Note: Within nine months of the publication of the mention of the grant of the European patent in the European Patent Bulletin, any person may give notice to the European Patent Office of opposition to that patent, in accordance with the Implementing Regulations. Notice of opposition shall not be deemed to have been filed until the opposition fee has been paid. (Art. 99(1) European Patent Convention).
The present disclosure generally relates to dialysis systems. More specifically, the present disclosure relates to systems and methods for hemodialysis or peritoneal dialysis that recycle used dialysate through an electrodeionization based regeneration system. These systems can perform high volume dialysis treatments without using large volumes of fresh dialysis fluid.

In both hemodialysis and peritoneal dialysis, two general classes of dialysis systems currently exist. The first class uses fresh fluid (e.g., from a solution bag or some sort of water purification system) to generate dialysis fluid that is used to dialyze the individual. The second class uses "sorbent" technology to remove uremic toxins from waste dialysate. Therapeutic agents such as ions and/or glucose can be injected into the treated dialysate, which is used to continue the dialysis of the individual. The main advantage of the sorbent based approach is that very low volumes of fluid are required to achieve high volume dialysis treatments.

Disadvantages of sorbent systems include their high cost, disposability, and concerns regarding the purity of the recycled solution, as many ions remain in the fluid after treatment and verification of purity is technically challenging to perform. For example, sorbents can have high cartridge costs, insufficient removal of all of the tap water impurities, and insufficient removal of all of the uremic toxins in the used dialysate (e.g., sulfate). In addition, possible chemicals may be released or leached from the sorbent cartridge (e.g., zirconium). There may also be potential issues with pH and sodium balance.

US 2003/0105424 discloses a regenerative dialysis system having a cartridge for removing toxins that contains a resin bed having a urease layer and a layer of carbon.

According to the present invention there is provided a portable dialysis fluid recycling system according to claim 1. The EDI systems and methods are utilized in portable dialysis devices such as wearable artificial kidneys. In a general embodiment, the dialysis system includes a carbon source, a urease source, and an EDI unit. The carbon source and urease source are in the form of removable cartridges. The EDI approach maintains the advantage of low fluid use in a sorbent system, but addresses the key shortcomings of the sorbent system. The EDI technology is re-usable over very long periods of time (e.g., 5-7 years) thereby reducing cost, and essentially removes all ionic contaminants from the waste dialysate (not just selective ions), resulting in verifiably pure recycled solution.

Also disclosed is a method of performing hemodialysis. The method comprises passing a spent dialysis fluid from a dialyzer through a carbon source, a urease source and an electrodeionization unit to produce a clean dialysis fluid, and passing the clean dialysis fluid through the dialyzer. The clean dialysis fluid can pass through an ion exchange unit before passing through the dialyzer. In addition, one or more dialysis components can be added to the clean dialysis fluid before the clean dialysis fluid passes through the dialyzer.

Also disclosed is a method of performing peritoneal dialysis. The method comprises passing a spent dialysis fluid from an individual through a carbon source, a urease source and an electrodeionization unit to produce a clean dialysis fluid, and returning the clean dialysis fluid to the individual. The clean dialysis fluid can pass through an ion exchange unit before returning to the patient. One or more dialysis components can be added to the clean dialysis fluid before returning to the individual. The clean dialysis fluid can also pass through a filter or an ultraviolet bactericidal light returning to the patient.

Also disclosed is a method of performing dialysis. The method comprises passing a spent dialysis fluid through a dialysis compartment of a dialyzer including an ion-rejection membrane that allows the passage of negatively charged ions and nonionic species but restricts the passage of positively charged ions. The ion-rejection membrane separates the dialysis compartment from a dialysate compartment of the dialyzer. The method further comprises passing used dialysate fluid generated from the dialysate compartment of the dialyzer through a carbon source, a urease source and an EDI unit to produce a clean dialysis fluid. A source containing any desired negative ions is then added to the clean dialysis fluid. The clean dialysis fluid passes through the dialysate compartment of the dialyzer.

In an alternative embodiment, the ion-rejection membrane allows the passage of positively charged ions and nonionic species but restricts the passage of negatively charged ions. In this regard, a source containing any desired positive ions is then added to the clean dialysis fluid.

An advantage of the present disclosure is to provide an improved hemodialysis system.

