



(51) International Patent Classification:

C25B 3/20 (2021.01) C25B 9/23 (2021.01)
C25B 3/26 (2021.01) C25B 11/031 (2021.01)
C25B 9/13 (2021.01) C25B 15/08 (2006.01)

(21) International Application Number:

PCT/NL2023/050316

(22) International Filing Date:

08 June 2023 (08.06.2023)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

2032221 20 June 2022 (20.06.2022) NL

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(81) Designated States (unless otherwise indicated, for every

kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CV, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IQ, IR, IS, IT, JM, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, MG, MK, MN, MU, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, ST, SV, SY, TH,

(54) Title: DEVICE FOR PERFORMING A BIOLOGICALLY CATALYSED ELECTROCHEMICAL REACTION

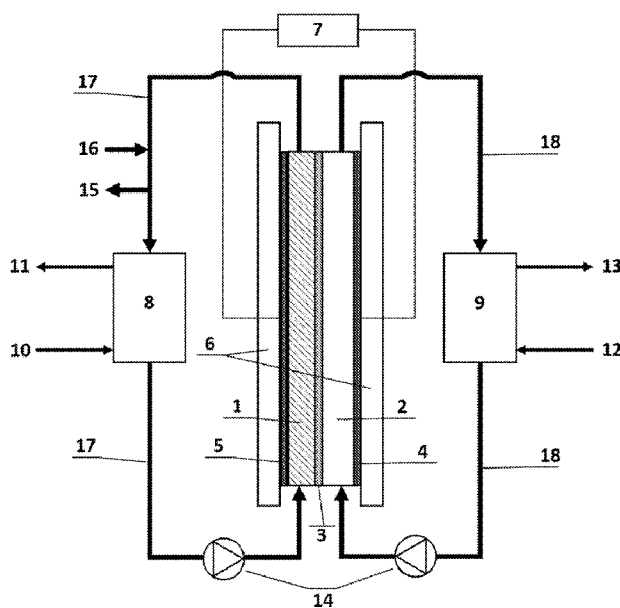


FIG. 1

(57) Abstract: The present invention relates to a device for performing a biologically catalysed electrochemical reaction, wherein the device comprises a reactor comprising a cathodic compartment, an anodic compartment and an ion exchange membrane, wherein each of the compartments comprises an electrode and an inlet for receiving and an outlet for discharging a medium, and wherein the ion exchange membrane is arranged between both compartments. The reactor further comprises an energy supply unit connected with the electrodes to control the energy supply, during operation of the device. Both compartments are provided with the same or substantially the same flow pattern for defining a flow path and flow direction of the medium and wherein each of the electrodes are allowed to be in contact with the medium of the respective compartment. The present invention further relates to a kit-of-parts, the use of the device and method of using the device of the present invention.

TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, WS,
ZA, ZM, ZW.

- (84) Designated States** (*unless otherwise indicated, for every kind of regional protection available*): ARIPO (BW, CV, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SC, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, ME, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

- *without international search report and to be republished upon receipt of that report (Rule 48.2(g))*

Title: Device for performing a biologically catalysed electrochemical reaction

Description:

The present invention relates to a device for performing a biologically catalysed electrochemical reaction. The present invention further relates to a kit-of-parts for assembling the device of the present invention, the use of the device of the present invention for performing a biologically catalysed electrochemical reaction. The present invention also relates to a method for performing a biologically catalysed electrochemical reaction using the device of the present invention.

The field of biologically catalysed electrochemical reactions (including microbial electrosynthesis; MES), is fast developing technological field due to its potential use in producing fuels, chemicals, feed, and food ingredients from carbon-waste, such as carbon dioxide, using electrical energy generated by either traditional power stations or preferably renewable electricity generation. The technique may have further relevant applications in the use of producing speciality chemicals such as drug precursors through microbially assisted electrocatalysis. Typically, microbial electrosynthesis is a form of microbial electrocatalysis in which electrons are supplied to living microorganisms via a cathode in an electrochemical cell by applying an electric current or potential. The electrons are then used by the microorganisms to reduce carbon dioxide to yield industrially relevant products.

In order to achieve a sustainable future, the further development and application of microbial electrosynthesis is needed in order to translate the laboratory scale results achieved nowadays to large scale industrial applications which are able to produce a relevant amount of carbon-based products produced from abundant molecules such as carbon dioxide and water, using renewable energy (electricity) as the sole source of energy for facilitating the synthesis. The current systems developed to perform a biologically catalysed electrochemical reaction are not yet ready or suitable for scale-up. Also further improvement on the productivity of the current systems is desired as well as an increase in energy efficiency.

In a first aspect of the present invention, the invention relates to a device for performing a biologically catalysed electrochemical reaction, wherein the device comprises a reactor comprising:

- a cathodic compartment comprising at least one cathodic electrode, a first side and an opposite second side parallel to the first side, wherein the cathodic compartment further comprises an inlet for receiving a medium, such as an electrolyte, and an outlet for discharging the medium; and

- an anodic compartment comprising at least one anodic electrode, a first side and an opposite second side parallel to the first side, wherein the anodic compartment further comprises an inlet for receiving a medium, such as an electrolyte, and an outlet for discharging the medium,

wherein the cathodic compartment and the anodic compartment are arranged such that the first side of the cathodic compartment faces the first side of the anodic compartment, the reactor further comprising:

- an ion exchange membrane arranged between the first side of the cathodic compartment and the first side of the anodic compartment, wherein the membrane is configured to allow ion exchange between the cathodic compartment and the anodic compartment and vice versa; and

- an energy supply unit connected with the at least one cathodic electrode and the at least one anodic electrode, wherein the energy supply unit is configured to control the energy supply, during operation of the device, between the at least one cathodic electrode and the at least one anodic electrode.

