-integrated electrophoresis device 4 according to a fourth embodiment. The configuration of the pretreatment-integrated electrophoresis device 4 is almost the same as that of the pretreatment-integrated electrophoresis device 2 according to the second embodiment, but the main body 111 is movable relative to the interface unit 109. Although not illustrated, a linear guide component such as a linear rail couples the top surface of the interface unit 109 to the bottom surface of the main body 111. In this case, the high-pressure pump 105, the optical system 104, and the like may be mounted on the interface unit 109. Some of the components included in the optical system 104, such as optical fibers and harnesses, are delicate, and by minimizing the movement of these components, the risk of failure can be reduced. In addition, highly durable components are generally expensive, and by arranging delicate components such as optical components on the non-movable portion, it is possible to adopt components with relatively low durability and low cost. As a result, the manufacturing cost of the pretreatment-integrated electrophoresis device can be reduced.

[0052]

Fifth Embodiment

Fig. 10 illustrates a front view (left) and a side view (right) of a pretreatment-integrated electrophoresis device 5 according to a fifth embodiment. As illustrated in Fig. 10, the capillary cartridge 101 may be connected to the main body 111 instead of the interface unit 109. In this case, various electrical components and fluid components are arranged on the main body 111. As in the first embodiment, by arranging the flow passage components below the electrical components in the vertical direction, liquid does not adhere to the electrical components even if liquid drips from the flow passage components. In the present embodiment, the interface unit 109 serves as a mounting base for the capillary cartridge 101, and also serves as a cover for the flow passage components and electrical components of the main body 111 when the interface unit 109 is closed.

[0053]

Sixth Embodiment

In the first to fifth embodiments, the pretreatment-integrated electrophoresis device configured so that the capillary cartridge 101 is detachably attached to the interface unit 109 or the main body 111 has been described. The unit which is detachably attached to the pretreatment-integrated electrophoresis device is not limited to the capillary cartridge 101.

[0054]

Fig. 11 is a side view of a pretreatment-integrated electrophoresis device 6 according to a sixth embodiment. As illustrated in Fig. 11, the pretreatment-integrated electrophoresis device 6 does not include the touch panel 108, and instead of the touch panel 108, a tablet terminal 1011 can be installed on the interface unit 109. In this case, the interface unit 109 is provided with connection components such as a connector for the tablet terminal 1011. In addition, the capillary cartridge 101 is placed on the top surface of the main body 111.

[0055]

In the present embodiment, the tablet terminal 1011 may be configured to implement the functions of the PC 107. In this case, the PC 107 can be removed from the main body 111, so that the pretreatment-integrated electrophoresis device can be made more compact. Fig. 11 illustrates the pull-out type interface unit 109, but it may also be a foldable interface unit 109 (such as the first embodiment).

[0056]

Seventh Embodiment

In the first to sixth embodiments, a configuration in which a single detachable unit is installed on the interface unit 109 of the pretreatment-integrated electrophoresis device has been described. As will be described in a seventh embodiment below, the configuration may be such that a plurality of detachable units can be installed on the interface unit 109.

[0057]

Fig. 12 is a side view of a pretreatment-integrated electrophoresis device 7 according to the seventh embodiment. As illustrated in Fig. 12, the tablet terminal 1011 and the high-voltage power supply 103 are installed on the interface unit 109 as detachable units. The reason for configuring the high-voltage power supply 103 to be detachable will be explained below. Connections between the components of an optical system and between the

components of a fluid delivery system (such as a high-pressure pump) both require specialized tools and a certain amount of force, and the user may need to be skilled in the art to make the connections. In contrast, the high-voltage power supply 103 requires only an electrical connection to the pretreatment-integrated electrophoresis device 7, and therefore no special skills are required for installation by the user. By configuring such components to be detachably attached to the pretreatment-integrated electrophoresis device 7 and removing them from the main body 111, the size of the main body 111 can be reduced.

[0058]

Note that in Fig. 12, the number of detachable units is two (the tablet terminal 1011 and the high-voltage power supply 103), but there may be three or more units.

[0059]

Eighth Embodiment

In the seventh embodiment, a configuration in which a plurality of detachable units are installed on the single interface unit 109 has been described. Alternatively, a plurality of interface units 109 may be provided. For example, the foldable interface unit 109 described in the first embodiment and the pull-out type interface unit 109 described in the second embodiment may be combined. The same type of interface unit 109 may also be provided. In addition, the plurality of interface units 109 do not all need to be installed at the same location. For example, some may be provided on the front side of the main body 111 and others may be provided on the rear side of the main body 111. Note that the number of interface units 109 may be the same as the number of detachable units, or may be different.

[0060]

The size of each of the plurality of interface units 109 can be designed to match the size of the detachable unit to be installed. This allows the size of the pretreatment-integrated electrophoresis device to be optimized when in use.

[0061]

[Modification]

The present disclosure is not limited to the embodiments described above, and includes various modifications. For example, the above-described embodiments have been

described in detail to clearly explain the present disclosure, and it is not necessary to include all of the configurations described. In addition, a part of one embodiment can be replaced with the configuration of another embodiment. Additionally, the configuration of another embodiment may be added to the configuration of one embodiment. Moreover, for a part of the configuration of each embodiment, a part of the configuration of another embodiment may be added, deleted, or replaced.