Another advantage of the present disclosure is to provide an improved peritoneal dialysis system.

Yet another advantage of the present disclosure is to provide a dialysis system that has a high purity of recycled fluid.

SUMMARY
dialysis fluid.

[0014] Still another advantage of the present disclosure is a dialysis system having low operating costs.

[0015] Additional features and advantages are described herein, and will be apparent from, the following Detailed
Description and the figures.

BRIEF DESCRIPTION OF THE FIGURES

[0016] FIG. 1 illustrates a schematic of a dialysis fluid recycling system for hemodialysis in an embodiment of the present
disclosure.

FIG. 2 illustrates a schematic of a dialysis fluid recycling system for peritoneal dialysis in an embodiment of the present
disclosure.

FIG. 3 illustrates a schematic of a dialysis fluid recycling system in another embodiment of the present disclosure.

FIG. 4 illustrates a schematic of a dialysis fluid recycling system for peritoneal dialysis in an embodiment of the present
disclosure.

FIG. 5 illustrates a schematic of a dialysis fluid recycling system for peritoneal dialysis in another embodiment of the present disclosure.

FIG. 6 is a graph showing the conductivity of a dialysis solution treated using an EDI unit versus the operating voltage of the EDI unit.

FIG. 7 is a graph showing the operating current of an EDI unit versus the operating voltage of the EDI unit.

DETAILED DESCRIPTION

[0017] The present disclosure relates to systems and methods for hemodialysis or peritoneal dialysis having integrated
EDI capabilities. In alternative embodiments, the EDI systems and methods can be utilized and implemented in various
hemodialysis and peritoneal dialysis technologies. Such dialysis systems are described in U.S. Patent No. 5,244,568,
5,350,357, 5,662,806, 6,592,542 and 7,318,892. The EDI systems and methods are utilized in portable dialysis devices
such as, for example, wearable artificial kidneys in which an individual may move freely during dialysis. Portable dialysis
devices are described in U.S. Patent Nos. 6,196,992, 5,873,853 and 5,984,891. The EDI systems and methods can be
used in medical centers and be implemented with on-site or at-home dialysis treatments.

[0018] It should be appreciated that the EDI systems discussed herein differ from electrodialyzers. There are major
differences between electrodialysis and EDI. An electrodialyzer is used to remove electrolytes from an aqueous feed
solution introduced into a diluate chamber. An example of an electrolyte is NaCl. However, the level of electrolyte removal
is not allowed to go below a certain limit. If one goes to a lower limit with very few electrolyte-based ions left in the
solution, water splitting occurs (also known as “electrolysis”), and a considerable amount of energy is wasted in splitting
the water. This water splitting is needed for the current to flow between the electrodes maintained in the electrodialysis
stack. The proton and the hydroxyl ion resulting from the water splitting will carry the current. It is to be avoided for a
variety of reasons.

[0019] An electrodeionizer is an electrodialyzer in which the diluate channel into which the feed solution is introduced
is filled with a bed of mixed ion exchange resin beads. At the top of the channel where the feed solution is introduced,
the electrolytes present in the feed solution carry the current. Even though the ion exchange resin beads are there, they
do not serve much of a deionization function. The mixed ion exchange resin beads in the electrodeionizer enhance the
efficiency of removing the electrolytes from the dialysate solution as well as alleviate the effects of water splitting as a
result of little to no electrolytes remaining in the solution further down the channel.

[0020] In a general embodiment, a dialysis fluid recycling system 10 for hemodialysis is illustrated in FIG. 1. As shown
in FIG. 1, a circuit 12 represents a standard blood circuit for a hemodialysis machine. Circuit 12 cycles blood from an
individual 16 via flow path 22 through a dialyzer 20 and returns it to the individual’s body via flow path 24. Dialyzer 20
can include a dialysate compartment and a blood compartment separated by a suitable membrane. A circuit 14 includes
an EDI unit or module 30 in dialysis fluid recycling system 10. Circuit 14 also includes a carbon source 40 and a urease
source 50 connected to carbon source 40 via flow path 42. Carbon source 40 and urease source 50 are connected to carbon source 40 via flow path 42. Carbon source 40 and urease source 50 are in the form of
removable cartridges.