It was found that by providing a device wherein both the cathodic and anodic compartments are provided with a flow pattern connected to the inlet and the outlet of the respective compartment therewith defining a flow path and a flow direction of the medium received by the respective compartment, which flow path and flow direction is in a plane parallel to the first and second side of the respective compartment, and wherein the at least one electrode of the respective compartment is positioned such that over at least a part of the flow path defined in the respective compartment the electrode is allowed to be in contact with the medium received by the respective compartment, a highly efficient system is provided, wherein a higher energy efficiency and a higher productivity is achieved compared to the systems known in the art. It was found that by providing the device of the present invention, a higher current density

and higher production rates are observed, while a lower cell voltage is needed to drive the microbial electrosynthesis performed in the reactor of the device of the present invention.

Given the device of the present invention and as a precondition, the flow pattern of both compartments, i.e. the cathodic compartment and the anodic compartment, is the same or substantially the same and the flow patterns of both compartments are arranged such that the flow path of one compartment is substantially or at least partially aligned with the flow path of the other compartment.

Given the above, it is noted that the flow path of the medium received by a compartment is defined by the design of the flow pattern of that compartment. In other words, the flow pattern defines a structure of flow channels and/or flow areas wherethrough the medium received by the compartment is forced to flow. Any suitable flow pattern may be used in the device of the present invention. An example of such suitable flow patterns is provided in Figure 2.

The flow direction of the medium received by a compartment is defined by the positioning of the inlet and outlet, or multiple inlets and/or outlets, of each compartment in relation to the flow pattern provided in that compartment. By switching the inlet and outlet, the flow direction of the medium through the flow path defined by the flow pattern may be directed into the reverse direction.

As used herein the terms "cathodic compartment" and "cathodic electrode" may also be referred to as "first compartment" and "first electrode" respectively. Also, in line with this, as used herein the terms "anodic compartment" and "anodic electrode" may also be referred to as "second compartment" and "second electrode" respectively. In other words, the present invention may refer to a device comprising a first compartment and a second compartment, wherein both compartments are provided with an electrode, i.e. the first and second electrode, respectively. Consequently, the terms "cathodic compartment" and "cathodic electrode" have to be construed as a compartment and electrode suitable for use as cathode in a method suitable for performing a biologically catalysed electrochemical reaction. Inherently, the terms "anodic compartment" and "anodic electrode" have to be construed as a compartment and electrode suitable for use as anode in a method suitable for performing an electrochemical reaction. It is noted that the anode of the device of the present invention is suitable for performing an electrochemical reaction, wherein the

electrochemical reaction is preferably catalysed by using a heterogeneous catalyst. Alternatively, the electrochemical reaction performed at the anode may also be catalysed biologically. In order to improve the readability of the application as such, the terms “cathodic” and “anodic” in combination with either “compartment” or “electrode” are used throughout the application in order to distinguish both parts of the reactor of the device.

As used herein, the term “parallel” has to be construed as within its general meaning. For the present application the term “parallel” is used to indicate the sandwich-like design of the reactor of the device of the present invention, i.e. the compartments and membranes being stackable upon one and each other to form an expandable, up scalable reactor.

As used herein, the term “medium” may refer to any fluid, like a liquid, gas or other material that continuously deforms under an applied shear stress, or external force. In the present invention, the term “medium” preferably refers to a liquid, more preferably a liquid comprising ions, such as an electrolyte.

It is further noted that the first side of the cathodic and anodic compartment is at least permeable for ions comprised in the medium received by the respective compartment. Alternatively, the first side of the cathodic and anodic compartment is provided with perforations (e.g. a mesh) or provided with a continuous opening following the flow pattern comprised by the respective compartment.

The second side of the cathodic and anodic compartment maybe impermeable for ions or other contents contained by the respective compartment. However, in order to increase the functionality and stackability of the reactor of the present invention, the second side of the cathodic and anodic compartment is similar to the first side of the respective compartment, i.e. at least permeable for ions or other components. Preferably the second side of the cathodic and anodic compartment is also provided with perforations (e.g. a mesh) or a continuous opening following the flow pattern comprised by the respective compartment.

The ion exchange membrane of the present invention may be selected from any membrane suitable for exchanging ions between one compartment to the other compartment. The membrane may be semi-permeable, i.e. being selective in the type of ions (cations or anions) passing through the membrane. The membrane of the present invention may be selected from the group consisting of, but not limited to,

cation exchange membranes (CEM), anion exchange membranes (AEM) and bipolar membranes (BPM).

The energy supply unit as used in the device of the present invention may be selected from a voltage regulator or power source, wherein the voltage applied to the electrodes of the reactor of the present invention can be controlled during operation of the device of the present invention.

It is noted that over at least a part of the flow path defined in the anodic and cathodic compartment the respective at least one electrode is positioned such that the electrode is allowed to be in contact with the medium received by that respective compartment. In order to allow the electrode to contact the medium received by the respective compartment, different suitable designs of the electrode are possible.

For example, the electrode may be positioned next to the compartment, i.e. facing the second side of the compartment, wherein the second side of the compartment is provided with perforations, discontinuous opening or continuous opening, following the flow path of the medium received by the compartment. By having a second side provided with perforations or a discontinuous opening, the electrode is able to contact the medium received by the compartment at pre-defined spots or pre-defined flow trajectories. By providing such spots or trajectories, a device can be designed wherein in different parts of the reactor different reactions can be facilitated. Alternatively, by providing a second side with a continuous opening following the flow path of the medium comprised in the respective compartment, the electrode is allowed to contact the medium throughout the complete flow path of the medium, resulting in a highly efficient reactor system.