[0062]

In the above-described embodiment, the hinge 110 and the linear rail 601 are described as examples of coupling members between the interface unit 109 and the main body 111. The coupling members between the interface unit 109 and the main body 111 are not limited to these, and any member can be used as long as it allows the interface unit 109 and the main body 111 to move relatively and allows the size of the pretreatment-integrated electrophoresis device to be changed.

List of Reference Signs

[0063]

1 to 7: Pretreatment-integrated electrophoresis device

101: capillary cartridge

102: sample cartridge

103: high-voltage power supply

104: optical system

105: high-pressure pump

106: pretreatment unit

107: PC

108: touch panel

109: interface unit (second main body)

110: hinge (coupling member)

111: main body (first main body)

201: capillary

202: heater
203: irradiation detection unit
204: optical fiber connection portion
205: cathode block
206: anode block
207: electrophoresis medium portion
208: waste liquid portion
209: electrophoresis reagent portion
210: pretreatment reagent portion
211: waste liquid portion
212: electrical interface
213: high-voltage interface
214: sample connection portion
215: coupling
216: positioning hole
217: pump
301: capillary anode end
302: valve
303: pump
401: positioning pin
402: body-side optical fiber connection portion
403: body-side sample connection portion
404: body-side reagent connection portion
405: anode actuator
406: latch
407: power supply unit
408: high-voltage application unit
409: magnet switch
410: protrusion

501: spigot structure

502: packing

601: linear rail (coupling member)

801: groove

802: ball plunger

1011: tablet terminal

Claims

[Claim 1]

A pretreatment-integrated electrophoresis device comprising:

a pretreatment unit that performs pretreatment on a biological sample to prepare a sample for electrophoresis; and

an optical system that irradiates the sample separated by electrophoresis in a capillary with light and detects the light from the sample, the pretreatment-integrated electrophoresis device further comprising:

a first main body and a second main body; and

a coupling member that couples the first main body and the second main body,

wherein

at least one of the first main body and the second main body has an installation surface on which a detachable unit is installed, and

the coupling member couples the first main body and the second main body in such a manner that one of the first main body and the second main body is movable relative to the other, so that an overall size of the pretreatment-integrated electrophoresis device is variable.

[Claim 2]

The pretreatment-integrated electrophoresis device according to claim 1, wherein

the coupling member couples the first main body and the second main body in such a manner that a size of the pretreatment-integrated electrophoresis device without the detachable unit installed is smaller than a size of the pretreatment-integrated electrophoresis device with the detachable unit installed, and

the installation surface is sealed between the first main body and the second main body when the size of the pretreatment-integrated electrophoresis device is reduced, and is exposed when the size of the pretreatment-integrated electrophoresis device is increased.

[Claim 3]

The pretreatment-integrated electrophoresis device according to claim 1, further comprising:

a positioning component for positioning the detachable unit; and

a flow passage component for fluid connection to the detachable unit, wherein both the positioning component and the flow passage component are arranged on the installation surface of one of the first main body and the second main body.

[Claim 4]

The pretreatment-integrated electrophoresis device according to claim 3, further comprising an electrical component for electrical connection to the detachable unit, wherein the electrical component is disposed on a surface different from the installation surface on which the positioning component and the flow passage component are arranged.

[Claim 5]

The pretreatment-integrated electrophoresis device according to claim 4, wherein, when the size of the pretreatment-integrated electrophoresis device is reduced, the flow passage component is disposed vertically below the electrical component.

[Claim 6]

The pretreatment-integrated electrophoresis device according to claim 1, wherein the coupling member has a hinge configured to allow one of the first main body and the second main body to open and close relative to the other.

[Claim 7]

The pretreatment-integrated electrophoresis device according to claim 6, wherein the first main body has a protrusion protruding toward the second main body and having the hinge, and

when the second main body rotates about the hinge into an open position relative to the first main body, the protrusion and the second main body are at least partially at the same height and form the installation surface.

[Claim 8]

The pretreatment-integrated electrophoresis device according to claim 7, wherein, when the second main body rotates about the hinge into a closed position relative to the first main body, the installation surface of the protrusion is surrounded by the second main body.

[Claim 9]

The pretreatment-integrated electrophoresis device according to claim 8, wherein the first main body and the second main body each have a stepped spigot structure, and when the second main body is closed, the spigot structures engage with each other.

[Claim 10]

The pretreatment-integrated electrophoresis device according to claim 8, wherein one of the first main body and the second main body has a sealing member on a surface facing the other when the second main body is closed.

[Claim 11]

The pretreatment-integrated electrophoresis device according to claim 1, wherein the detachable unit has at least one capillary, a reagent for use in the electrophoresis, and a reagent for use in the pretreatment.

[Claim 12]

The pretreatment-integrated electrophoresis device according to claim 1, wherein the detachable unit includes an input device for inputting operation instructions to the pretreatment-integrated electrophoresis device.

[Claim 13]

The pretreatment-integrated electrophoresis device according to claim 1, wherein the coupling member has a linear guide component configured such that one of the first main body and the second main body is linearly movable relative to the other.

[Claim 14]

The pretreatment-integrated electrophoresis device according to claim 13, wherein the first main body has a space capable of accommodating the second main body, and

linear movement of the second main body causes the second main body to be housed in the first main body or pulled out from the first main body.