[0021] EDI unit 30 can include a central chamber 32, an anion chamber 34 having an anode 35, and a cation chamber
36 having a cathode 37. As fluid exiting urease source 50 flows to central chamber 32 via flow path 44, a potential
difference between anode 35 and cathode 37 causes the electrolytes in the fluid in central chamber 32 to flow into anion
chamber 34 and cation chamber 36. Specifically, negatively charged ions flow into anion chamber 34 while positively
charged ions flow into cation chamber 36 where they are subsequently removed. The treated fluid that passes through
EDI unit 30 exits as part of a treated fluid stream via flow path 52. A waste fluid stream filled with electrolytes exits via
EDI unit 30 can also be modified so that a suitable quantity of fluid can be recirculated around EDI unit 30 via flow path 56. This reduces the amount of fluid flowing through EDI unit 30 that would end up as part of the waste fluid stream. As a result, a higher quantity of fluid exits as the treated fluid stream as compared to the quantity of treated fluid from an EDI unit without recirculation.

During operation, after priming system 10 with an appropriate amount of fluid (in this case, priming fluid can be any of, dialysis fluid, sterile bagged water, tap water in its raw form, tap water purified through standard means such as deionization and/or reverse osmosis, or a combination therein), the dialysis solution is recirculated through circuit 14 via flow path 18 in the direction indicated. Used dialysis fluid leaves dialyzer 20 saturated with uremic toxins, as well as normal dialysis fluid components such as dextrose and ions (e.g., sodium, calcium, magnesium, etc.). The organic toxins of the fluid, as well as the lactate or bicarbonate buffer of the solution, are then removed from the fluid through adsorption onto a carbon surface (e.g. activated carbon or other appropriate organic neutralizing surface) of carbon source 40.

Urea, which is not well removed by carbon, is then exposed to urease source 50. Urease is an enzymatic catalyst which facilitates the breakdown of urea into ammonium and ammonia (e.g., depending on pH). Urease source 50 can be immobilized on any suitable surface that allows the passage of a liquid or be a membrane impregnated with cross-linked urease enzyme crystals.

After EDI unit 30, ions and/or fluids can be replaced in the clean fluid stream through the addition of one or more concentrated dialysis components from a concentrate or fluid metering source 80 via flow path 82. The concentrated dialysis components can include one or more osmotic agents (e.g., dextrose, icodextrin, glucose polymers, glucose polymer derivatives, amino acids), buffers (e.g., lactate, bicarbonate) and electrolytes (e.g. sodium, potassium, calcium, magnesium) from a small fluid source. After this addition, the fluid is compositionally equivalent to fresh dialysis solution and can be used to remove additional uremic toxins from the individual's blood stream.

To further realize the benefits of EDI over existing sorbent systems, EDI unit 30 would not be expected to be replaced over the foreseeable lifetime of the hemodialysis systems/devices. Carbon source 40 and urease source 50 can be replaced at some determined interval, but these are much lower cost components than sorbent cartridges and do not negatively impact the economic benefits of the system.

In an embodiment shown in FIG. 1, additions can be made to enhance the functionality and/or safety of the system. For example, biological purity of system 10 can be assured through replacement of circuits 12 and 14 after each treatment, along with dialyzer 20. However, circuits 12 and 14 can also be re-used for multiple treatments if suitable disinfection and sanitation methods were undertaken. These can include all currently accepted methods, such as heat sanitization, chemical sanitization (including ozonation), addition of ultraviolet ("UV") bactericidal lights, and the addition of additional dialyzers and/or ultrafilters in the system with a pore size appropriate for the removal of bacterial and sub-bacterial contaminants.

The monitoring of system 10 can be enhanced through the inclusion of an optional ammonia sensor in the loop after EDI unit 30 to ensure that all ammonia has been removed. Because fluid of resistance approaching 5 MΩ·cm can be made after passing through EDI unit 30, an optional conductivity sensor may be used to assure there is no ammonia versus the traditional approach of using an ammonia sensor. Finally, one or more optional ion exchanger unit 60 that have low cost and/or high capacity can be used to supplement EDI unit 30 to improve its performance or reduce its necessary size. These optional ion exchangers can include a phosphate removal exchanger with a bicarbonate counter ion to enhance phosphate removal or a cation exchanger that helps to remove any remaining ammonia.