In another example, the electrode may be positioned in the flow path defined by the flow pattern of the respective compartment. Such electrode positioned in the flow path may have the form of a fibrous or porous material. Such electrode may be present in a part of the flow path or throughout the complete flow path. Also, several electrodes may be present in different parts of the flow path to define particular reaction sites or spots within the same reactor.

As already mentioned above, the electrode may be present over a part of the flow path of the compartment in order to contact the medium over just a part of the flow path of the medium received by the respective compartment. However, beneficial results are observed by providing an electrode that is present over at least 50% of the

flow path of the compartment. Even better results are obtained by providing an electrode that is present over at least 60%, at least 70%, at least 80% or at least 90% of the flow path of the compartment. Most beneficial is the presence of an electrode that is present over the complete, i.e. about 100%, flow path of the compartment.

5 Irrespective the actual location of the electrodes, in a preferred embodiment of the present invention, the flow pattern of the cathodic compartment and the flow pattern of the anodic compartment are arranged such that the at least one cathodic electrode and at least one anodic electrode are in close proximity to each other. In other words, in such preferred embodiment the electrodes are arranged such that, in
10 the parallel construction of the device of the present invention, both electrodes are aligned with each other or, in other words, the electrodes are allowed to contact the medium in an aligned parallel manner.

It was found that particular good results are obtained by providing a device of the present invention wherein the at least one cathodic electrode is an electrode made
15 of porous material, such as a carbon felt electrode, which extends through at least a part of the flow path of the cathodic compartment. In a further preferred embodiment, the flow path of the cathodic compartment is completely filled with the electrode made of porous material. As used herein, the term "completely filled" has to be construed as to refer to a cross-sectional view of the flow path wherein the cross-section of the flow
20 path is completely covered by the cathodic electrode. In other words, the medium received by the cathodic compartment is forced to flow through the cathodic electrode. By providing a flow path completely filled with the cathodic electrode, either extending over a part of the flow path or extending throughout the complete flow path, the medium is not able to flow around the cathodic electrode.

25 With regard to the anodic electrode, it was found that the at least one anodic electrode is preferably arranged along at least a part of the flow path of the anodic compartment. Whereas the cathodic electrode is preferably of a 3D shape and provided in the flow path itself, the anodic electrode is either of a 2D shape and provided at the edges of the flow path, or of a 3D shape and provided in the flow path
30 itself, i.e. similar to the configuration of the cathodic electrode. Such 2D configuration may be provided by providing an anodic electrode facing the second side of the anodic compartment or by providing an anodic electrode provided as a coating onto the flow path defined by the anodic compartment.

With regard to the inlets and outlets for receiving a medium and discharging the medium respectively, it is noted that a compartment may be provided comprising a single inlet and a single outlet. However, the cathodic compartment and/or the anodic compartment may comprise a number of inlets for receiving the medium by the
5 respective compartment and/or a number of outlets for discharging the medium from the respective compartment. In a preferred embodiment, the number of inlets is equal to the number of outlets in order to provide a constant, controllable flow speed of the medium flowing through the flow pattern provided. Alternatively or in addition, the number of inlets and/or outlets between compartments is the same in order have
10 similar flow profiles in adjacent compartments.

In a further embodiment the flow direction of the medium in each of the compartments may be controlled by defining the inlet(s) and outlet(s) of the medium for that respective compartment. Preferably, the flow direction defined in the anodic compartment is equal to the flow direction defined in the cathodic compartment.
15 However, alternatively, the flow direction defined in the anodic compartment is opposite to the flow direction defined in the cathodic compartment.

In order to provide a constant flow of gas to the cathodic compartment, preferably a constant flow of carbon dioxide, the reactor of the device of the present invention may further comprise:

20 - a gas compartment comprising an inlet for receiving a gaseous medium and an outlet for discharging the gaseous medium,

wherein the gas compartment is arranged such that a gas permeable side of the gas compartment faces the second side of the cathodic compartment, the reactor further comprising:

25 - a gas exchange membrane arranged between the gas permeable side of the gas compartment and the second side of the cathodic compartment, wherein the membrane is configured to allow gas exchange between the gas compartment and the cathodic compartment and vice versa.

The gas compartment may further comprise a flow pattern which is the same or
30 substantially the same as the flow pattern of the cathodic compartment. Such flow pattern, connected to the inlet and outlet of the gas compartment, defines a flow path and flow direction of the gaseous medium, which flow path and flow direction is in a plane parallel to the gas permeable side of the gas compartment. The flow pattern of

the gas compartment may be arranged such that, during operation of the device, gas exchange between the medium received by the cathodic compartment and the gaseous medium received by the gas compartment is facilitated.

5 The gas exchange membrane may be any suitable membrane permeable to a gaseous medium or contents comprised in such gaseous medium. One example of such gas exchange membrane is a gas diffusion layer (GDL).

10 With regard to the stackability of the device of the present invention, it is noted that the device may be part of a stackable system for performing a biologically catalysed electrochemical reaction. By providing a stackable system, the reaction volume of the reactor of the device can be increased without resulting in a reduction of efficiency of the method performed by the device of the present invention. In other words, a system obtained by stacking a plurality of devices of the present invention may have a similar or slightly deviating efficiency in performing the biologically catalysed electrochemical reaction.

15 It is further noted that the system comprised of a plurality of devices of the present invention stacked in parallel may have many different configurations. For example, such system may be comprised of a reactor wherein each anodic compartment is flanked by a cathodic compartment, wherein adjacent compartments are separated by an ion exchange membrane.

20 In case a gas compartment is present, such system comprised of a plurality of devices of the present invention stacked in parallel may have the configuration wherein each anodic compartment is flanked by a cathodic compartment, wherein adjacent anodic and cathodic compartments are separated by an ion exchange membrane, and wherein the cathodic compartments are further connected to a gas compartment separated by a gas exchange membrane. In such configuration, each of the gas compartments may be flanked by a cathodic compartment, wherein adjacent compartments are separated by the gas exchange membrane.

25 It is further noted that by providing the stackable device of the present invention, the device is able to provide a highly efficient method for performing a biologically catalysed electrochemical reaction, wherein both the electrochemical parameters and biological parameters are balanced in order to obtain an optimal performance.

30 In an alternative embodiment of the present invention, the device may comprise two or more cathodic electrodes, wherein the two or more cathodic electrodes are

arranged such that each of the cathodic electrodes is allowed to be in contact with the medium received by the cathodic compartment over a distinct, different part of the flow path. Also, in another alternative embodiment, or in addition to the above alternative embodiment, the device of the present invention may comprise two or more anodic electrodes, wherein the two or more anodic electrodes are arranged such that each of the anodic electrodes is allowed to be in contact with the medium received by the anodic compartment over a distinct, different part of the flow path. As already explained above, by providing a reactor wherein two or more electrodes are present, different spots or trajectories may be defined for performing similar or different synthetic reactions.

In a second aspect of the present invention, the invention relates to a kit-of-parts for assembling the device according to any of the preceding claims, the kit-of-parts comprising:

- at least one cathodic compartment comprising an inlet for receiving a medium, such as an electrolyte, and an outlet for discharging the medium;
- at least one anodic compartment comprising an inlet for receiving a medium, such as an electrolyte, and an outlet for discharging the medium;
- at least one cathodic electrode and at least one anodic electrode;
- an ion exchange membrane; and
- an energy supply unit connectable with the at least one cathodic electrode and the at least one anodic electrode,

wherein each of the compartments is provided with a flow pattern connected to the inlet and the outlet of the respective compartment, wherein the flow pattern of the anodic compartment is the same or substantially the same as the flow pattern of the cathodic compartment, and wherein each of the at least one electrodes is configured to be positioned over at least a part of the flow path defined by the flow pattern such that the respective electrode is allowed to be in contact with the medium received by the respective compartment in an assembled state of the device.

The kit-of-parts of the present invention may further comprise:

- at least one gas compartment comprising an inlet for receiving a gaseous medium and an outlet for discharging the gaseous medium; and
- at least one gas exchange membrane.

It is noted that the kit-of-parts may comprise various compartments having different flow patterns. Preferably the kit-of-parts comprises a various sets of similar flow patterns in order to design a reactor wherein flow patterns can be aligned in a stackable manner.

5

In a third aspect of the present invention, the invention relates to the use of the device according to the present invention in a biologically catalysed electrochemical reaction, preferably a microbial electrosynthesis.

As used herein, the term “electrochemical reaction” refers to a method wherein the method includes (at least) an anodic reaction and a cathodic reaction. In the method of the present invention, the term “biologically catalysed” relates to at least a cathodic reaction that is biologically catalysed. The anodic reaction may be provided with heterogeneous catalysts wherein the anodic reaction is able to produce oxygen. On the other hand, the anodic reaction may be biologically catalysed as well.

15

In a fourth aspect of the present invention, the invention relates to a method of performing a biologically catalysed electrochemical reaction, wherein the method is carried out in a device according to the present invention. The biologically catalysed electrochemical reaction is preferably a microbial electrosynthesis.

20

Embodiments of the device of the present invention will next be explained by means of the accompanying figures, wherein:

Fig. 1 shows a schematical view of an embodiment of the device of the present invention;

Fig. 2 shows an example of a schematical view (cross-section) of a flow pattern used in the device of the present invention;

Fig. 3 shows the evolution of current over time at a cathode using the embodiment of Figure 1;

Fig. 4 shows acetate, n-butyrate and n-caproate concentrations over time using the embodiment of Figure 1;

30

Fig. 5 shows an embodiment of the reactor of the present invention; and

Fig. 6 shows a further embodiment of the reactor of the present invention.

Figure 1 shows a schematical view of an embodiment of the device of the present invention comprising the cathodic compartment 1, anodic compartment 2, wherein both compartments 1, 2 are separated by an ion exchange membrane 3. Both compartments are enclosed by supporting plates 6, being solid plates non-permeable for medium or contents of the medium comprised in the compartments 1, 2. The supporting plates 6 are separated from the compartments 1, 2 by means of a 2D anode electrode 2 and a current collector 5. It is noted that the cathodic compartment 1 is filled with a 3D electrode, e.g. a carbon felt electrode (not shown).

The device as depicted in Figure 1, further comprises an energy supply 7 connected to the cathodic electrode (not shown) and the anodic electrode 2. In addition, the device further comprises, at the cathodic compartment side, a recirculation bottle 8 for gas sparging, including a CO₂ gas inlet 10 and a gas outlet 11. At the anodic compartment side, the device further comprises a recirculation bottle 9 for gas stripping, including a N₂ gas inlet 12 and a gas outlet 13. Both recirculation circuits, providing the recirculation of catholyte 17 and the recirculation of anolyte 18 are provided with recirculation pumps 14. The catholyte recirculation 17 is provided with a medium inlet 16 and a medium outlet 15. The inlets and outlets of the flow patterns comprised in the cathodic compartment 1 and the anodic compartment 2 are not shown.

Figure 2 shows a flow pattern example that may be used in the device of the present invention for both the anodic compartment and cathodic compartment. In Figure 2, the flow pattern shown is a flow pattern typically used in the cathodic compartment, comprising an inlet and an outlet for medium (indicated by the arrows) and a serpentine-shaped flow path (indicated in black) wherein the flow path is completely filled with a porous cathodic electrode. Preferably, the anodic flow pattern has a similar design, wherein the flow path is optionally completely filled with an anodic electrode.