The dialyzers in any embodiments of the present disclosure can include an ion-rejection membrane that allows the passage of negatively charged ions and nonionic species but restricts the passage of positively charged ions. Alternatively, the dialyzers in any embodiments of the present disclosure can include an ion-rejection membrane that allows the passage of positively charged ions and nonionic species but restricts the passage of negatively charged ions.

In another embodiment, a dialysis fluid recycling system 110 for peritoneal dialysis is illustrated in FIG. 2. As shown in FIG. 2, a circuit 112 cycles spent dialysis fluid from an individual 116 via flow path 122 through a dialyzer 120 and returns it to the individual's body via flow path 124. Dialyzer 120 can include a dialysate compartment and a peritoneal dialysis fluid compartment separated by a suitable membrane. A circuit 114 includes an EDI unit 130 in the dialysis fluid recycling system. Fluid from dialyzer 120 transfers to circuit 114 via flow path 118.
Circuit 114 also includes a carbon source 140 and a urease source 150 connected to carbon source 140 via flow path 152. Flow path 152 can lead directly back to dialyzer 120. Carbon source 140 and urease source 150 and optionally ion exchange unit 160 are in the form of removable cartridges.

EDI unit 130 can include a central chamber 132, an anion chamber 134 having an anode 135, and a cation chamber 136 having a cathode 137. As fluid flows through central chamber 132 via flow path 144, a potential difference between anode 135 and cathode 137 causes the electrolytes in the fluid in central chamber to flow into anion chamber 134 and cation chamber 136. The treated fluid that passes through EDI unit 130 exits as part of a treated fluid stream 152 that leads back to dialyzer 120. A waste fluid stream filled with electrolytes exits via flow path 54 that leads to a drain 170.

EDI unit 130 can also be modified so that a suitable quantity of fluid can be recirculated around EDI unit 130 via flow path 156. This reduces the amount of fluid flowing through EDI unit 130 that would end up as part of the waste fluid stream.

System 110 is nearly identical to the hemodialysis system 10 of Fig. 1. However, in this embodiment, the solution being passed through circuit 112 represents peritoneal dialysis fluid, rather than individual’s 116 own blood. The peritoneal dialysis procedure can be run, for example, in a “continuous flow” mode, where used dialysis fluid exits the individual’s peritoneum as new fluid enters it through a dual lumen catheter. The used fluid is passed through dialyzer 120 where uremic toxins are removed and the waste fluid is treated just as it would be in hemodialysis. The composition of a concentrate addition to the fluid stream in flow path 152 from a concentrate or fluid metering source 180 via flow path 182 may be specifically tailored for peritoneal dialysis.

Additions to this type of system, along with those described for the hemodialysis system, can be included to enhance effectiveness or safety of the system. In an embodiment, the typical dialyzer membrane can be replaced with an ion-rejection membrane that allows the passage of negatively charged ions and nonionic species, but restricts the passage of positively charged ions (or vice versa). In this case, the peritoneal dialysis loop that is recirculating to the individual would be cleared of uremic toxins (which are neutrally or negatively charged), but the concentrate addition would not need to include replacement of the positive ions of the dialysis solution, which enhances the efficiency of the system.

In an alternative embodiment, a dialysis fluid recycling system 210 for hemodialysis or peritoneal dialysis is illustrated in FIG. 3. As shown in FIG. 3, a circuit 212 cycles fluid from an individual 216 through a dialyzer 220 and returns it to the individual's body. A circuit 214 includes an EDI unit or module 230 in the dialysis fluid recycling system. Circuit 214 also includes a carbon source 240 and a urease source 250 connected to carbon source 240 via flow path 242. Circuit 214 can further include an optional ion exchange unit 260 in fluid connection with EDI unit 230 via flow path 252. Flow path 252 can lead directly back to dialyzer 220. Carbon source 240 and urease source 250 and optionally ion exchange unit 260 are in the form of removable cartridges.

EDI unit 230 can include a central chamber 232, an anion chamber 234 having an anode 235, and a cation chamber 236 having a cathode 237. As fluid flows through central chamber 232 via flow path 244, a potential difference between anode 235 and cathode 237 causes the electrolytes in the fluid in central chamber to flow into anion chamber 234 and cation chamber 236. The treated fluid that passes through EDI unit 230 exits as part of a treated fluid stream 252. A waste fluid stream filled with electrolytes exits via flow path 254 that leads to a drain 270.