Figure 3 show the evolution of the current density over time at an applied cathode potential of -0.85V compared to a standard hydrogen electrode (SHE). The current evolution is normalized to the projected surface area (PSA) and the cathodic compartment volume using the embodiment setup depicted in Figure 1.

Figure 4 shows the concentrations of acetate (circle), n-butyrate (square) and n-caproate (triangle) over time using the embodiment setup depicted in Figure 1.

Figures 5 and 6 show two different embodiments of the reactor of the present invention comprising a cathodic compartment 1 and anodic compartment 2 separated by a ion exchange membrane 4. In Figure 6, the gas compartment 3 is added to the reactor separated with the cathodic compartment 1 by a gas exchange membrane 5.

Example

The embodiment setup of the device as depicted in Figure 1 was used to measure the key performance indicators for a microbial electrosynthesis (MES) compared to the measured key performance indicators for the same microbial electrosynthesis disclosed in the prior art (Jourdin, L., S. Raes, C. Buisman, and D. Strik, Critical biofilm growth throughout unmodified carbon felts allows continuous bioelectrochemical chain elongation from CO₂ up to caproate at high current density. Frontiers in Energy Research, 2018. 6: p. 7). The comparative results are provided in Table 1.

	Current density (kA m ⁻³)	Production rate (kg m ⁻³)	Energy efficiency (%)
Prior art	7.84	27	38
Invention	Up to 50	86	50

CLAIMS

1. Device for performing a biologically catalysed electrochemical reaction, wherein the device comprises a reactor comprising:

5 - a cathodic compartment comprising at least one cathodic electrode, a first side and an opposite second side parallel to the first side, wherein the cathodic compartment further comprises an inlet for receiving a medium, such as an electrolyte, and an outlet for discharging the medium; and

10 - an anodic compartment comprising at least one anodic electrode, a first side and an opposite second side parallel to the first side, wherein the anodic compartment further comprises an inlet for receiving a medium, such as an electrolyte, and an outlet for discharging the medium,

15 wherein the cathodic compartment and the anodic compartment are arranged such that the first side of the cathodic compartment faces the first side of the anodic compartment,

 the reactor further comprising:

20 - an ion exchange membrane arranged between the first side of the cathodic compartment and the first side of the anodic compartment, wherein the membrane is configured to allow ion exchange between the cathodic compartment and the anodic compartment and vice versa; and

 - an energy supply unit connected with the at least one cathodic electrode and the at least one anodic electrode, wherein the energy supply unit is configured to control the energy supply, during operation of the device, between the at least one cathodic electrode and the at least one anodic electrode,

25 **characterised in that**

30 - the cathodic compartment is provided with a flow pattern connected to the inlet and the outlet of the cathodic compartment therewith defining a flow path and a flow direction of the medium received by the cathodic compartment, which flow path and flow direction is in a plane parallel to the first and second side of the cathodic compartment, and wherein the at least one cathodic electrode is positioned such that over at least a part of the flow path defined in the cathodic compartment the cathodic electrode is allowed to be in contact with the medium received by the cathodic compartment; and

- the anodic compartment is provided with a flow pattern connected to the inlet and the outlet of the anodic compartment therewith defining a flow path and a flow direction of the medium received by the anodic compartment, which flow path and flow direction is in a plane parallel to the first and second side of the anodic compartment, and wherein the at least one anodic electrode is positioned such that over at least a part of the flow path defined in the anodic compartment the anodic electrode is allowed to be in contact with the medium received by the anodic compartment,

in that the flow pattern of the anodic compartment is the same or substantially the same as the flow pattern of the cathodic compartment, and

in that the flow pattern of the cathodic compartment and the flow pattern of the anodic compartment are arranged such that the flow path of the cathodic compartment is substantially or at least partially aligned with the flow path of the anodic compartment.

2. Device according to claim 1, wherein the flow pattern of the cathodic compartment and the flow pattern of the anodic compartment are arranged such that the at least one cathodic electrode and at least one anodic electrode are in close proximity to each other.

3. Device according to claim 1 or 2, wherein the at least one cathodic electrode is an electrode made of porous material, such as a carbon felt electrode, which extends through at least a part of the flow path of the cathodic compartment.

4. Device according to claim 3, wherein the flow path of the cathodic compartment is completely filled with the electrode made of porous material.

5. Device according to any of the preceding claims, wherein the at least one anodic electrode is arranged along at least a part of the flow path of the anodic compartment.

6. Device according to any of the preceding claims, wherein the cathodic compartment and/or the anodic compartment comprises a number of inlets for receiving the medium by the respective compartment and/or a number of outlets for discharging the medium from the respective compartment.

7. Device according to claim 6, wherein:

- the number of inlets is equal to the number of outlets; and/or
- the number of inlets and/or outlets between compartments is the same.

8. Device according to any of the preceding claims, wherein:

- the flow direction defined in the anodic compartment is equal to the flow direction defined in the cathodic compartment; or
- the flow direction defined in the anodic compartment is opposite to the flow direction defined in the cathodic compartment.

9. Device according to any of the preceding claims, wherein the reactor further comprises:

- a gas compartment comprising an inlet for receiving a gaseous medium and an outlet for discharging the gaseous medium,

wherein the gas compartment is arranged such that a gas permeable side of the gas compartment faces the second side of the cathodic compartment,

the reactor further comprising:

- a gas exchange membrane arranged between the gas permeable side of the gas compartment and the second side of the cathodic compartment, wherein the membrane is configured to allow gas exchange between the gas compartment and the cathodic compartment and vice versa.

10. Device according to any of the preceding claims, wherein the device comprises two or more cathodic electrodes, wherein the two or more cathodic electrodes are arranged such that each of the cathodic electrodes is allowed to be in contact with the medium received by the cathodic compartment over a distinct, different part of the flow path.

11. Device according to any of the preceding claims, wherein the device comprises two or more anodic electrodes, wherein the two or more anodic electrodes are arranged such that each of the anodic electrodes is allowed to be in contact with the medium received by the anodic compartment over a distinct, different part of the flow path.

12. Kit-of-parts for assembling the device according to any of the preceding claims, the kit-of-parts comprising:

- at least one cathodic compartment comprising an inlet for receiving a medium, such as an electrolyte, and an outlet for discharging the medium;
- at least one anodic compartment comprising an inlet for receiving a medium, such as an electrolyte, and an outlet for discharging the medium;
- at least one cathodic electrode and at least one anodic electrode;

- an ion exchange membrane; and
- an energy supply unit connectable with the at least one cathodic electrode and the at least one anodic electrode,

5 wherein each of the compartments is provided with a flow pattern connected to the inlet and the outlet of the respective compartment, wherein the flow pattern of the anodic compartment is the same or substantially the same as the flow pattern of the cathodic compartment,

and wherein each of the at least one electrodes is configured to be positioned over at least a part of the flow path defined by the flow pattern such that the respective
10 electrode is allowed to be in contact with the medium received by the respective compartment in an assembled state of the device.

13. Kit-of-parts according to claim 12, wherein the kit-of-parts further comprises:

- at least one gas compartment comprising an inlet for receiving a gaseous medium and an outlet for discharging the gaseous medium; and
- 15 - at least one gas exchange membrane.

14. Use of the device according to any of claims 1-11 in a biologically catalysed electrochemical reaction, preferably a microbial electrosynthesis.

15. Method of performing a biologically catalysed electrochemical reaction, wherein the method is carried out in a device according to any of the claims 1-11.