EDI unit 230 can also be modified so that a suitable quantity of fluid can be recirculated around EDI unit 230 via flow path 256. This reduces the amount of fluid flowing through EDI unit 230 that would end up as part of the waste fluid stream.

After leaving EDI unit 230 via flow path 252, one or more dialysis components from a concentrate or fluid metering source 280 via flow path 282 may be specifically tailored for the specific type of dialysis performed. An additional purification or treatment component 290 in the form of a filter or ultraviolet bactericidal light can be added to circuit 212, as shown in FIG. 3. Fluid exiting dialyzer 220 via flow path 226 can be further filtered or subject to a bactericidal light to enhance the bacterial purity of system 210. The treated fluid can then enter individual 216 via flow path 224. Purification component 290 can be especially important to peritoneal dialysis because bacterial contamination is a significant concern for the treatment.

In yet another embodiment, a dialysis fluid recycling system 310 for peritoneal dialysis is illustrated in FIG. 4. As shown in FIG. 4, a circuit 312 cycles blood from an individual 316 through a circuit 314. In order to perform the peritoneal dialysis treatment as shown in FIG. 4, flow path 318 of recycling system 310 can be constructed such that spent dialysis fluid from individual 316 is sent directly to recycling system 310 without the need for “dialyzing” the PD fluid. The peritoneal dialysis procedure can be run, for example, in a “continuous flow” mode.

Circuit 314 includes an EDI unit or module 330 in the dialysis fluid recycling system. Circuit 314 also includes a carbon source 340 and a urease source 350 connected to carbon source 340 via flow path 342. Circuit 314 can further include an optional ion exchange unit 360 in fluid connection with EDI unit 330 via flow path 352. Flow path 352 can lead directly back to dialyzer 320. Carbon source 340 and urease source 350 and optionally ion exchange unit 360 are
EDI unit 330 can include a central chamber 332, an anion chamber 334 having an anode 335, and a cation chamber 336 having a cathode 337. As fluid flows through central chamber 332 via flow path 344, a potential difference between anode 335 and cathode 337 causes the electrolytes in the fluid in central chamber to flow into anion chamber 334 and cation chamber 336. The treated fluid that passes through EDI unit 330 exits as part of a treated fluid stream 352. A waste fluid stream filled with electrolytes exits via flow path 354 that leads to a drain 370.

EDI unit 330 can also be modified so that a suitable quantity of fluid can be recirculated around EDI unit 330 via flow path 356. This reduces the amount of fluid flowing through EDI unit 330 that would end up as part of the waste fluid stream.

After leaving EDI unit 330 via flow path 352, one or more dialysis components from a concentrate or fluid metering source 380 via flow path 382 may be specifically tailored for the type of dialysis performed. An additional purifying component 390 such as a filter, UV light, and/or other commonly accepted methods can optionally be used on the inlet line to the individual’s 316 peritoneal cavity to prevent bacterial contamination and also on the line from the individual back to system 310 (not shown) to prevent retro-contamination to individual 316. The purified dialysis solution can be provided to individual 316 via flow path 322.

In yet another embodiment, a dialysis fluid recycling system 410 for peritoneal dialysis is illustrated in FIG. 5. As shown in FIG. 5, a circuit 412 cycles dialysis fluid from an individual 416 to via flow path 422 to a three way valve 490. From three-way valve 490, the fluid flows to a circuit 414 via flow path 418 where the fluid is recycled. System 410 is designed to operate in a standard peritoneal dialysis therapy mode where fluid is injected, allowed to dwell, then removed from individual 416. Once the dialysis fluid has been purified, the dialysis fluid is then sent back to individual 416 via flow path 418, allowed to dwell, removed, purified, and repeated. The control of the flow direction can be accomplished with three-way valve 490 as shown in FIG. 5.

Circuit 414 includes an EDI unit 430. Circuit 414 also includes a carbon source 440 and a urease source 450 connected to carbon source 440 via flow path 442. Circuit 414 can further include an optional ion exchange unit 460 in fluid connection with EDI unit 430 via flow path 452. Flow path 552 can lead directly back to dialyzer 420. Carbon source 440 and urease source 450 and optionally ion exchange unit 460 are in the form of removable cartridges. After leaving EDI unit 430 via flow path 452, one or more dialysis components from a concentrate or fluid metering source 480 via flow path 482 may be specifically tailored for the type of dialysis performed.

EDI unit 430 can include a central chamber 432, an anion chamber 434 having an anode 435, and a cation chamber 436 having a cathode 437. As fluid flows through central chamber 432 via flow path 444, a potential difference between anode 435 and cathode 437 causes the electrolytes in the fluid in central chamber to flow into anion chamber 434 and cation chamber 436. The treated fluid that passes through EDI unit 430 exits as part of a treated fluid stream 452. A waste fluid stream filled with electrolytes exits via flow path 454 that leads to a drain 470.

EDI unit 430 can also be modified so that a suitable quantity of fluid can be recirculated around EDI unit 430 via flow path 456. This reduces the amount of fluid flowing through EDI unit 430 that would end up as part of the waste fluid stream.

In addition to the modifications described herein, the dialysis fluid recycling systems can be further enhanced in several ways. First, the dialysis fluid recycling system can remove nearly all solutes from the used or spent dialysis solution (including therapeutically beneficial solutes, which would then need to be re-added). The dialysis fluid recycling system can also be designed to allow reduced removal of the active osmotic agent in the peritoneal dialysis fluid (e.g., glucose or dextrose). The osmotic reagent can be replaced with a longer acting molecule, such as glucose microspheres that can be reintroduced into the dialysis fluid, to maintain the osmotic gradient in the individual.

EXAMPLES

By way of example and not limitation, the following example is illustrative of an embodiment of the present disclosure.

EXAMPLE 1

Experiments to determine the extent of the electrolyte removal using an EDI unit were performed. The experiments simulated EDI treatment of a post-urease dialysate. A peritoneal dialysis solution was spiked with 3200 ppm of Ammonium Carbonate (2000 ppm of urea can be converted into 3200 ppm of ammonium carbonate by urease). In different studies, the dialysis solution was passed through the EDI unit at a flow rate of 100 mL/min and 200 mL/min.

A Millipore EDI-15 Cell with a PK Precision VSP-12010 DC power supply was used as the EDI unit. Conductivity of the dialysis solution was measured using an Amber Science EC3084 Conductivity Meter.

During the experiments, the conductivity of the treated dialysis solution versus corresponding voltage/current of the EDI unit was measured. The final conductivity was compared to the original conductivity of the untreated dialysis
solution. A summary of the results is shown in Table 1 and FIGS. 6 and 7. FIG. 6 shows the conductivity of a dialysis solution treated using the EDI unit versus the operating voltage of the EDI unit. FIG. 7 shows the operating current of the EDI unit versus the operating voltage of the EDI unit.

<table>
<thead>
<tr>
<th>Dialysate flow rate (mL/min)</th>
<th>Voltage (Volts)</th>
<th>Current (Ampere)</th>
<th>Conductivity (mS/cm)</th>
<th>% Removal</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>0</td>
<td>0</td>
<td>15.9</td>
<td>0</td>
</tr>
<tr>
<td>100</td>
<td>20</td>
<td>2.1</td>
<td>8.4</td>
<td>47</td>
</tr>
<tr>
<td>100</td>
<td>40</td>
<td>3.6</td>
<td>2.28</td>
<td>86</td>
</tr>
<tr>
<td>100</td>
<td>60</td>
<td>4.3</td>
<td>0.48</td>
<td>97</td>
</tr>
<tr>
<td>200</td>
<td>80</td>
<td>5.6</td>
<td>0.08</td>
<td>99</td>
</tr>
</tbody>
</table>

As shown in Table 1 and FIGS. 6 and 7, a 99% electrolyte removal from the dialysis solution can be achieved using the EDI unit. It was also found that the EDI unit can be operated at a reduced voltage and reduced current to allow a specific percentage of electrolytes to pass through. This could allow the use of a smaller size EDI unit for better portability. In this case, the small amount of residue electrolytes, including ammonium ions, can be removed by a supplemental ion-exchange resin column downstream from the EDI unit.

It should be understood that various changes and modifications to the presently preferred embodiments described herein will be apparent to those skilled in the art.