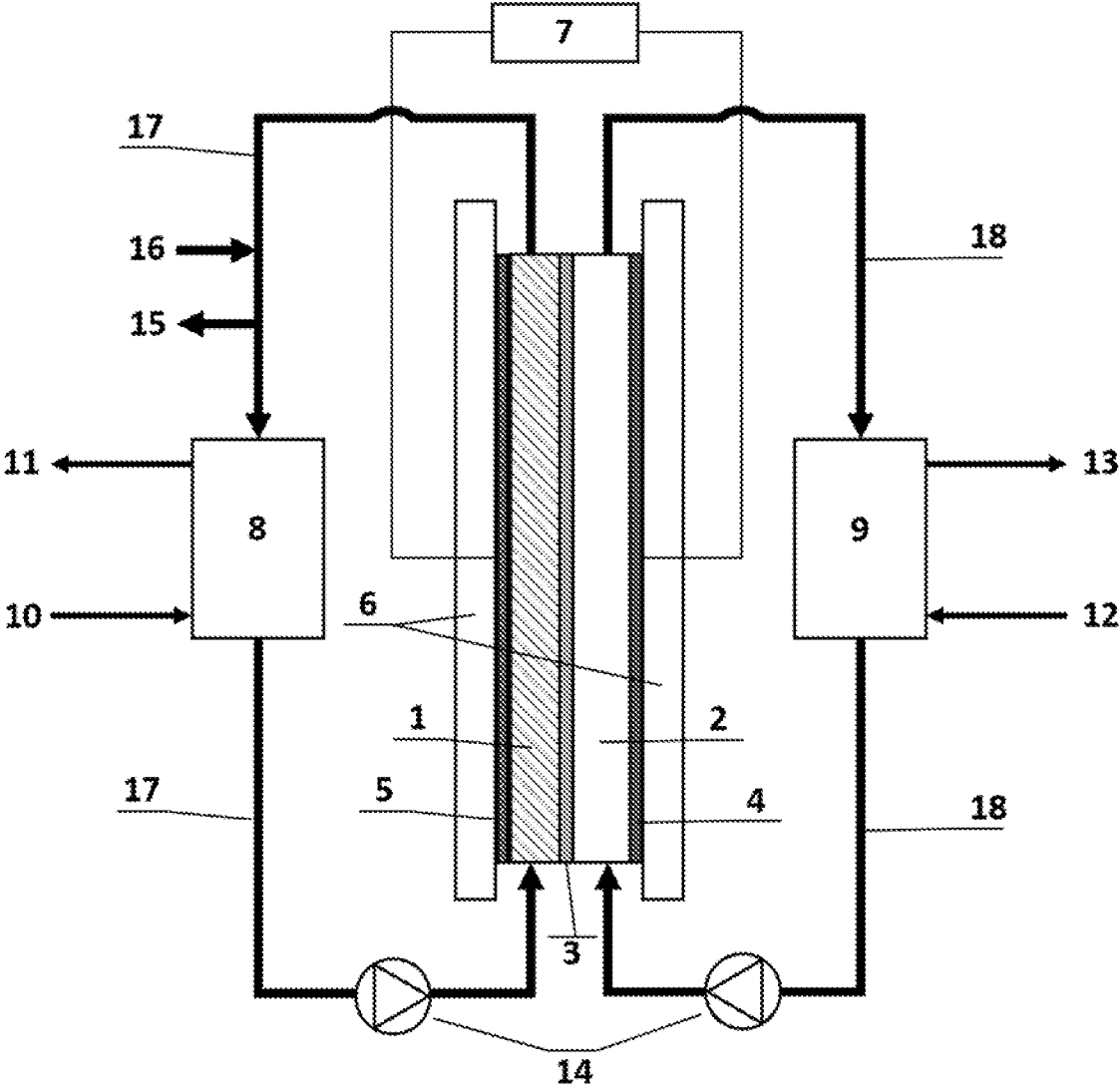


FIG. 1

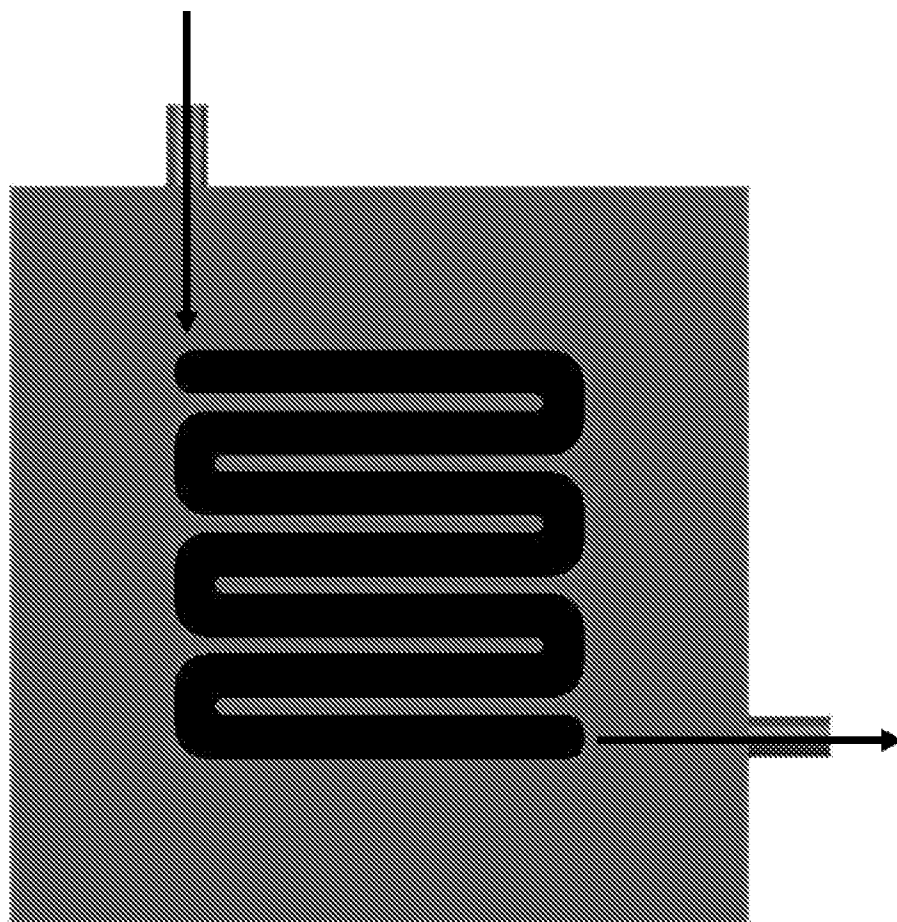
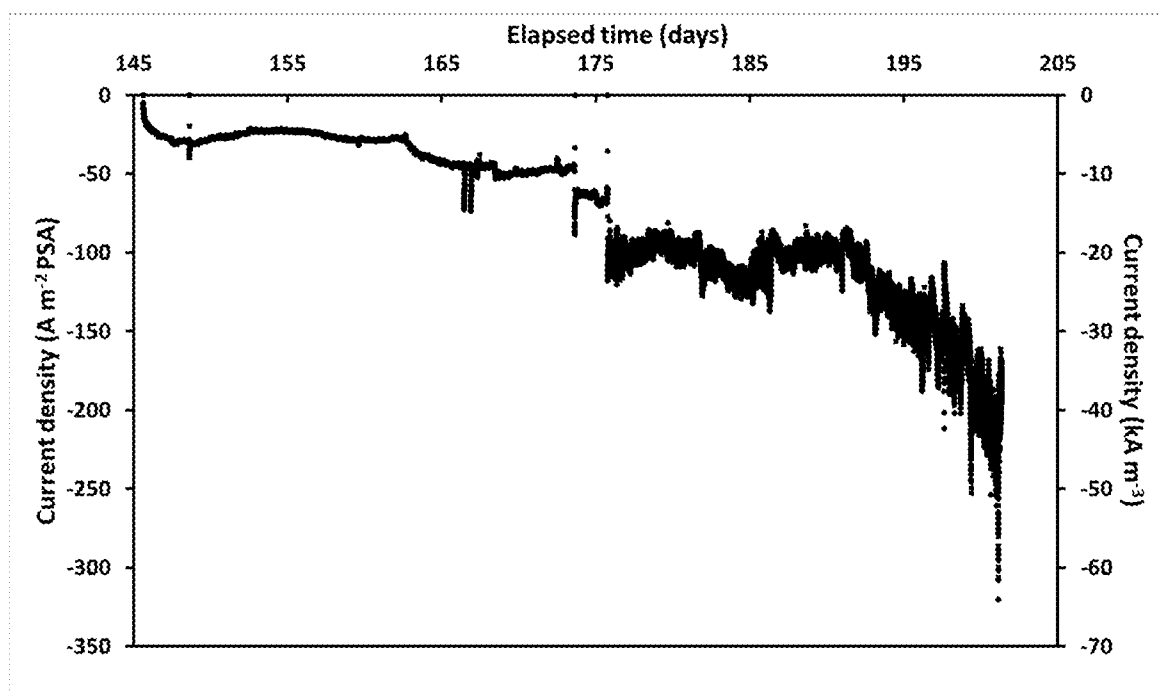