Claims

1. A portable dialysis fluid recycling system (10, 110, 210) comprising:

   a carbon source (40, 140, 240); and
   a urease source (50, 150, 250) in fluid communication with the carbon source,
   characterized in that the system comprises an electrodeionization unit (30, 130, 230) in fluid communication with the urease source and in that the carbon source and the urease source are in the form of removable cartridges.

2. The dialysis fluid recycling system of Claim 1, which includes an ion exchange unit (60, 160, 260) in fluid communication with the electrodeionization unit (30, 130, 230).

3. The dialysis fluid recycling system of Claim 1 or 2, which includes a metering source (80, 280) in fluid communication with the electrodeionization unit (30, 230).

4. The dialysis fluid recycling system of Claim 1, said system being a hemodialysis system and comprising a dialyzer (20) in fluid communication with the electrodeionization unit (30).

5. The hemodialysis system of Claim 4, which includes an ion exchange unit (60) in fluid communication with the dialyzer (20).

6. The hemodialysis system of Claim 4 or 5, which includes a metering source (80) in fluid communication with the dialyzer (20).

7. The hemodialysis system of any one of Claims 4 to 6, which includes a filter in fluid communication with the dialyzer (20).

8. The hemodialysis system of any one of Claims 4 to 7, which includes an ultraviolet bactericidal light in fluid communication with the dialyzer (20).
9. The dialysis fluid recycling system of Claim 1, said system being a peritoneal dialysis system (110).

10. The peritoneal dialysis system of Claim 9, which includes an ion exchange unit (160) in fluid communication with the electrodeionization unit (130).

11. The peritoneal dialysis system of Claim 9 or 10, which includes a metering source in fluid communication with the electrodeionization unit (130).

12. The peritoneal dialysis system of any one of Claims 9 to 11, which includes a filter in fluid communication with the electrodeionization unit (130).

13. The peritoneal dialysis system of any one of Claims 9 to 12, which includes an ultraviolet bactericidal light in fluid communication with the electrodeionization unit (130).

14. The system of any one of claims 1, 4 and 9, wherein the electrodeionisation unit (30, 130, 230) includes a central chamber (32, 132, 232), an anion chamber (34, 134, 234) having an anode (35, 135, 235), and a cation chamber (36, 136, 236) having a cathode (37, 137, 237).

15. The system of any one of claims 1, 4 and 9, wherein the electrodeionisation (EDI) unit (30, 130, 230) is configured such that a quantity of fluid can be recirculated around the EDI unit via a flow path (56, 156, 256).

Patentansprüche

1. Tragbares Dialysefluidrückführungssystem (10, 110, 210), das Folgendes umfasst:
   eine Kohlenstoffquelle (40, 140, 240); und
eine Ureasequelle (50, 150, 250) in Fluidverbindung mit der Kohlenstoffquelle,
dadurch gekennzeichnet, dass das System eine Elektrodeionisationseinheit (30, 130, 230) in Fluidverbindung mit der Ureasequelle umfasst und dass die Kohlenstoffquelle und die Ureasequelle in Form entferbarer Kartuschen vorliegen.

2. Dialysefluidrückführungssystem nach Anspruch 1, das eine Ionenaustauscheinheit (60, 160, 260) in Fluidverbindung mit der Elektrodeionisationseinheit (30, 130, 230) beinhaltet.

3. Dialysefluidrückführungssystem nach Anspruch 1 oder 2, das eine Dosierquelle (80, 280) in Fluidverbindung mit der Elektrodeionisationseinheit (30, 230) beinhaltet.

4. Dialysefluidrückführungssystem nach Anspruch 1, wobei das System ein Hämodialyse- system ist und einen Dialysator (20) in Fluidverbindung mit der Elektrodeionisationseinheit (30) umfasst.

5. Hämodialyse- system nach Anspruch 4, das eine Ionenaustauscheinheit (60) in Fluidverbindung mit dem Dialysator (20) beinhaltet.

6. Hämodialyse- system nach Anspruch 4 oder 5, das eine Dosierquelle (80) in Fluidverbindung mit dem Dialysator (20) beinhaltet.

7. Hämodialyse- system nach einem der Ansprüche 4 bis 6, das einen Filter in Fluidverbindung mit dem Dialysator (20) beinhaltet.

8. Hämodialyse- system nach einem der Ansprüche 4 bis 7, das ein bakterienabtötendes UV-Licht in Fluidverbindung mit dem Dialysator (20) beinhaltet.

9. Dialysefluidrückführungssystem nach Anspruch 1, wobei das System eine Peritonealdialyse- system (110) ist.

10. Peritonealdialyse- system nach Anspruch 9, das eine Ionenaustauscheinheit (160) in Fluidverbindung mit der Elektrodeionisationseinheit (130) beinhaltet.
11. Peritonealdialysesystem nach Anspruch 9 oder 10, das eine Dosierquelle in Fluidverbindung mit der Elektrodeionisationseinheit (130) beinhaltet.

12. Peritonealdialysesystem nach einem der Ansprüche 9 bis 11, das einen Filter in Fluidverbindung mit der Elektrodeionisationseinheit (130) beinhaltet.

13. Peritonealdialysesystem nach einem der Ansprüche 9 bis 12, das ein bakterienabtötendes UV-Licht in Fluidverbindung mit der Elektrodeionisationseinheit (130) beinhaltet.


15. System nach einem der Ansprüche 1, 4 und 9, wobei die Elektrodeionisations(EDI)-Einheit (30, 130, 230) so konfiguriert ist, dass eine Fluidmenge um die EDI-Einheit herum über einen Strömungsweg (56, 156, 256) rezirkuliert werden kann.

Revendications

1. Système de recyclage du fluide de dialyse portable (10, 110, 210) comprenant :
   une source de carbone (40, 140, 240) ; et
   une source d’uréase (50, 150, 250) en communication fluidique avec la source de carbone,
   caractérisé en ce que le système comprend une unité d’électrodésionisation (30, 130, 230) en communication fluidique avec la source d’uréase et en ce que la source de carbone et la source d’uréase ont la forme de cartouches amovibles.

2. Système de recyclage du fluide de dialyse selon la revendication 1, qui comprend une unité d’échange d’ions (60, 160, 260) en communication fluidique avec l’unité d’électrodésionisation (30, 130, 230).

3. Système de recyclage du fluide de dialyse selon la revendication 1 ou 2, qui comprend une source de mesure (80, 280) en communication fluidique avec l’unité d’électrodésionisation (30, 230).

4. Système de recyclage du fluide de dialyse selon la revendication 1, ledit système étant un système d’hémodialyse et comprenant un dialyseur (20) en communication fluidique avec l’unité d’électrodésionisation (30).

5. Système d’hémodialyse selon la revendication 4, qui comprend une unité d’échange d’ions (60) en communication fluidique avec le dialyseur (20).

6. Système d’hémodialyse selon la revendication 4 ou 5, qui comprend une source de mesure (80) en communication fluidique avec le dialyseur (20).

7. Système d’hémodialyse selon l’une quelconque des revendications 4 à 6, qui comprend un filtre en communication fluidique avec le dialyseur (20).

8. Système d’hémodialyse selon l’une quelconque des revendications 4 à 7, qui comprend une lumière ultraviolette bactéricide en communication fluidique avec le dialyseur (20).

9. Système de recyclage du fluide de dialyse selon la revendication 1, ledit système étant un système de dialyse péritonéale (110).

10. Système de dialyse péritonéale selon la revendication 9, qui comprend une unité d’échange d’ions (160) en communication fluidique avec l’unité d’électrodésionisation (130).

11. Système de dialyse péritonéale selon la revendication 9 ou 10, qui comprend une source de mesure en communication fluidique avec l’unité d’électrodésionisation (130).
12. Système de dialyse péritonéale selon l’une quelconque des revendications 9 à 11, qui comprend un filtre en communication fluidique avec l’unité d’électrodésionisation (130).

13. Système de dialyse péritonéale selon l’une quelconque des revendications 9 à 12, qui comprend une lumière ultraviolette bactéricide en communication fluidique avec l’unité d’électrodésionisation (130).


15. Système selon l’une quelconque des revendications 1, 4 et 9, dans lequel l’unité d’électrodésionisation (EDI) (30, 130, 230) est configurée de sorte qu’une quantité de fluide puisse être remise en circulation autour de l’unité EDI par l’intermédiaire d’un chemin d’écoulement (56, 156, 256).
FIG. 6

FIG. 7
REFERENCES CITED IN THE DESCRIPTION

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