FIG. 2

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**FIG. 3**

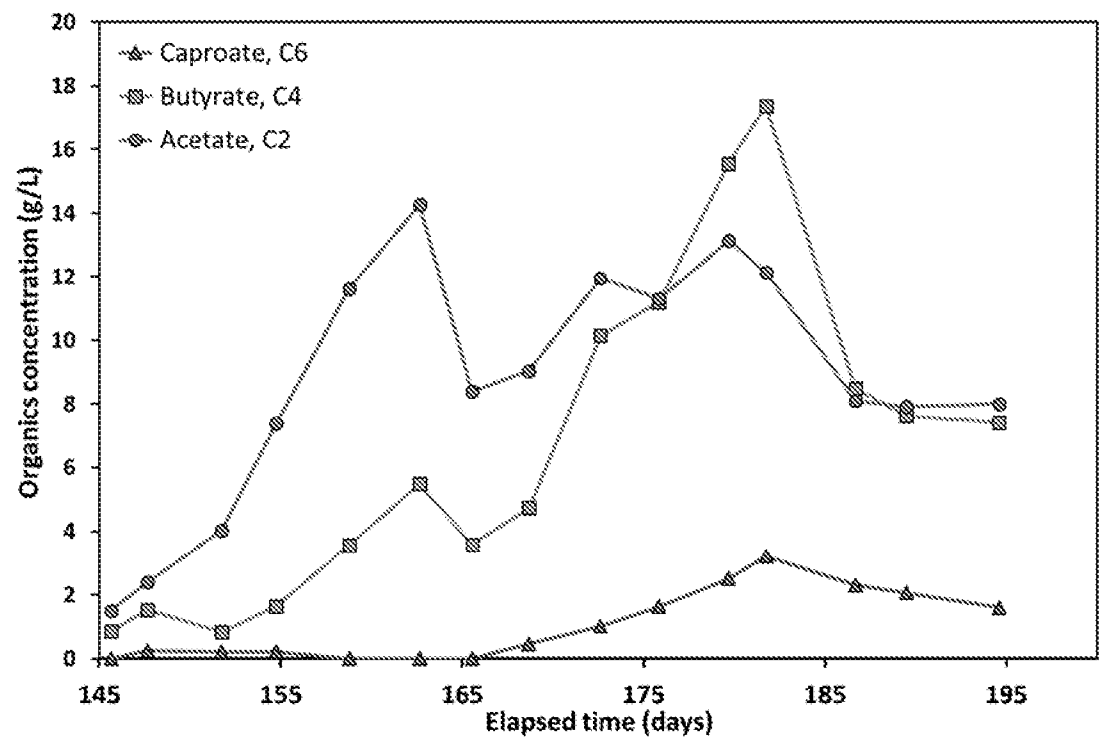


FIG. 4

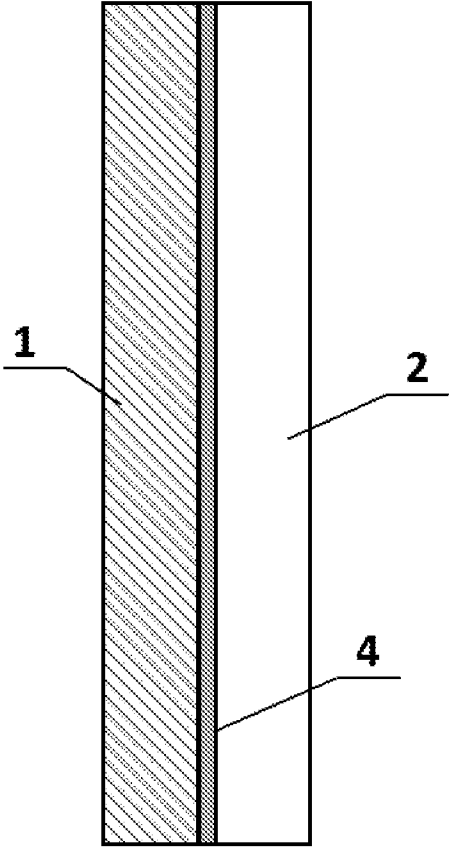


FIG. 5

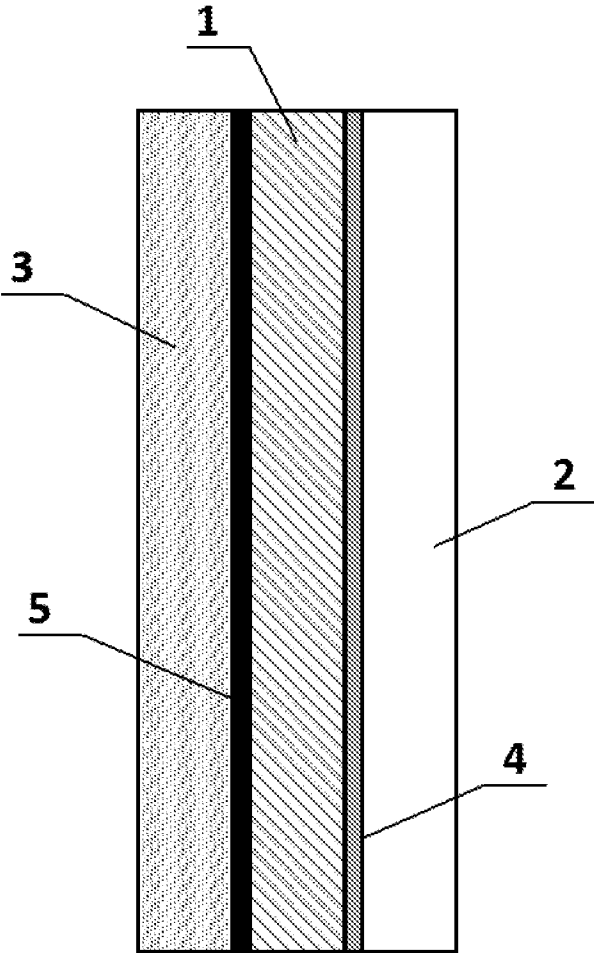


FIG. 6